WESTERN RESOURCE ADVOCATES

SMART Water

A Comparative Study of Urban Water Use Efficiency Across the Southwest

WESTERN RESOURCE ADVOCATES

SMART Water

A Comparative Study of Urban Water Use Efficiency Across the Southwest

SMART Water

A Comparative Study of Urban Water Use Across the Southwest

Produced and written by Western Resource Advocates

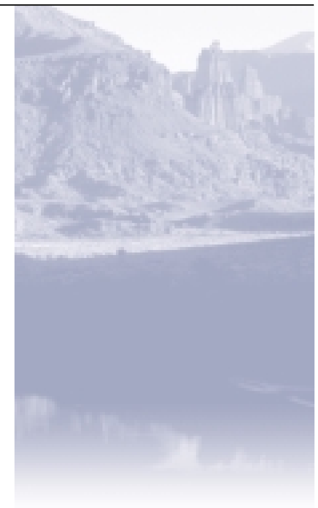
Graphic Design, Cover Design:
Karen Y. Gerhardt/Westerly Design
Cover Photos: Jeff Widen

Copies of *Smart Water* may be obtained by contacting:
Western Resource Advocates
2260 Baseline Road, Suite 200
Boulder, CO 80302
Tel: (303) 444-1188 x247
Fax: (303) 786-8054
www.westernresourceadvocates.org

WESTERN RESOURCE
ADVOCATES

Western Resource Advocates uses law, economics, and policy analysis to protect land and water resources and assure that energy demands are met in environmentally sound and sustainable ways. It collaborates with environmental and community groups to protect the natural environment of the Interior West, taking into account the economic and cultural framework of the region.

Printed on recycled paper



Foreword/Acknowledgements

This report was made possible by grants from the William and Flora Hewlett Foundation, the Surdna Foundation, and the Turner Foundation. We are extremely grateful for their support.

Bruce Driver, Executive Director of Western Resource Advocates, conceived of the report. He was co-author along with Bart Miller (Water Program Director) and Don Wojcik (Smart Water Technical Analyst). Claudia Putnam (Communications Director) and Melanie Newton (Program Assistant) provided editing and production assistance.

Western Resource Advocates wishes to thank many others who contributed. First and foremost, we must thank Amy Vickers. Well-known across the country for her work on urban water conservation, Amy served as a special consultant on the report. She provided crucial guidance and input throughout the process.

Eli Feldman drafted the Smart Water survey and carried out substantial preliminary research. Jarett Zuboy contributed research related to the connection between water and sprawl. Tim Carstensen assessed water rate data and helped generate the rate curves in Chapter 3. Greg Adams supplemented research on programs and systems of specific water providers. Traci Garner completed research on legal authorization for water rates.

We are very grateful for efforts of the water providers who completed our Smart Water survey, responded to subsequent requests for information, and provided comments on a draft of Chapter 3 and Appendices A and B. Specifically, we wish to thank the helpful staff of the City of Albuquerque Public Works Department, City of Boulder Water Utilities Department, Denver Water, El Paso Water Utilities, City of Grand Junction Water Utilities Department, Centennial Water and Sanitation District, Las Vegas Valley Water District, City of Mesa Utilities Department, City of Phoenix Water Services Department, City of Scottsdale Water Resources Department, Taylorsville-Bennion Improvement District, Tempe Water Utilities Department, and City of Tucson Water Department.

A number of individuals provided insightful comments on drafts of the complete report. We thank Val Little, Bonnie Colby, Dan Luecke, David Nickum, Melinda Kassen, Ann Livingston, Leanne Leith, Kara Gillon, Erica Thoen, and Alan Matheson.

The report's findings, views, and opinions are those of Western Resource Advocates and do not imply endorsement by our funders, contributors, and reviewers. Any factual inaccuracies are the sole responsibility of Western Resource Advocates.

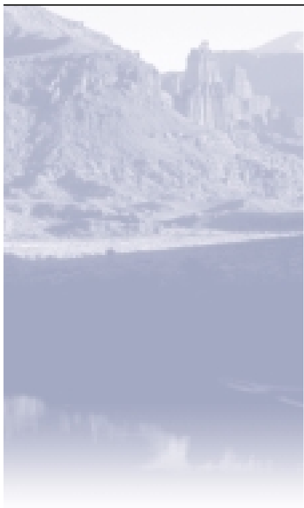
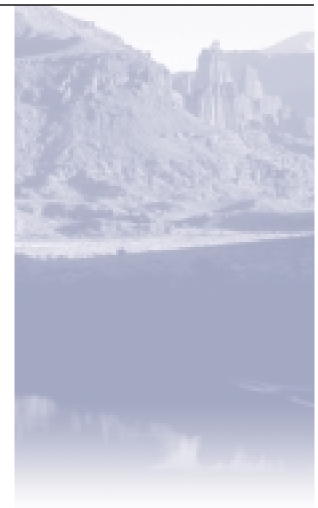


Table of Contents



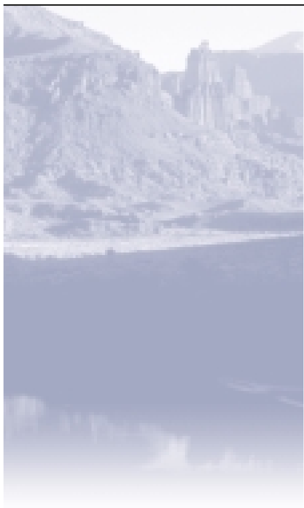
Chapter 3 (continued)

Chapter 4

Chapter 5

Appendix A

Appendix B



Space for Notes

Chapter 3

Comparative Analysis of Water Providers in the Southwest: Water Use and Demand-Side Efficiency

Overview

As urban expansion and population growth continue at a break-neck pace in the southwestern United States, municipal water efficiency has become increasingly critical. Over the past several years, some cities have made improvements in this area. However, great disparities remain between the per capita water use in cities across the region, suggesting that many municipal water providers have room for significant gains. Cities could maximize savings by considering and implementing many of the state-of-the-art efficiency measures and programs noted in Chapter 2.

To provide a snapshot of where we stand, Chapter 3 reports on the status of municipal water consumption and efforts toward efficiency in 2001 (prior to the unusually dry year of 2002). Thanks to the cooperation of many urban water providers who completed our Smart Water survey, we can provide the first-ever regional comparative analysis of:

- Per capita water use across many categories;
- System leaks and losses;
- Conservation programs and policies;
- Rate structures;
- Conservation budgets; and
- Recent trends in these categories.

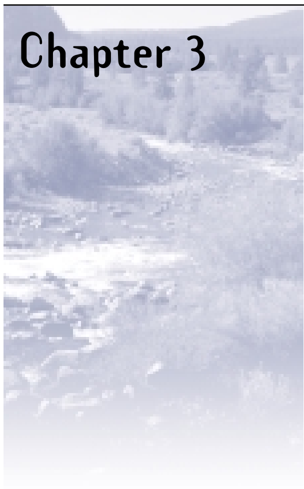
This chapter will aid members of the public in making personal water use decisions, assist water managers with efficiency program implementation, and help officials formulate future water policy.

Although supply-side efficiency is also important, the comparative analysis component of Smart Water was designed to focus on water demand and on conservation efforts in various water service areas throughout the region. As a result, chapter 3 focuses on ways to measure conservation, including what we label "ends" and "means."

For the water providers in our survey sampling, we look at "ends" such as Single-Family Residential water consumption rates, outdoor water consumption, system-wide consumption rates, and levels of Unaccounted for Water. These indicators shed light on the comparative efficiency of urban water use in a representative subset of the major systems in our region. Later in the chapter, we assess the "means"—actual water conservation measures, incentives, and programs—implemented by these same water providers and municipalities to influence efficiency.

Two attached appendices supplement Chapter 3. Appendix A explains methodology and analysis assumptions. Appendix B contains many additional specifics on each participating urban water provider (including water supply system information, consumption rates/trends, conservation programs and policies, and supply-side efficiency projects).

"A river is the report card for its watershed."
-Alan Levere



Based on this analysis, it is clear that across the Southwest:

- Urban water use is steadily increasing as urban populations continue to grow.
- Water use efficiency, as measured through per capita use, varies substantially in southwestern cities and is not correlated with climate conditions—cities in the hottest, driest areas do not necessarily use more water.
- Cities throughout the region have a lot of room for improving municipal water use efficiency.
- Outdoor water consumption accounts for a large proportion of total water sold to residential customers and offers the biggest target for future water savings.
- Unaccounted for Water (UFW) is high in many systems, leaving room for improvement in repairing leaks, metering, and accounting for water use.
- Increasing block rate pricing structures can provide strong incentives for cost-based conservation, and are an integral part of any plan to enhance urban efficiency.
- The content and budget of conservation programs varies considerably throughout the region, but is uniformly quite low, an average of 1 percent of total water service budget.

Background: Smart Water Survey Participants

In the spring of 2002, Western Resource Advocates distributed a comprehensive Smart Water survey to 32 urban water providers throughout the Southwest. The survey contained several dozen questions related to retail water demand in calendar years 1994 and 2001 and asked for water management plans and related materials. We chose these two data years to reveal trends over time without going too far back in time (where utility record-keeping may be less complete). Most of the analysis in this chapter focuses on the 2001 data. As a result, the effects of the drought in 2002 did not influence the outcome of the comparative analysis (*e.g.*, 2002 consumption figures and program implementation were not analyzed). The 2001 data analyzed resulted from relatively "normal" operating conditions for most water providers.

During an overall data collection period of nearly a year, a total of 13 water providers participated by submitting survey data during the summer and fall of 2002. Providers participating include those for major urban areas in Arizona, Colorado, New Mexico, Nevada, Texas, and Utah[1] and constitute a cross-section of urban area providers throughout the Southwest, from small to large.[2]

1 The service areas for most municipal water providers are not necessarily consistent with the city's political boundaries. Some water providers serve areas outside of the city's jurisdictional boundary. Some do not serve the full area within the city's jurisdictional boundary. However, for ease of reference throughout this chapter, each water provider is referenced by the primary municipality that it serves, instead of the name of the particular utility.

2 Appendix A contains details on the Smart Water survey participation, analysis methodology, and data assumptions.

3 The following water providers did not respond to the Smart Water survey: City of Aurora Utilities Dept. (CO), Parker Water & Sanitation District (CO), Colorado Springs Utilities (CO), City of Thornton Water Resources Dept. (CO), Town of Castle Rock Utilities Dept.(CO), City of Chandler Water Conservation Office (AZ), City of Glendale Utilities Dept. (AZ), City of Peoria Utilities Administration (AZ), City of West Jordan Utilities (UT), City of Sandy Public Utilities Dept. (UT), Salt Lake City Public Utilities (UT), City of St. George Water Dept. (UT), City of Las Cruces Water Resources Dept. (NM), Washoe County Water Resources Dept. (Reno, NV), Cheyenne Board of Public Utilities (WY), Mountain Water Company (Missoula, MT), and United Water Idaho (Boise, ID). The Town of Gilbert Water Conservation Department (AZ) did respond to the survey, but provided insufficient data to be included in the analysis and declined to submit additional data. The City of Santa Fe Public Utilities Dept. (NM) participated in part but stated they were unable to retrieve a significant amount of requested water accounting data due to a database/system problem that occurred in 2001.

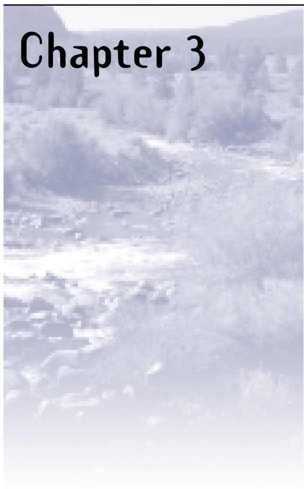
Table 3.1 provides a 2001 system snapshot for each of the municipal water providers in the study.[3] This table provides a basic look at the size of each water provider system.

Table 3.1

Basic System Information for Participating Water Providers

City/Water Provider 2001	Service Area (sq.mi.)	Total Water Utility Employees	2001 Total Water Utility Budget	2001 Retail Population Served	2001 Total Retail Water Sold (Million Gallons)
Albuquerque, NM [City of Albuquerque Public Works Dept.]	187	n/a	n/a	482,577	31,693
Boulder, CO [City of Boulder Water Utilities Dept.]	26	75	$63,973,955	113,600	6,511
Denver, CO [Denver Water]	328	1,026	$220,000,000	1,081,000	58,385
El Paso, TX [El Paso Water Utilities]	250	621	$165,890,000	645,641	33,639
Grand Junction, CO [City of Grand Junction Water Utilities Dept.]	10	25	$3,993,007	25,545	1,897
Highlands Ranch, CO [Centennial Water & Sanitation District]	20	60	$48,566,183	80,000	5,336
Las Vegas, NV [Las Vegas Valley Water District]	307	839	$264,628,291	1,021,475	106,463
Mesa, AZ [City of Mesa Utilities Department]	122	114	$45,000,000	440,000	30,804
Phoenix, AZ [City of Phoenix Water Services Dept.]	514	1,206	$558,699,363	1,284,000	100,194
Scottsdale, AZ [City of Scottsdale Water Resources Dept.]	188	140	$42,070,129	212,000	24,999
Taylorsville, UT [Taylorsville-Bennion Improvement District]	12	23	$11,180,657	62,000	4,825
Tempe, AZ [Tempe Water Utilities Dept.]	42	130	$35,072,000	171,000	18,389
Tucson, AZ [City of Tucson Water Dept.]	300	590	$103,000,000	630,000	34,392

Source Smart Water survey responses.
Note: Appendix B provides a comprehensive description of the above water providers, including supply system summaries, water demands, conservation programs and policies, and supply-side efficiency projects. "Retail Water" refers to treated potable water sold to private customers (including residential, commercial, industrial, and institutional sectors).



Climatic Differences

Because outdoor water use accounts for a substantial portion of total water use, it is important to consider the climatic differences between each water provider service area.

Table 3.2 provides a basic summary list of key climate variables in surveyed cities. Average temperatures, precipitation, and humidity vary widely across the study region. The average annual precipitation in the study ranges from 4.1 inches per year in Las Vegas to 18.3 inches per year in Boulder. The average annual temperature ranges from 51 °F in Boulder, Denver, and Santa Fe, to 73 °F in Phoenix. Average high temperatures range from 64 °F in Boulder, Denver, and Salt Lake City, to 86 °F in Phoenix.

While a detailed climate analysis is beyond the scope of this report, Table 3.2 and the following sections of this report suggest high urban water consumption is not a foregone conclusion for areas with high temperatures and/or low precipitation.

Table 3.2

Basic Climate Data for Urban Areas included in Smart Water Report

City or Metropolitan Area	Average Temperature (°F)	Average High Temperature (°F)	Average Low Temperature (°F)	Average Probability for Sunshine	Average Annual Precipitation (in.)
Albuquerque, NM	57	70	43	76%	8.5
Boulder, CO	51	64	38	n/a	18.3
Denver, CO	51	64	37	69%	15.4
El Paso, TX	64	78	50	83%	8.6
Grand Junction, CO	53	65	40	71%	8.6
Las Vegas, NV	67	80	54	85%	4.1
Phoenix, AZ	73	86	59	86%	7.7
Salt Lake City, UT	52	64	40	66%	15.6
Tucson, AZ	69	82	55	85%	11.7

Source www.weatherbase.com.
Notes: Climate data for Phoenix also applies to Mesa, Tempe, and Scottsdale. Climate data for Denver also applies to Highlands Ranch. Climate data for Salt Lake City also applies to Taylorsville.

Smart Water Survey Results and Analysis: Inter-City Comparison

"Ends"—2001 Water Use Comparisons

Urban water use is growing. In the past several decades, millions of people have flocked to cities in the Southwest. (Although regional urban population growth has recently slowed somewhat in response to an economic downturn, most believe rapid growth will return when the economy improves.) A dramatic increase in water demand to serve the needs of homes, businesses, parks, and other urban uses has accompanied this population growth. Increased water demand, in turn, has tapped further into the surface and groundwater systems of an arid desert environment. As discussed in Chapter 1, this growth threatens to overwhelm the region's river systems.

Figures 3.1 and 3.2 provide a graphical representation of participating water providers' system populations and total retail sales. Region-wide, the Smart Water survey covers a served population of over 6.2 million people. In the year 2001, this population purchased nearly 458 billion gallons of water, equivalent to over 1.4 million acre-feet.

By comparing Figures 3.1 and 3.2, we see that total retail water sold is not necessarily proportional to the service population. Instead, variations among cities' per capita water use, a topic covered in greater detail in the following sections, means that in some cases, larger service populations consume less water than smaller ones do. Figure 3.2 also highlights some of the water service areas with the highest water use in the Southwest, places where policy changes can have the most impact.

Figure 3.1

2001 Retail Service Area Population

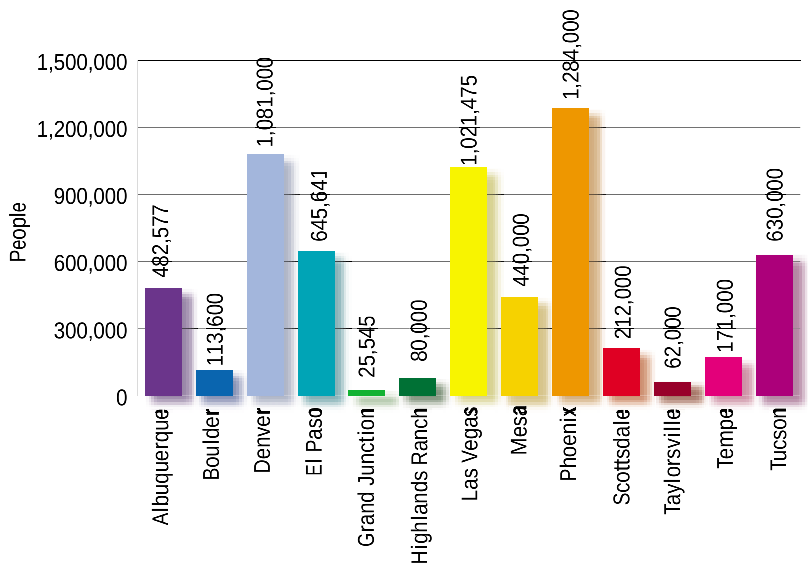
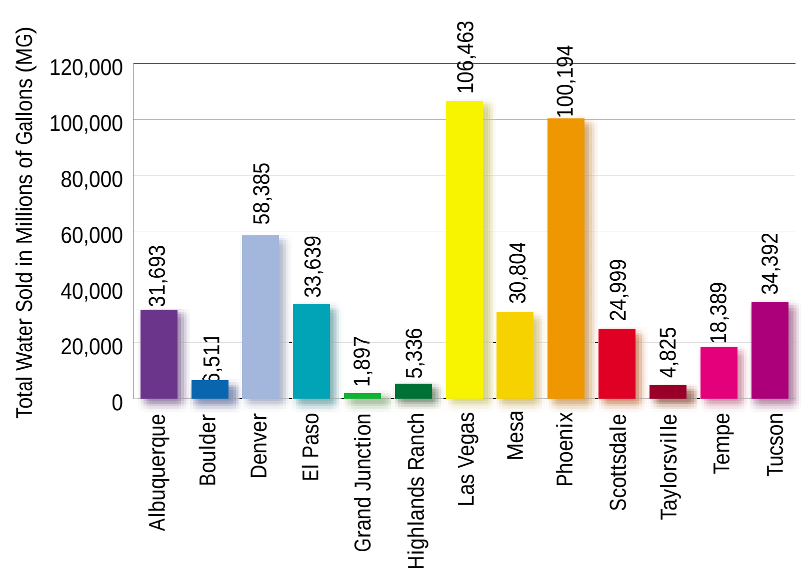
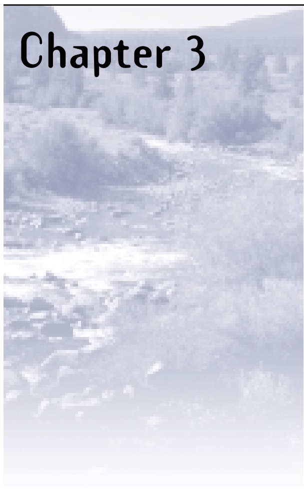


Figure 3.2

2001 Total Retail Water Sold





Chapter 3

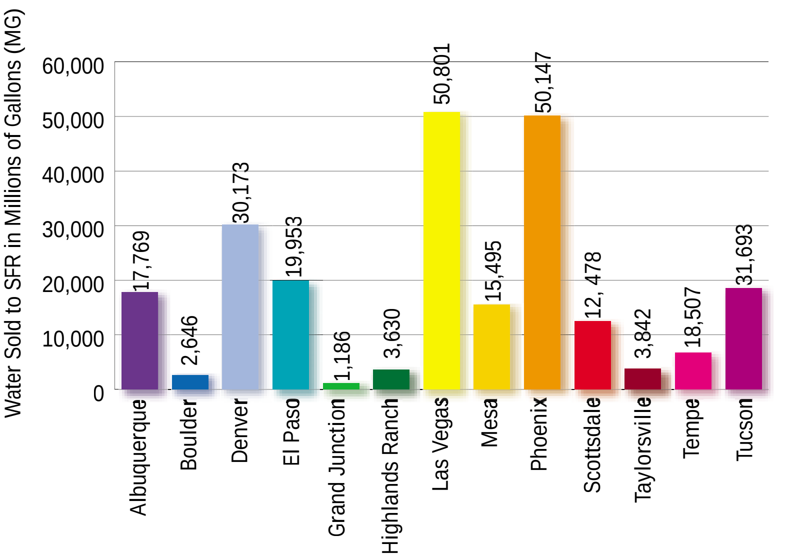
Single-Family Residential Consumption[4]

For the purposes of this study, we focus on per capita water consumption rates in a single sector—Single-Family Residential (SFR). Though we acknowledge the widespread use of a "system-wide" water use variable by the water industry, we conclude that the SFR consumption variable is a superior comparative tool for a host of reasons,[5] including:

- The SFR variable minimizes the sources of analytical error inherent to the system-wide per consumption variable (described in later sections and in Appendix A);[6]
- SFR is derived easily from raw-sales accounting data and census data;
- SFR is the largest consumption sector in all participating water service areas;
- SFR holds a very high potential for demand reduction given the large proportion of outdoor water consumption (*e.g.*, lawn irrigation);
- SFR customers are the primary focus of most water conservation programs offered by water providers throughout the study area.

Figure 3.3

2001 Retail Water Sold to Single-Family Residential



Notes: Denver Water groups multi-plex residences with the Single-Family Residential billing category. This may have some minor effects on Denver's SFR consumption rates due to typically smaller multi-plex yards.

The Taylorsville-Bennion Improvement District groups all single-family and multi-family water consumption into one billing category. The above Taylorsville SFR usage totals include all housing types. Therefore, the displayed total SFR water sales for this water provider is higher than the actual SFR volume since multi-family housing sales are included.

The Salt River Project (SRP) in Arizona provides untreated urban irrigation water to residential customers in Phoenix, Mesa, Tempe, and portions of Scottsdale. The SRP delivers and bills independently from the municipal water providers. SRP water is typically available every two weeks from April through September, and once a month from October through March. The use of SRP water for outdoor irrigation in these Phoenix-area service areas most likely lessens the amount of treated municipal water applied to residential landscapes. Thus, the applicable consumption volumes in the above graph may be somewhat lower than what they would be without the SRP deliveries.

Our focus on the SFR variable does not imply that efficiency in other sectors is unimportant. Water providers excelling in SFR demand reduction may not necessarily be excelling in demand reduction in other sectors, and vice versa. With non-SFR water use accounting for roughly 50 to 60 percent of urban water use in most cities of our region, addressing efficiency in all sectors is vitally important for achieving significant savings and yielding equity in public policy. However, SFR use is a good place to start in measuring a city's efficiency performance. A comparative analysis of urban water use efficiency outside the SFR sector is beyond the scope of this report.

Total Retail Water Sales to Single-Family Residential Accounts

Prior to assessing per capita consumption rates within the Single-Family Residential sector, we take a quick look at SFR retail sales volumes for each partici-

4 This report uses the terms "consumption" and "use" interchangably, as do most writings on the subject. Technically speaking, the terms have distinct meanings. "Water consumption" implies water used and not returned to the system. "Water use" is a broader term, including water consumed plus water returned via pipes to wastewater treatment facilities.

5 Greater detail on the SFR variable and other data variables appears under Data Variables and Assumptions section in Appendix A.

6 Although the SFR per capita consumption variable offers many advantages, the variable does not completely eliminate the possibility of yielding biased comparison results. *See* Appendix A.

pating water provider. The variation in service area size is demonstrated by the large disparity in total SFR retail sales volumes in each service area. Figure 3.3 provides a graphical display of this disparity in 2001 SFR sales data. The relative size of the bars in Figure 3.3 bears a striking resemblance to Figure 3.2, revealing that water sold to SFR accounts is roughly the same percentage of total retail water sold by each provider.

Single-Family Residential Daily per capita Water Consumption

Per capita SFR use varies greatly across the study area.

Figure 3.4 displays the 2001 SFR daily per capita consumption rates for the participating water service areas. To derive per capita consumption rates within the SFR sector requires knowledge of SFR occupancy rates, which vary between urban areas analyzed. Using data from the 2000 U.S. Census, we derived these rates for each area analyzed.[7] Although the mean 2001 SFR daily per capita consumption rate is 161 gallons per capita per day (gpcd), city-by-city rates range from 107 gpcd in Tucson to 230 gpcd in Las Vegas.

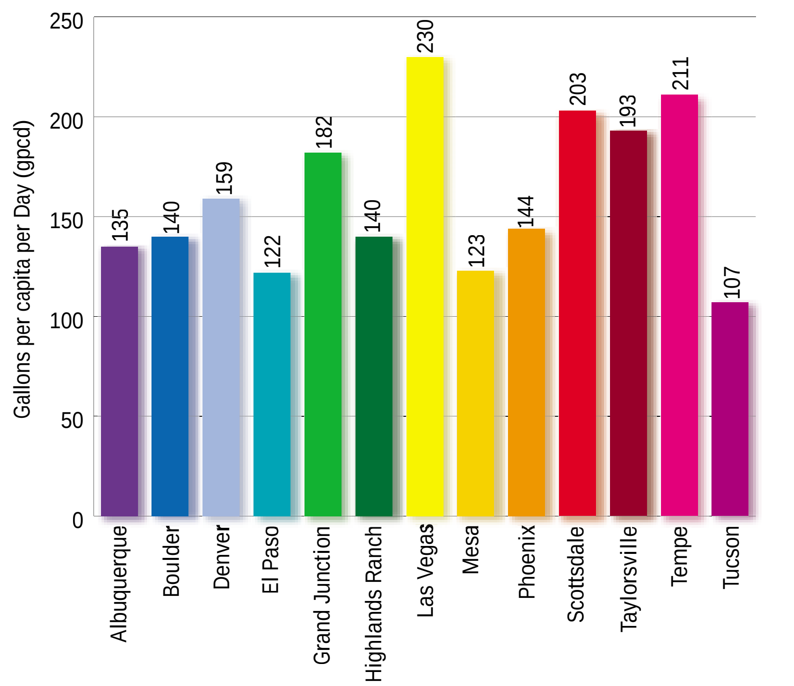
The very low SFR per capita consumption in Tucson is noteworthy, particularly given the very arid climate of southeastern Arizona. This consumption rate is roughly half of some of the consumption rates of other water service areas in the region, particularly other areas with similar climates.

The significant disparity in SFR per capita consumption throughout the region indicates the enormous potential for improved water use efficiency inside almost every urban area.

The substantial SFR consumption disparity from water provider to water provider raises two very important questions: (1) Why are the SFR consumption figures in some municipal water service areas so low, and others so high?; and (2) What are the water providers and their customers with low SFR consumption doing to attain these figures? Though some water managers and public officials have indicated that the potential water savings from conservation efforts is insignificant or already fully “tapped,” this cannot be so if

Figure 3.4

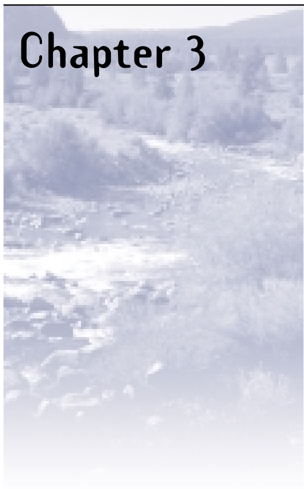
2001 Single-Family Residential Daily per capita Water Consumption



Note: See notes to Figure 3.3.

7 Appendix A contains the methodology and results of the household occupancy rate derivation. For the purposes of this study, the SFR per capita consumption variable can be defined as follows:

$$\text{SFR per capita Consumption} = \frac{\text{Retail Water Sold to SFR Accounts}}{\text{Number of SFR Accounts}} \times \frac{1}{\text{Avg. Occup. / SFR Household}}$$



a neighboring city, or a city with a drier climate, is saving more water.

While assessing the SFR consumption figures in Figure 3.4 and considering the above questions, we look at the two primary attributes to SFR water use: indoor water use and outdoor water use. In contrast to outdoor use, per capita indoor residential water use remains relatively constant from season to season and year to year, and does not vary much from region to region.[8] According to the American Water Works Association Research Foundation (AWWARF) Residential End Uses of Water Study ("REUWS"), the mean indoor residential per capita consumption for the North American cities in the study was 69.3 gpcd (with a range from 57.1 to 83.5 gpcd).[9] The range of per capita indoor use likely is based on variations in social norms, the age and efficiency of household water fixtures, the presence of evaporative coolers, and other factors.

Although the Smart Water survey included a data request for an indoor/outdoor breakdown of residential water consumption, almost no respondents had this information available. Therefore, we were unable to perform a direct data analysis of indoor water use trends. However, many of the means to improve indoor efficiency discussed in Chapter 2 are available for cities in the study area to lower annual indoor use.

With variations in indoor use being relatively minimal across the region, we can deduce that most of the SFR consumption variation reported in Figure 3.4 results from variations in per capita outdoor water use (*i.e.*, urban landscape irrigation). Yet, there appears to be very little correlation, if any, between water consumption and local climate. With landscape irrigation accounting for a majority of SFR water consumption in most cities, we might expect a direct, distinct correlation between urban water use and climate. However, the water providers with the lowest SFR per capita consumption rate in this study are exposed to very similar climate conditions as the water providers with some of the highest SFR per capita consumption rates in the study.

The absence of a correlation between climate and per capita water consumption rates underscores that an "appropriately developed landscape" is defined differently throughout the region. It appears that while some communities have adjusted their urban landscape expectations to coincide with the climate in which they reside, others have maintained their preference for non-native, high-water-use urban landscapes. Several other factors that contribute to these disparities in SFR use (*e.g.*, water rates, conservation efforts, etc.) are assessed later in this chapter. Other variables beyond the scope of this study are highlighted in Appendix A (*e.g.*, community socioeconomics).

8 The variation in indoor residential per capita consumption is relatively minimal due to relatively constant daily consumption patterns in an average household, regardless of location in North America. However, as discussed in Chapter 2, per capita indoor consumption could drop significantly over time due to the installation of high-efficiency water appliances and fixtures in new development and the retrofit of such appliances in existing development.

9 Peter Mayer, Residential End Uses of Water Study (REUWS), American Water Works Association Research Foundation (AWWARF), 1999, at 90.

Estimated SFR Outdoor Daily per capita Water Consumption

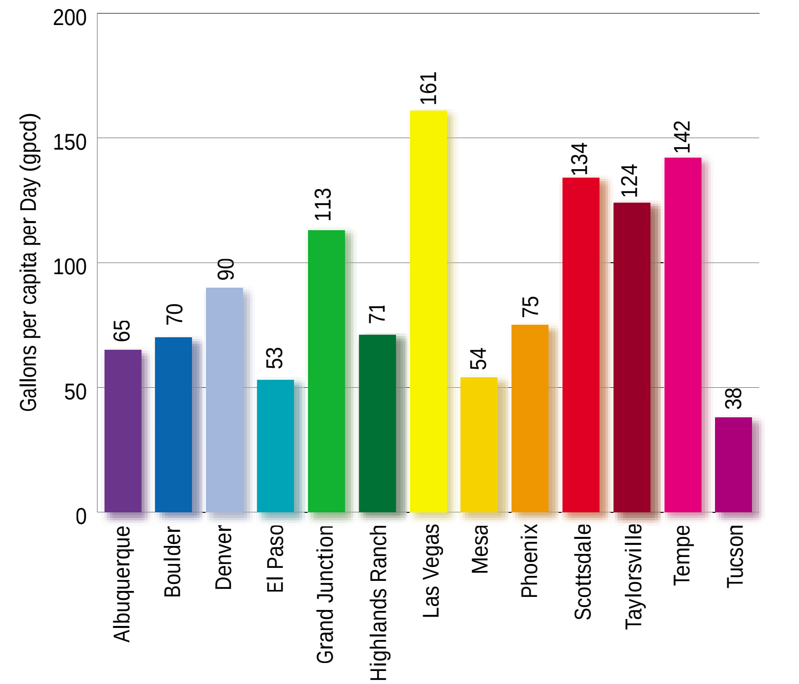
Outdoor use is the primary component of Single-Family Residential water consumption in most cities of the semi-arid and arid Southwest. Most of these outdoor uses are "elective," or discretionary uses. While some of this outdoor water is used for filling swimming pools and washing cars, the vast majority is for landscape irrigation. Thus, the quantity of water allocated to outdoor use varies considerably from season to season and year to year, depending on the frequency and amount of precipitation during the respective time period.

There is a dramatic variation in outdoor water consumption between sampled providers. This variation can be seen in Figure 3.5.[10] The estimated outdoor per capita consumption rates in some water service areas are three to four times greater than Tucson's rate of 38 gpcd. Among sampled providers, the mean 2001 SFR daily per capita consumption rate for outdoor water use is 92 gpcd, with individual consumption rates ranging from 38 gpcd in Tucson to 161 gpcd in Las Vegas. The implication from these data is that outdoor use efficiency offers the greatest opportunity for water demand reduction in most southwestern cities.

The differences among outdoor water use in cities with similar climates may be the result of variations in conservation programs, water rate structures, municipal ordinances, and urban landscape expectations among residents. Therefore, the incentives and measures used to attain outdoor use reduction will be unique to each water provider. Chapter 2 provides a framework of state-of-the-art outdoor water use efficiency measures, programs, and policies to be considered by all water providers. In addition, Chapter 4 takes a look at the benefits of smart development strategies, as they relate to the effect of urban sprawl on outdoor water use.

Figure 3.5

2001 Estimated Single-Family Residential Outdoor Use, Represented as a Daily per capita Use



Notes: The methodology used to derive the estimated SFR outdoor use figures is provided in footnote 10 of this chapter.

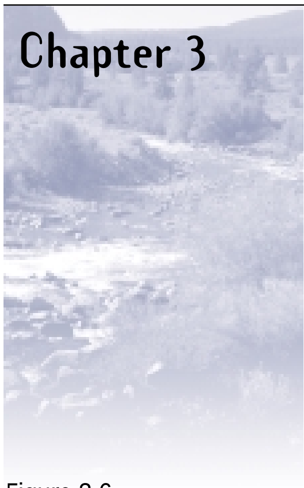
The Salt River Project (SRP) in Arizona provides untreated urban irrigation water to residential customers in Phoenix, Mesa, Tempe, and portions of Scottsdale. The SRP delivers and bills independently from the municipal water providers. SRP water is typically available every two weeks from April through September, and once a month from October through March

The use of SRP water for outdoor irrigation in these Phoenix-area water service areas most likely lessens the amount of treated municipal water applied to residential landscapes. Thus, the applicable outdoor consumption rates in the above graph may be somewhat lower than what they would be without the SRP deliveries.

10 By applying the previously listed SFR per capita consumption rates and the indoor average of 69.3 gpcd, the estimated SFR daily per capita outdoor consumption rates can be derived. In general, this variable can be defined as follows:

Estimated SFR Daily per capita Outdoor Consumption = SFR Daily per capita Consumption - 69.3 gpcd

Because most participating water providers did not provide indoor water use data in their survey responses, we chose to assign the average per capita indoor use of 69.3 gpcd to all Smart Water survey participants (as derived from the AWWARF REUWS). By assuming this average indoor use applies to all water providers in the study, we are able to derive an estimated outdoor per capita SFR consumption rate for each.

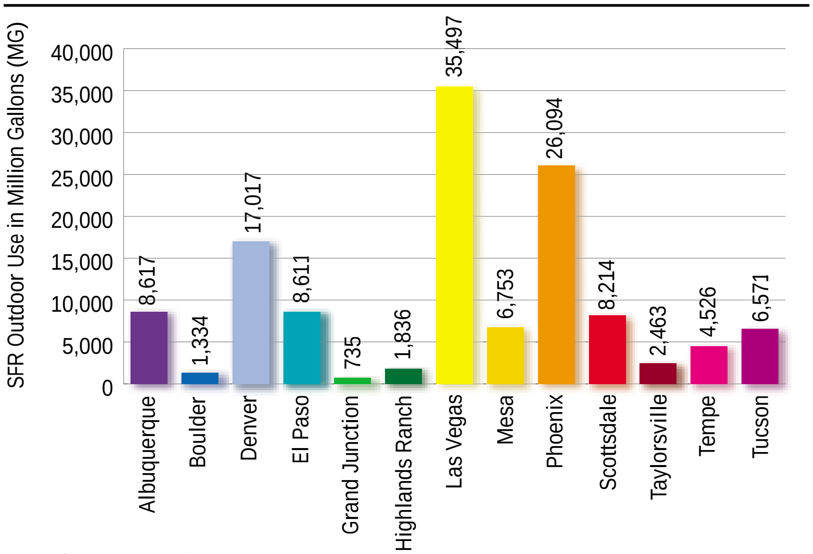


Estimated Annual Total of SFR Outdoor Water Consumption

The significance of SFR outdoor water use becomes more apparent when the above-mentioned per capita SFR outdoor rates (from Figure 3.5) are converted to total annual volumes. Figure 3.6 displays the estimated 2001 annual totals for each participating water provider.[11] The sum of all estimated outdoor SFR water consumption in the 13 participating water service areas equals 128,268 million gallons annually (approximately 393,639 acre-feet). This notable amount of outdoor water only applies to the Single-Family Residential sector. Other sectors also apply a significant amount of water to outdoor uses.

Figure 3.6

2001 Estimated Total Single-Family Residential Outdoor Water Use



Note: See notes to Figure 3.5.

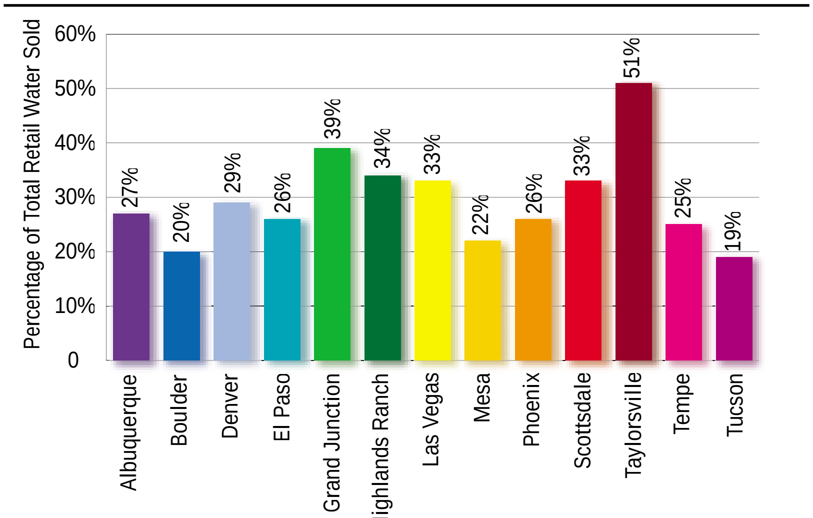
Estimated Annual SFR Outdoor Water Consumption, as a Percentage of Total Retail Water Sold

An equally revealing observation can be made when the estimated SFR outdoor volumes are compared to the actual 2001 total annual retail water sold in each water service area (as listed in Table 3.1). Figure 3.7 displays the percentage of 2001 total retail water sold allocated to SFR outdoor consumption in each water service area. Across the region, nearly one-third of all retail water sold by the participating water providers is applied to outdoor SFR consumption.

These percentages only include SFR outdoor water consumption. If outdoor consumption in the Commercial, Multi-Family Residential, Industrial, and Institutional sectors is included, the percentages become much larger.

Figure 3.7

2001 Estimated Single-Family Residential Outdoor use, Represented as a Percentage of Total Retail Water Sold



Note: See notes to Figure 3.5.

11 These volumes are calculated by multiplying the per capita outdoor figures by the number of SFR accounts, the average SFR household occupancy in each urban area, and 365 days (See Appendix A for details on household occupancy rates).

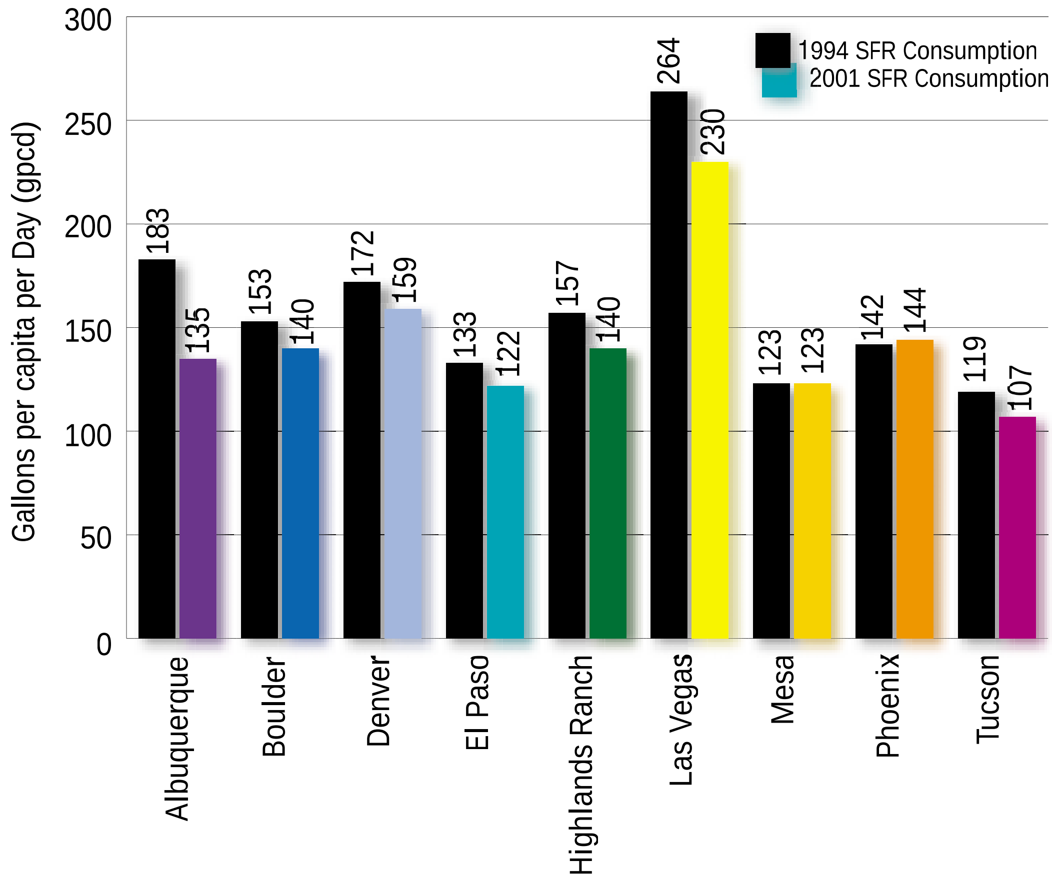
Changes in Single-Family Residential Use Between 1994-2001

Trends during the past decade indicate many water providers have improved demand-side efficiency but considerable additional progress is possible.

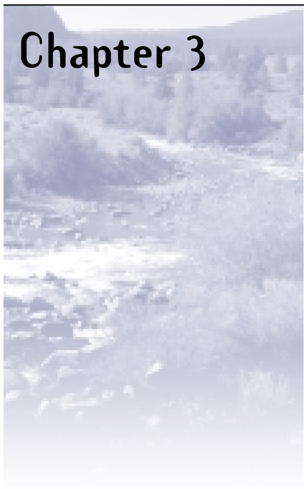
Figure 3.8 displays the changes in SFR daily per capita consumption, from 1994 to 2001.[12] The sampled trends reveal an average SFR per capita consumption reduction of 9.2 percent from 1994 to 2001, with a range from –1 percent in Phoenix to 26 percent in Albuquerque. Per capita consumption rates in most water service areas are declining despite increases in population and developed land area. In some cities, the majority of the reduced per capita consumption rates can be attributed to changes in landscape development standards over the years. However, the degree of reduction is small compared to the reduction potential.

Figure 3.8

Changes in Single-Family Residential Daily per capita Water Consumption, from 1994 to 2001



12 The 2000 U.S. Census information on average SFR household occupancy was applied to both 1994 and 2001 figures. Not all Smart Water participants are included in this figure since complete 1994 data were not provided by all water providers.



System-wide per capita Water Consumption

System-wide daily per capita consumption is a commonly used standard in the water supply industry.[13] This indicator is intended to represent the overall per capita demand across all consumer sectors. Figure 3.9 displays the 2001 system-wide daily per capita consumption rates for the participating water providers. Per capita distribution losses (UFW) are included in these system-wide figures. The mean system-wide daily per capita consumption rate for this sampling of water providers is 229 gpcd. The rates range from 170 gpcd in Tucson to 366 gpcd in Scottsdale[14].

Although the water supply industry commonly uses this demand variable as a system demand indicator, the probability for comparison error in the system-wide per capita variable is relatively high, resulting in an "apples-to-oranges" comparison. Therefore, the displayed values in Figure 3.9 should be considered individually, instead of comparatively, to avoid erroneous conclusions on water consumption.

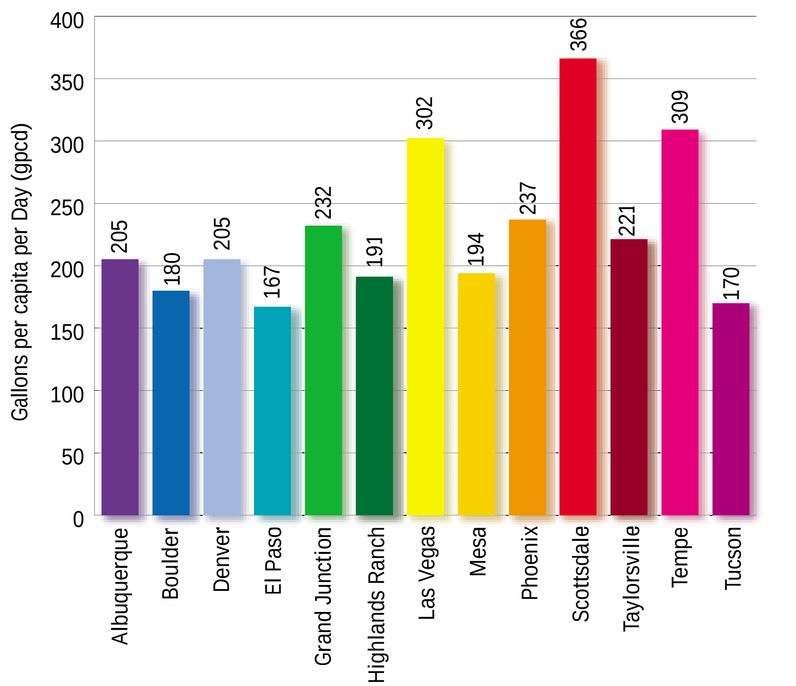
As discussed in Appendix A, data analysis bias in the system-wide consumption indicator can originate in municipal water service areas that:

1. function as employment centers and receive significant amounts of inflow commuting;
2. possess a relatively large industrial, commercial, or institutional (ICI) consumption sector;[15]
3. serve large airports; or
4. distribute large quantities of wholesale water.

Varying definitions of Unaccounted For Water (UFW) across water providers also contribute to the bias in the system-wide consumption variable. As a result, Chapter 3 de-emphasizes the system-wide indicator, focusing instead on Single-Family Residential per capita consumption.

Figure 3.9

2001 System-Wide Daily per capita Water Consumption



13 The industry-standard definition of system-wide per capita consumption is the total raw water extracted from supply sources divided by the water provider's service area population:

$$\text{System-wide per capita consumption} = \frac{\text{Total Raw Water Extracted from Supply Sources}}{\text{Service Area Population}}$$

14 The City of Mesa Utilities Department alluded to a possible raw water master meter discrepancy between the City and the Central Arizona Project (CAP). Apparently, the actual CAP raw water deliveries may be higher than the recorded/billed volume. CAP raw water deliveries constitute roughly 30 percent of Mesa's supply. Since the system-wide per capita figures are directly based on the volume of total raw water drawn from supply sources, Mesa's system-wide consumption rate in Figure 3.9 may be slightly lower than the actual value.

15 As an example, Tempe's system-wide consumption rate is notably higher than nearby Mesa or Phoenix. However, Tempe's non-residential consumption accounts for 45 percent of its retail water sold, compared to 30 percent and 33 percent in Mesa and Phoenix, respectively. The higher proportion of commercial, industrial, and institutional water use will yield a higher system-wide per capita figure in Tempe.

Unaccounted For Water (UFW)

Many water providers have room to improve the efficiency of their water delivery systems.

Many water providers in the sampled group lose track of large volumes of water each year through the water delivery systems they build, operate, and maintain. This loss—generally referred to as Unaccounted For Water (UFW)—is defined as the percentage difference between total raw water extracted from supply sources and the total water sold.[16] If a hypothetical water provider extracts 100 units of raw water from a reservoir storage system and, following water treatment, sells 90 units of water to consumers, the remaining 10 units are lost in the system (10 percent UFW). UFW is comprised of three general categories:

- Real losses: Actual losses of water due to delivery system leaks, private service line leaks (between main and meter), inefficient treatment systems, and theft
- Apparent losses: "Paper/computational losses" due to faulty metering and system accounting errors/flaws
- Beneficial uses: Unmetered water used for fire fighting, watermain flushing, cleaning, and construction use

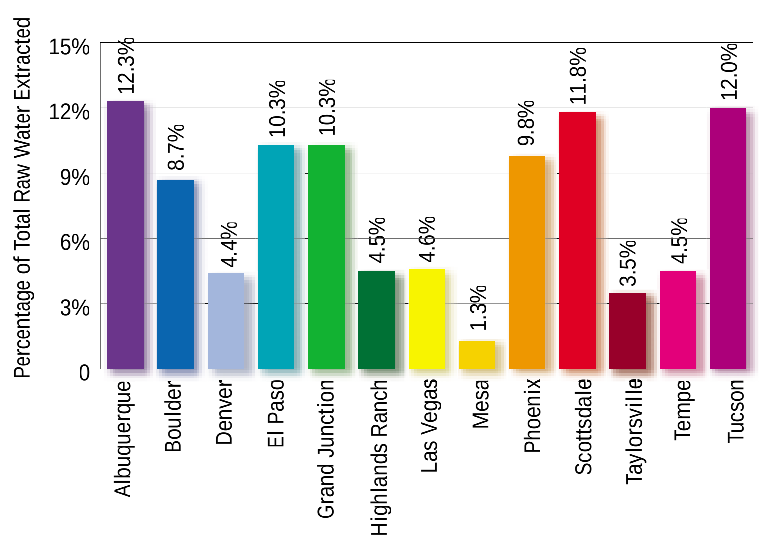
The percentage breakdown of UFW in each water system varies considerably. In some water systems, the vast majority of UFW results from real losses (*e.g.*, leaks). Since real losses translate to a direct loss of "wet water," they are the most critical type of loss. In other systems, faulty meters or accounting errors may comprise most of the UFW. Although these apparent losses do not translate to "wet water" lost, they distort consumer water usage data critical for developing future demand models and conservation plans, evaluating conservation program effectiveness, building water supply infrastructure, and designing equitable pricing mechanisms. The amount of UFW attributed to beneficial uses is relatively small compared to the aforementioned losses in most water systems. UFW can be decreased through ongoing leak detection and repair, system upgrades, accounting quality control, and meter repair and replacement.

Unaccounted For Water (UFW) as a Percentage of Total Water Extracted from Supply Sources

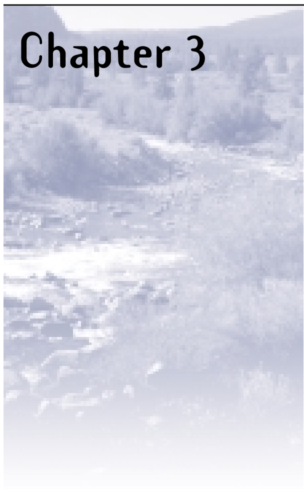
Figure 3.10 shows the UFW percentages reported by the participating water providers or derived from extraction and sales data. The mean 2001 UFW percentage for the sampled water providers is 7.5 percent. The 2001 UFW percentages range from 1.3 percent in Mesa to 12.3 percent

Figure 3.10

2001 Unaccounted For Water (UFW) as Percentage of Total Raw Water Extracted



16 Some water providers maintain slightly different definitions of UFW. See Appendix A for further explanation. In addition, a discrepancy exists between water wholesalers and water retailers. Typically, water providers that sell large amounts of wholesale water have lower UFW percentages than water providers that only sell retail water.

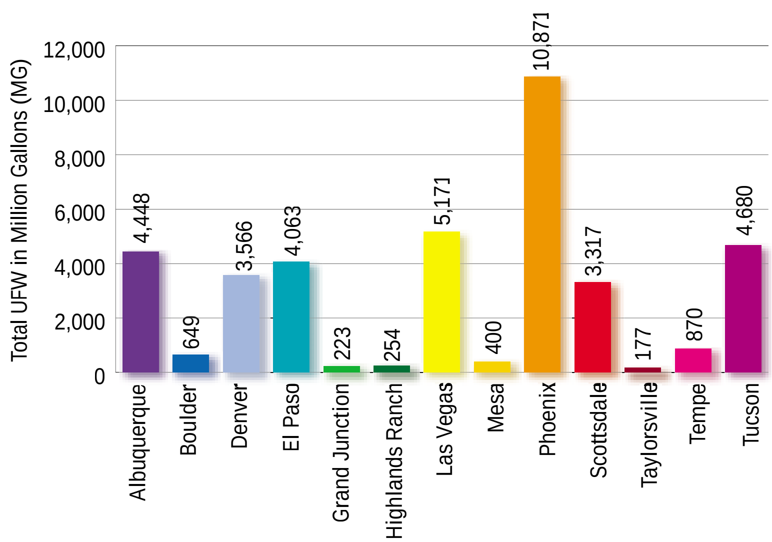


Chapter 3

in Albuquerque.[17] Figure 3.10 demonstrates that approximately half of the surveyed water providers possess UFW percentages that hover around 10-11 percent, while the other half hover around 4-5 percent. These data show no correlation between system size and UFW percentage. The water providers with lower UFW percentages demonstrate the significant potential and capacity for water loss reduction in municipal water systems.

Figure 3.11

2001 Estimated Volume of Unaccounted For Water



Unaccounted For Water (UFW), as a Total Volume "Lost" per Year

Tens of millions of gallons of water are lost through UFW in systems of the sampled providers each year. Added together, the 13 Smart Water survey participants lost track of 38,689 million gallons of water in 2001 (the equivalent of 118,732 acre-feet). Figure 3.11 presents the estimated total annual volumes "lost" in 2001. These values are derived by multiplying the UFW percentages by the total raw water extraction volumes of each provider. Thus, the 2001 UFW values displayed in Figure 3.11 are a factor of both UFW percentage and system size/capacity. A small water provider with a high UFW percentage will not generate nearly as much volume loss or resource impact as a large water provider with an equal UFW percentage. For example, Boulder, El Paso, Grand Junction, and Phoenix had relatively similar UFW percentages in 2001. However, since Phoenix's water use volume is much higher than the other three service areas, the Phoenix UFW volume is substantially higher.

This graphic can also be interpreted from another perspective. For example, Phoenix and Las Vegas sell similar volumes of retail water (each sell just over 50 billion gallons each year); however, Las Vegas had a 2001 UFW that was less than half of Phoenix's UFW. The resulting 2001 UFW volume in Las Vegas is half that of Phoenix. Not surprisingly, the large municipal water systems account for the lion's share of this overall loss.

17 The City of Mesa Utilities Department indicated that the 1.3 percent UFW figure may be lower than Mesa's actual UFW value, due to a possible master meter discrepancy between the City and the Central Arizona Project (CAP). CAP water deliveries constitute roughly 30 percent of Mesa's supply. According to Utilities Department representatives, the actual UFW value could deviate from this reported value by a couple percent, but still be below 5 percent.

Unaccounted For Water (UFW), as a Daily Volume "Lost" per capita

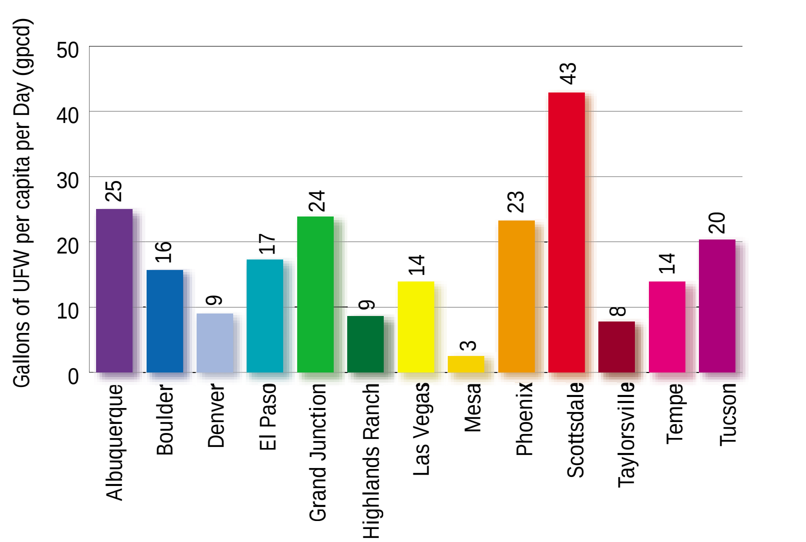
Analyzing UFW losses on a per capita basis is also revealing.[18] Since Figure 3.11 only reports total UFW loss volume estimates, it does not provide a fair per capita UFW comparison across the various water providers (due to system size variations). Figure 3.12 presents the per capita results for the 2001 data. Although all UFW water is not physically lost due to leaks, these per capita UFW results hint at the scale of potential savings in per capita consumption (as measured by the "system-wide" consumption variable). The mean 2001 per capita UFW for the water providers in this survey is roughly 17 gpcd. The 2001 per capita UFW rates range from 3 gpcd in Mesa to 43 in Scottsdale. Interestingly, the lowest and the highest per capita UFW in this regional sampling are located within the same metropolitan area.

The significance of these per capita UFW values is evident when we compare the UFW value in Figure 3.12 to a hypothetical demand reduction goal. For example, assume a particular water service area has a current SFR per capita consumption rate of 150 gpcd and a per capita UFW of 15 gpcd (which are both near or at the averages from the Smart Water survey). If this water provider sets its long-term SFR per capita demand reduction goal at 20 percent, it is aiming to have its SFR customers reduce their water use by 30 gpcd. The per capita UFW rate of 15 gpcd represents one-half of the target demand reduction. Thus, cutting the UFW rate in half would meet 25% of the total target demand reduction.

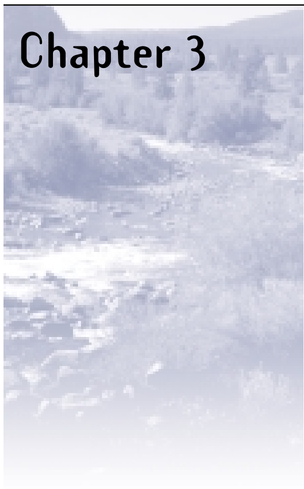
In addition to underscoring the significance of UFW with respect to water savings potential, this hypothetical example also illustrates the effect of UFW on a water provider's public relations efforts. A water provider may have a difficult time trying to encourage its customers to conserve water and repair leaks if the water provider's delivery system is losing track of more water per capita than an individual customer loses to inefficient use.

Figure 3.12

2001 Unaccounted For Water, Represented As Daily Consumption Loss per capita



18 This is done by dividing the total UFW losses by the respective service area population of each water provider (with the appropriate time unit conversions).



1994 to 2001 Changes in Unaccounted For Water (UFW), as a Percentage of Total Water Extracted from Supply Sources

Although Figure 3.12 exposed a substantial potential for water loss reduction (i.e, decreased UFW) in municipal water supply systems in the West, some water providers have made some progress in recent years. Figure 3.13 identifies the changes in UFW percentages between 1994 and 2001 for the participating water providers.[19]

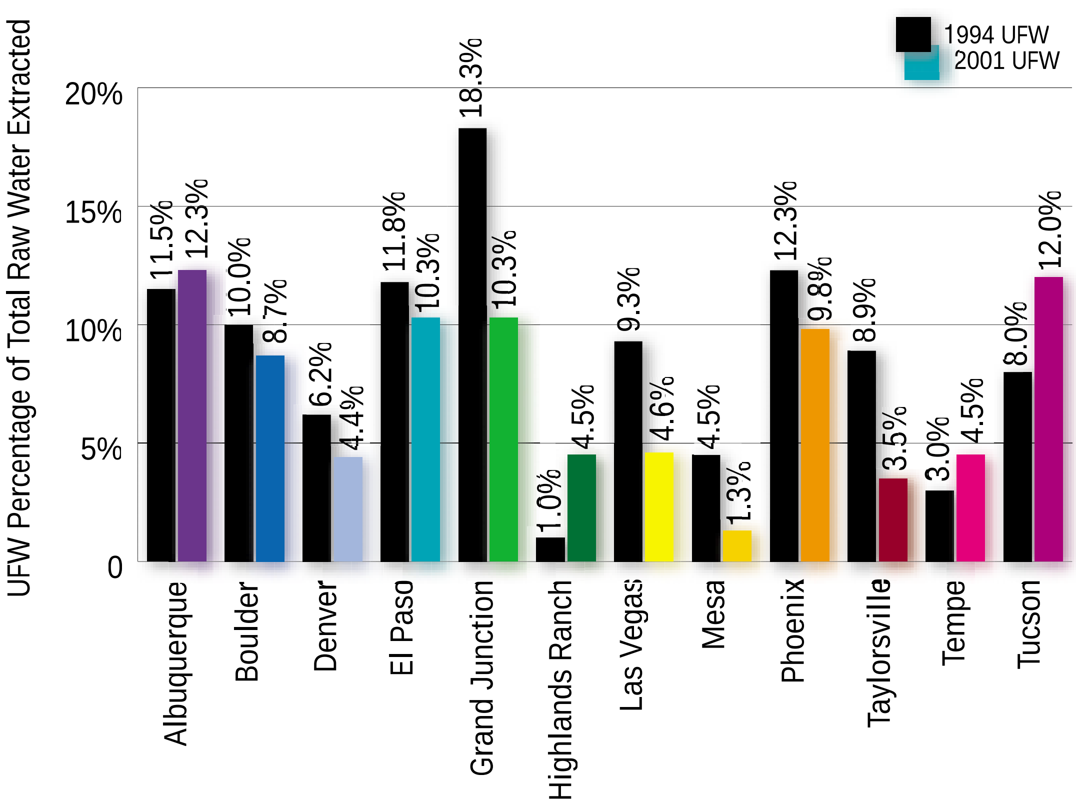
Between 1994 and 2001, Grand Junction, Las Vegas, Mesa, and Taylorsville all realized a significant reduction in UFW. The majority of the other providers achieved modest reductions, partly because some of them may have had UFW reduction programs in place for decades. Albuquerque, Highlands Ranch, and Tucson experienced an increase in UFW over this same time period (although the resulting 2001 Highlands Ranch UFW is still relatively low). These UFW increases are most likely attributed to aging water supply systems and service lines.

At least two potential water efficiency improvements are evident from this UFW analysis:

1. Water providers with UFWs that hover around 10-11 percent would save a substantial amount of water if they streamline their systems down to the lower tier of UFW values (*i.e.*, around 4-5 percent).
2. Even water providers with relatively low UFW percentages may be able to "squeeze out" additional savings by aggressively seeking more loss reductions via leak detection and repair, system upgrades, as well as metering and accounting upgrades.

Figure 3.13

Changes in Unaccounted For Water (UFW) Percentages, from 1994 to 2001



19 Not all Smart Water participants are included in this figure, since complete 1994 data were not provided by all water providers.

"Means": 2001 Water Conservation Measures, Incentives, and Programs

Overview

The previous sections of Chapter 3 focused on the consumption demand, or "ends," of the participating water supply systems. The following section provides a summary comparison of many of the "means" used to attain efficiency in these systems. The available means to achieve demand-side water use efficiency fall into the following four categories:

Incentives

- water rate structure (*i.e.*, price incentives)
- rebate programs for indoor water appliances, turf replacement, etc.

Regulatory Controls

- municipal ordinances
- utility mandates

Public Education and Awareness

- education offerings, media drives, information leaflets, etc.
- indoor and outdoor water use audits

Utility Maintenance Programs

- metering streamlining and repair
- leak detection and repair (system-wide and private service lines)

Survey responses and other research suggest the above means act synergistically to improve demand-side water use efficiency. The overall effectiveness of these means likely depends upon whether a provider sends a consistent and clear conservation message to its customers.

Many water providers we spoke with noted customers have unique response "triggers" or "motivators." Thus, providers should consider a wide array of conservation opportunities and incentives. For example, some customers may make water use decisions based strictly on the price of water. Others may respond best to regulatory controls and enforcement. For others, simple education on conservation and supply issues may be most of what is needed to induce positive results. Therefore, considering a "diversified portfolio" is important to a water conservation program.

However, diversification is not the complete answer. Program effectiveness is also dependent on many other attributes, such as program promotion, conservation message consistency, diligent program accounting and monitoring, proactive policy-making, rate and rebate pricing, and local government acting as a role model.

A few key observations can be made.

First, without up-to-date and thorough monitoring and accounting for conservation program components, program strengths and weaknesses cannot be accurately discerned. As a result, effective implementation or improvement of a particular program becomes difficult. Studies conducted by the American Water Works Association Research Foundation (AWWARF) indicate that a significant lack of conservation program accounting exists throughout the water supply industry. According to AWWARF's report titled Effectiveness of Residential Water Conservation Price and Nonprice Programs, "Although specific water pricing data is documented by water utilities, information about nonprice conservation programs is often not recorded in any detail or degree of consistency."[20]

Second, a conservation program with potential for yielding significant water savings can be rendered ineffective if public

"A river is more than an amenity, it is a treasure."
–Justice Oliver Wendell Holmes

(quoted by the Supreme Court in its decision in U.S. v. Republic Steel, 1960)

20 Ari Michelsen, J. Thomas McGuckin, and Donna M. Stumpf, *Effectiveness of Residential Water Conservation Price and Nonprice Programs,* American Water Works Association Research Foundation (AWWARF), 1998, at 25.

education and program promotion efforts do not adequately convince customers that valuable resources are at stake if conservation is not pursued.

Third, the influence of a program's "conservation message" can be compromised if other aspects of the program do not send the same message (in degree or scope). For example, a conservation message is compromised when a municipal water supply utility promotes aggressive conservation practices to its private customers while allowing wasteful water use by its public institution and public facilities customers. Similarly, the effect of a utility's state-of-the-art conservation programs and measures can be diminished if the utility implements a weak water rate structure that undervalues water.

Lastly, water providers and municipalities need to be more proactive by enacting effective, comprehensive conservation programs, incentives, and measures *prior* to the next drought crisis. Long-term policy shifts toward more efficient water use in both wet and dry years will help protect us from the drought cycles that are inherent to our region.

Rebates, Education, and Regulations

The following sections: (1) set forth the basic measures, incentives, and programs that were reported as being implemented by the participating water providers in 2001 (see also more detailed descriptions of each provider's programs in Appendix B); and (2) provide a detailed analysis of one of the most effective means to water conservation—water rate structures.

Table 3.4 (facing page) provides a summary of water conservation programs, incentives, and regulations implemented by participating water providers in 2001.[21] A more complete explanation of water conservation programs in each participating service area is provided in Appendix B, the "City-by-City Analysis."

Many of the participating water providers have discussed, enacted, or implemented new water conservation measures, incentives, and programs since 2001. The majority of these recent program enhancements were in response to the 2002 and 2003 drought conditions throughout the Southwest. These program changes involved measures such as water appliance rebate programs, Xeriscape rebate programs, more aggressive increasing block rate structures, and landscape ordinances for new development. Some water providers have introduced and maintained these new measures as permanent changes. However, in areas where drought conditions have since subsided, many other water providers and municipalities have already discontinued the recently-instituted conservation programs and policies. This trend highlights the distinction between short-term reactionary fixes and proactive, long-term policy shifts.

We retain the focus on 2001 data to maintain consistency between 2001 conservation programs and 2001 consumption patterns and provide a cross-section of existing programs and policies in a relatively normal water supply year (*i.e.*, a year without severe drought conditions).

Table 3.4 reveals that, as of 2001, all water providers participating in the Smart Water survey were doing something aimed toward conservation. Of this group, all had some sort of conservation education program. These programs ranged in scope, from minimal publications and website information to comprehensive educational programs, classes, mailings, and citizen outreach targeting adults and various school-aged populations (tomorrow's water consumers).

The vast majority of surveyed providers had Xeriscape demonstration gardens, some sort of water use ordinance, leak detection, and audit program, as well as building codes requiring water-efficient

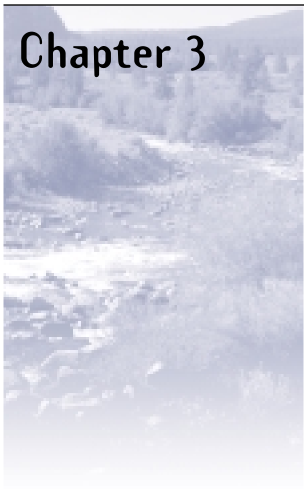
21 Data were derived from Smart Water survey responses, water provider conservation plans and documents, water provider websites, as well as telephone and email correspondence with water provider representatives.

Table 3.4

2001 Water Conservation Efforts via Rebate Programs, Regulations, and Education

	Albuquerque	Boulder	Denver *(a)	El Paso	Grand Junction	Highlands Ranch	Las Vegas	Mesa	Phoenix *(b)	Scottsdale *(c)	Taylorsville	Tempe *(d)	Tucson *(e)
Building Codes Requiring Water-Efficient Fixtures	●		●	●	●	●	●		●			●	●
Indoor Fixture Retrofit Program (Faucet, showerhead, etc.)				●			●		●	●		●	●
Toilet Rebate Program	●			●						●		●	
Clothes Washer Rebate Program	●	●		●			●						
Xeriscape Rebate Program	●	●		●			●	●		●		●	
Xeriscape Demonstration Garden		●	●		●	●	●	●			●	●	●
Water Conservation Education Programs	●	●	●	●	●	●	●	●	●	●	●	●	●
Irrigation Timer and/or Rain Sensor Retrofits or Rebates		●	●				●						
Landscaping Ordinances	●		●	●			●		●	●		●	●
Water Use/Waste Ordinances/Mandates	●		●	●	●		●	●	●	●		●	●
Indoor Water Use Audit Programs *(f)	●	●	●	●	●	●	●	●	●	●		●	●
Irrigation Audit Programs	●	●	●	●		●	●		●	●	●	●	●
Leak Detection and Repair Programs *(g)			●	●	●	●	●		●	●		●	●

Notes:
(a) Denver: The indoor water use audit program is available to commercial and industrial customers, but does not apply to residential customers. The irrigation audit program is available to multi-family residential, commercial, and industrial customers.
(b) Phoenix: The indoor water use audit program applies to commercial, industrial, institutional, and multi-family uses, but not to SFR uses. The irrigation audit program applies to commercial uses.
(c) Scottsdale: The fixture replacement program is actually both a retrofit and rebate program. Rebates are offered for showerheads, faucet aerator retrofits are free. Also, the landscape ordinance does not apply to single-family residential customers.
(d) Tempe: The landscaping ordinance only applies to non-residential developments.
(e) Tucson: The landscaping ordinance applies to commercial and multi-family residential developments, but not to single-family residential projects. The indoor fixture retrofit program is actually a part of the indoor water use audit program.
(f) Indoor Water Use Audit Programs: This section includes both onsite inspections by water provider staff and self-audit kits provided by the water provider.
(g) Leak Detection and Repair: This category includes any water provider program that offers detection and repair of leaks in the delivery system along public rights-of-way, or in the private service line on a customer's property.



> "Children of a culture born in a water-rich environment, we have never really learned how important water is to us. We understand it, but we do not respect it."
>
> -William Ashworth
>
> From "Nor Any Drop to Drink"

fixtures for new construction. However, the scope, implementation, and enforcement of these programs and regulations vary considerably from city to city.

Programs targeting reductions in specific types of use were more rare. Only half of the providers had some kind of landscaping ordinance or Xeriscape rebate program. Notably, fewer than half of the providers had indoor fixture retrofit programs. Only four providers had toilet rebates and clothes washer rebates. Only three had Irrigation Time/Rain Sensor rebates.

While gathering conservation program data for this report, we discovered a distinct lack of analyses by water providers related to water savings effectiveness and cost-effectiveness of specific conservation programs. Although benefit/cost analysis is a common tool for justifying structural water supply improvements and planning in other areas, this tool is rarely applied to assess the cost-effectiveness of water conservation measures.

The previously cited AWWARF study reaches a similar conclusion—a lack of detailed and consistent program monitoring makes it extremely difficult to perform an objective analysis of program effectiveness.[22] It is possible that a conservation program with a carefully selected, actively promoted, yet limited scope of incentives and measures may yield more effective water conservation results than one with poorly implemented, yet comprehensive conservation incentives. We feel there will be a great benefit for providers around the region—those tasked with program implementation on a daily basis—to monitor closely the results of programs they implement. We look forward to working with individual providers in the future to investigate many of these water savings effectiveness and cost-effectiveness issues.

Water Rate Structures and Billing

Background of Rate Structure Analysis

Among all the tools available to encourage water use efficiency, water rate structure is a crucial component of an effective demand-side efficiency program.

Water rate structures are premised on the notion that consumers will buy less water as its price rises and more as its price declines. As long as the water prices that consumers face are based on the costs that a water provider and society would incur if the consumers increase their consumption, a water rate structure automatically will increase efficiency, saving money as well as mitigating environmental or other social costs. The cost that a provider would incur if a consumer increased his/her consumption is known as the "avoidable" or "marginal" cost. We use both interchangeably in this section.

Prices based on avoidable or marginal costs enhance efficiency. For example, suppose that a water customer is paying $2.00 per each 1,000 gallons consumed, whether the overall amount is large or small. Suppose also that if customers consume large quantities of water, the cost the water provider would soon begin to incur is actually $4.00 per 1,000 gallons. This higher cost to the provider results from the need to build another expensive impoundment and related infrastructure to store water to meet increasing demand (including the costs of environmental mitigation). If the consumer sees only a $2.00 price, the customer will consume as if the costs he/she is imposing on the provider is only $2.00, forcing the provider to spend $4.00 to meet demand that the consumer values

22 Michelsen, McGuckin, and Stumpf, AWWARF, at 25.

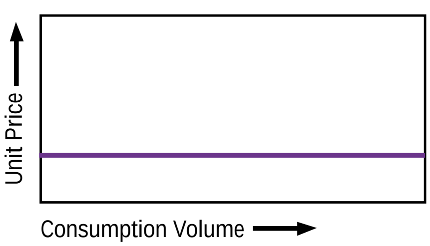
only at $2.00. This mismatch between price and cost causes society to divert scarce resources to the provision of a commodity that the consumer values less than its cost.

When customers see water rate structures that communicate the true costs of water provision, customers and water providers alike can save money and protect the environment simultaneously. Under most circumstances, consumers will reduce their use of water through turf replacement, lower-water-using appliances, behavioral changes, and other measures in light of the economic and environmental costs that are saved when they do that.

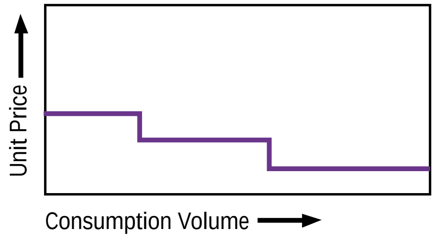
On most urban water systems in our region, avoidable or marginal costs vary with the level of consumption on the system, reflecting strong population growth, recurrent droughts, and the value of avoiding new expensive and environmentally damaging dams and reservoirs. As a result, water rate structures that charge more as consumption levels increase typically track avoidable costs and, thus, promote efficiency and cost-based conservation. Avoidable costs are almost always higher in the growing season, since daily urban water demand doubles or triples then, largely attributable to lawn watering. As a result, rate structures that show higher charges for water in this season usually track providers' avoidable costs and promote efficiency.

Four general types of water rate structure can be found among urban water providers:

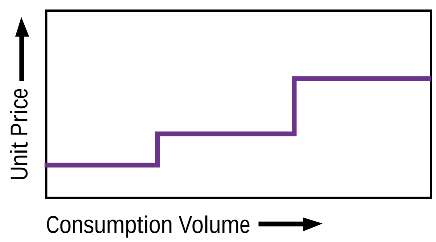
Uniform Rates: The unit rate for water is constant, or flat, regardless of the amount of water consumed.



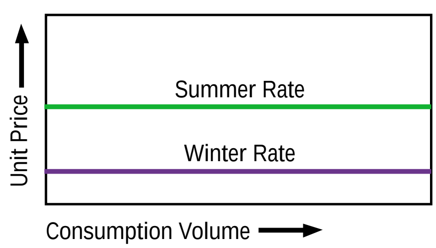
Decreasing Block Rates: The unit rate for water decreases as the consumption volume increases. The structure consists of a series of "price blocks", which are set quantities of water that are sold at a given unit price. The unit prices for each block decrease as the price block quantity increases.

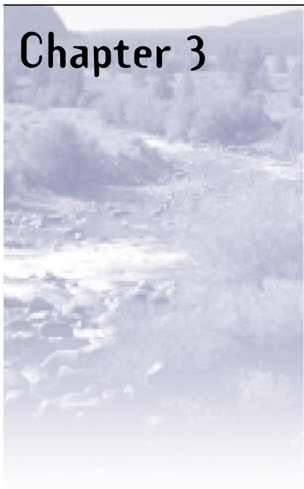


Increasing Block Rates: The unit rate for water increases as the consumption volume increases. As with the previous, this structure consists of a series of "price blocks", which are set quantities of water that are sold at a given unit price. In this case, the unit prices for each block increase as the price block quantity increases. The last block is often called the "tail block."



Seasonal Rates: The unit rate for water varies from season to season. In most cases, two rates are set: summer rates and winter rates. Summer water rates are typically higher than winter rates.





In our region, seasonal and increasing block rate structures offer a price incentive for water conservation that is based on avoidable costs and, predictably, will enhance efficiency. The increasing block rate structure charges a higher unit rate for higher consumption (*i.e.*, a higher marginal price as consumption increases). The seasonal rate structure charges a higher unit rate when outdoor uses are the highest (*i.e.*, summer months). However, the effectiveness of a particular seasonal or increasing block rate structure is also dependent on other factors, as examined later in this section. Typically, uniform rate and decreasing block rate structures provide no cost-based incentive for water conservation. Thus, they rarely promote efficiency and they waste resources, economic as well as environmental.

Turning the straightforward principle—that, for efficiency purposes, water rates should communicate the costs that a customer's water provider avoids when they decrease their consumption—into actual water rate structures is not without challenges. These challenges result mainly from the fact that water rates are designed to meet a multiplicity of purposes, not simply efficiency. Generally, we believe that water providers in our region need to stress efficiency as an objective more than they have to date. However, knowing that purposes other than efficiency will not and should not drop from consideration, we describe some of the problems that the establishment of efficient water rate design confronts in a world in which efficiency is not the only objective.

Perhaps the biggest problem occurs because water providers need to make sure they raise sufficient revenues to cover their unavoidable, fixed costs. These are costs of past investment and current operations that cannot be avoided no matter the degree to which customers limit demand. The understandable temptation among water providers is to recover their fixed costs through service charges that do not vary with consumption, thereby maximizing the chance that they will recover these costs in sales revenues. However, recovering fixed costs in this manner can negate the price signal of an increasing block rate structure. In some cases, fixed service charges can even make it appear as if the unit price for water decreases as consumption increases, even when the rate structure involves increasing block rates. This effect is dependent on the amount of the fixed charge and the amount of the tail block rate. If these amounts are inappropriately set, a customer focusing on his/her total bill may notice the average cost of service declining with usage. According to AWWARF research:

"A rate structure with increasing marginal prices while the average price is declining sends mixed signals to consumers about their economic incentives to conserve water. This mixed incentive system creates problems in both understanding and analyzing consumer responses. Rate structures with any service charges, and in particular relatively large service charges in relation to the per unit cost and total water bill, are apt to create these mixed price signal conditions. Most water utilities, including those with inclining block rate structures, continue to use a service charge as part of their rate structure. . . . Some researchers have suggested that rather than using and responding to the marginal price of water, consumers instead may use the total bill amount (average price) as the basis for deciding how much water to consume."[23]

Rate managers on many water systems have worked on the problem of how to assuredly recover fixed costs while encouraging efficiency, some for many years. One solution is to make sure that the increasing block rate design is steep and the tail-

23 Michelsen, McGuckin, and Stumpf, (AWWARF), at 13-14.

block (last) rate very high, thereby making sure that average costs incline with consumption.

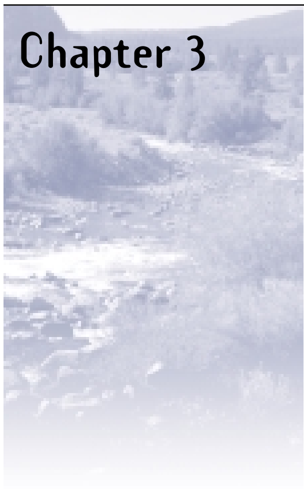
Before customers respond to a rate structure of this nature, however, a water provider ironically could end up raising more money than actual costs of service in the short-run. Under the municipal ordinances we have examined, water providers may lawfully use this money to establish a reserve or to subsidize investments by their customers in water use efficiency, such as turf replacement or water-efficient appliances.

Another problem, known as “income insensitivity,” occurs when some customers at the highest end of the income spectrum may not fully respond to rates that reflect avoidable costs because they have significant disposable income to spend on water consumption. In other words, they're wealthy enough that price signals have little or no effect on their consumption. To our knowledge, the importance of this issue in our region has not been analyzed. For example, there is a price for water that will get nearly everyone's attention. However, we may not know what that price is on most systems. In any event, many would say that there is equity in charging at least avoidable cost rates to these customers even if they do not change their consumption, as it is largely their *discretionary* consumption that tends to drive system expansion.

On some systems, water is sold to low-income customers below actual average costs, not to mention avoidable costs. While much of this water is for essential purposes and thus, not a target for conservation encouraged by rate design, some of this water may be used inefficiently on lawns or in inefficient appliances. Equity considerations suggest that rebate programs are an appropriate means to reach this quantity of water.

Although much discretion is left to the local rate-setting body of the municipality or water district, the primary legal constraint applicable to a publicly owned water provider is that rates and rate structure design must be just and reasonable, and rationally related to the cost of providing the service (*e.g.*, operations, maintenance, conservation programs, etc.). This rule applies to all water providers, whether privately or publicly owned, and whether mandated by statute or imposed by the courts. Generally speaking, this can be referred to as the “cost-of-service” approach.

The cost-of-service principal applies to the overall rate structure rather than to each individual block in an increasing block rate structure. This means that (1) there is no legal prohibition against setting that last tailblock rate at a higher-than-cost rate; and (2) if the last tailblock rate is set at a high rate (in an attempt to discourage consumption), then the rates on the lower tiers will need to decrease in order to stay within the predicted revenue requirements. With that said, case law indicates that there is no legal prohibition against a publicly owned water provider using marginal or avoidable costs in setting its rates and rate structure, once again, as long as a nexus exists between the expected revenues and the costs—whether the costs involve current system operation costs or long-term avoidable costs.



Chapter 3

Rate Structure Analysis

Table 3.5 lists the rate structures that were implemented by various water providers in 2001.[24] The majority of the water providers in the analysis sample applied an increasing block rate structure. However, we found significant variations in these increasing block rate structures. Two of the providers utilized a seasonal rate structure. The remaining two providers used a uniform rate structure. Although the analysis in this section concentrates on 2001 rate structures, we acknowledge that there have been more recent rate structure changes in most participating service areas. We retain the focus on 2001, however, to maintain consistency between 2001 rate structures and 2001 consumption patterns.

Photo by Jeff Widen.

The variations in increasing block rate structures include the strategy that is applied by Boulder and El Paso. The price structure used in these water service areas is based on an increasing block rate system. However, instead of using fixed consumption volumes as thresholds for each block rate, the blocks are determined by the Average Winter Consumption (AWC) of each individual account. This type of price structure serves two objectives. First, as with standard block rate structures, efficient and/or low-use customers pay a low unit rate, while inefficient and/or high-use customers pay a high unit rate. Second, the use of AWC baselines builds an additional incentive into the water pricing. The AWC provides an estimate of a household's "essential" or indoor use (measured and averaged during winter months). In turn, an individual consumer's water rates are based on the amount of water consumed by "elective" or discretionary landscape irrigation uses. This mechanism encourages customers to conserve water during the time of year when system demands are highest (*i.e.*, summer months).

These pricing strategies are also relatively effective at discouraging customers from increasing their block allotments by deliberately increasing water consumption in winter months. According to Hydrosphere Consultants (contracted by the City of Boulder), if customers intentionally try to increase their AWC in an attempt to raise the amount of water they are allocated in the low price block during summer months, the savings will be almost totally offset by the increased wastewater costs. In other words, these wastewater charges discourage the abuse of the AWC pricing mechanism. However, under the AWC pricing mechanism, it is conceivable, if unlikely, that some customers may abuse the system by "dumping" water outdoors during winter months to increase their AWC without contributing to wastewater flows.

24 Unlike previous sections of this chapter, you will notice that all participating water providers are not included in all parts of this water rate analysis section. Given the complexity of the analysis and graphic displays, a subset sample of providers was chosen. Salt Lake City Public Utilities was included in this analysis, even though they have not responded to the Smart Water survey, because: (1) they round off the list of the largest water providers in the Southwest; and (2) some rate and billing data from this water provider were already compiled in other reports.

Table 3.5

2001 Water Rates and Surcharges for Residential Accounts (<1" Service Lines)

Water Provider	2001 Rate Structure Type	Fixed Service Charge: Monthly Base Rate/Surcharge	Consumption Rate: Unit Rate per 1,000 Gallons of Water Consumed	Additional Monthly Rates or Fees
Albuquerque	Uniform	$6.28/month	$1.06 for up to 200% AWC *(b) $1.34 for over 200% AWC ($0.28 surcharge per 1,000 gal. above 200% residential AWC, which is set at 11,220 gal.)	Sustainable Water Supply Fee: $0.50 per 1,000 gal.; State Water Conservation Fee: $0.03 per 1,000 gal.
Aurora	Uniform	$2.87/month	$2.04	None
Boulder	Increasing Block Rate, AWC *(b)	$8.12/month	$1.60 for up to AWC *(b) $2.85 for AWC - 350% AWC $4.25 for over 350% AWC	None
Denver	Increasing Block Rate	$2.22/month*(a)	$1.53 for first 11,000 gal. $1.84 for 11,000 - 30,000 gal. $2.30 for over 30,000 gal.	None
El Paso	Increasing Block Rate, AWC *(b)	$3.73/month (includes first 2,992 gal.)	For over 2,992 gal.: *(b) $1.14 for up to 150% of AWC $2.15 for 150% - 250% AWC $2.77 for over 250% AWC	Water Supply Replacement Charge per service: $3.96
Grand Junction	Increasing Block Rate	$8.00/month (includes first 3,000 gal.)	$1.85 for 3,000 – 10,000 gal. $1.90 for 10,000 - 20,000 gal. $1.95 for over 20,000 gal.	None
Las Vegas	Increasing Block Rate	$4.23/month	$0.98 for first 7,500 gal. $1.42 for 7,500 - 22,500 gal. $1.92 for 22,500 - 66,000 gal. $2.27 for over 66,000 gal.	None
Phoenix	Seasonal	$5.16/month (includes first 4,448 gal. Oct.-May and 7,480 gal. June-Sept)	Dec.-Mar.: $1.56 for over 4,448 gal. Apr., May, Oct., Nov.: $1.85 for over 4,448 gal. June-Sept: $2.35 for over 7,480 gal.	Environmental Charge: $0.11 per 1,000 gal.
Salt Lake City	Seasonal	$8.08/month (includes first 3,740 gal.)	Oct.-May: $0.79 for over 3,740 gal. June-Sept: $1.19 for over 3,740 gal.	None
Tucson	Increasing Block Rate	$5.35 (includes first 748 gal.)	$1.48 for 748 – 11,220 gal. $4.46 for 11,220 - 22,400 gal. $6.12 for 22,400 - 33,660 gal. $8.82 for over 33,660 gal.	None

Sources: Smart Water survey responses and utility websites.
Notes:
(a) Denver Water implements a bi-monthly billing cycle with a bi-monthly surcharge of $4.43 in 2001. The volume thresholds shown for each consumption rate are based on monthly consumption. Volume thresholds on the bi-monthly system are 22,000 gal., and 60,000 gal., accordingly.
(b) "AWC" = Average Winter Consumption (on a monthly basis). Individual blocks are calculated for each customer, based on the AWC for that account. Boulder AWC covers Dec.-March. El Paso AWC covers Dec.-Feb. Albuquerque AWC is set at average of all residential customers with similar taps (11,220 gal.).

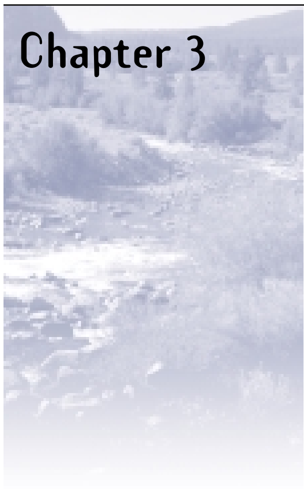


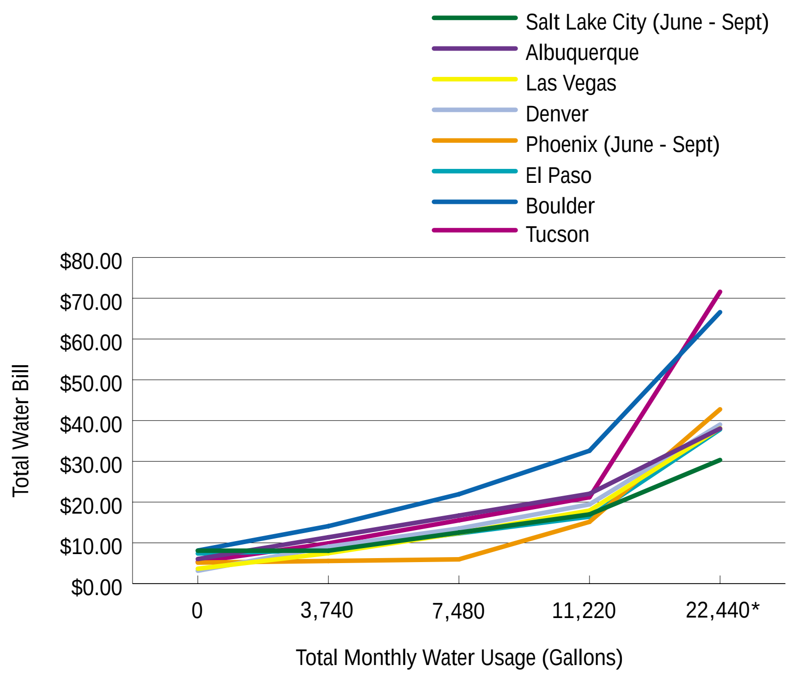
Figure 3.14 provides a snapshot of average water bills for varying consumption levels throughout the region. The monthly water bill amounts graphed in Figure 3.14 are drawn directly from the 2002 Water and Wastewater Rate Survey, conducted and reported by Raftelis Financial Consulting, PA.

A customer's response to water rates can also be dependent on the billing cycle and the availability of account information (*i.e.*, consumption volumes for a particular household). For example, Denver Water and the Centennial Water and Sanitation District (Highlands Ranch) are the only providers in the Smart Water survey that use a bi-monthly billing cycle. All other providers in the study use monthly cycles.[25]

There are other areas for improved customer interaction. Customers are more likely to practice water conservation if they have easy access to their account information. Although billing statements typically summarize each household's water use during the previous month period, other opportunities could be made available on a day-to-day basis. For example, as computerized utility accounting systems become more streamlined and modernized, it will be possible to provide real-time account access via the utility website. With this type of customer-interaction tool, a particular customer would have the opportunity to monitor daily or weekly water use trends. As a customer becomes more aware of his/her use trends, this customer becomes more adept at practicing water conservation in the home and in the yard. Being informed leads to being efficient.

Figure 3.14

2001 Average Monthly Water Bill



Source: Raftelis Financial Consulting, PA, Raftelis Financial Consulting 2002 Water and Wastewater Rate Survey, *Charlotte, N.C.: Raftelis Financial Consulting, PA, 2002.*
**Please note that the horizontal axis is not to scale for consumption values higher than 11,220 gallons*

Marginal Price of Water

Analysis of the marginal price curves of the various water rate structures reveals differences in price incentives. As mentioned earlier, the water providers in this analysis implemented uniform rate structures, seasonal rate structures, and increasing block rate structures in 2001. Each of these rate structures has a unique marginal price curve.[26] Plotting all of these marginal price curves on one graph exposes the significant distinction in economic effect of each price structure.

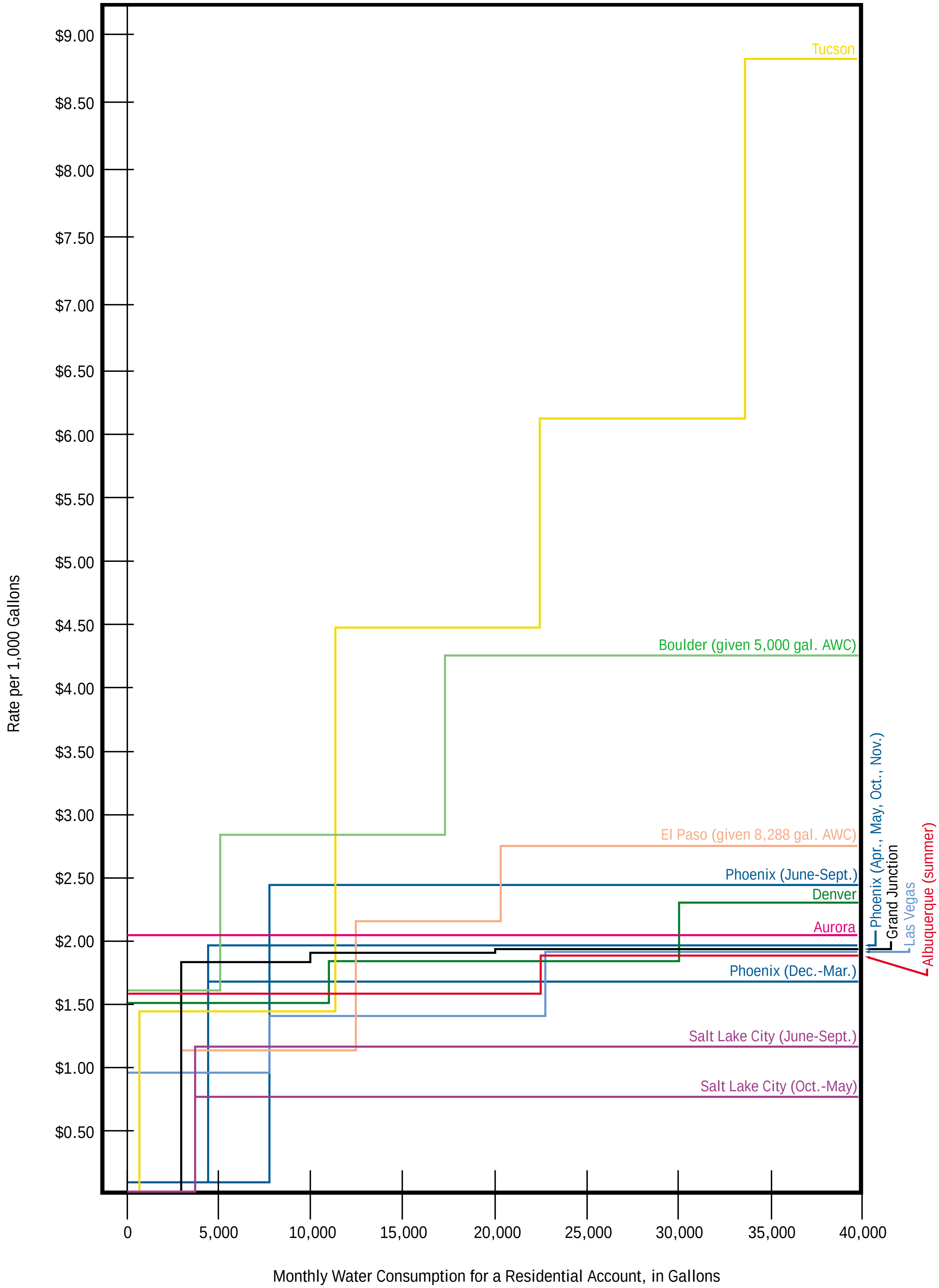
Figure 3.15 (facing page) illustrates this effect. All of the price structures listed in Table 3.5 have been graphed in a color-coded format for comparative analysis.

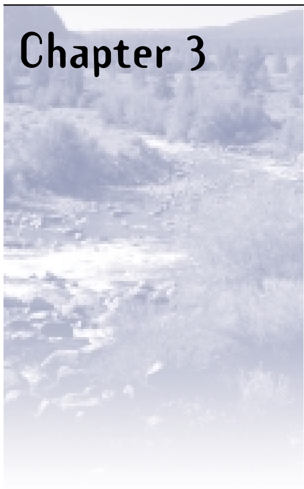
25 Through anecdotal evidence from various Denver Water customers, we see that this bi-monthly billing cycle is an information hurdle to water conservation efforts in the home. Many "conservation-minded" or "money-savings minded" customers adjust their home water use on an incremental basis, in response to the consumption reported in each billing statement. This practice is particularly common during the summer irrigation months. With a bi-monthly billing cycle, the irrigation season is roughly half over by the time customers are notified of their recent consumption quantities. This is counterproductive to efficient conservation. Although water providers switching from bi-monthly billing to monthly billing cycles incur costs (*e.g.*, computer system upgrades, mailing costs, metering, etc.), the long-term potential savings from conservation warrants consideration (in terms of avoided costs for expensive dams, pipelines, and treatment facilities).

26 The marginal price curves represent the change in the unit prices of water as consumption levels increase. The marginal prices represent the prices that the customers pay for the next unit of water consumed (*e.g.*, price for the next 1,000 gallons). In an increasing block rate structure, the marginal price curves move upward in a "staircase" manner, with each "stair" representing each block rate.

Figure 3.15

Marginal Price Curves of Various 2001 Water Rate Structures





Two features of Figure 3.15 are particularly revealing:

- Differences in curves between the uniform, seasonal, and increasing block rate marginal price curves (as defined earlier in this subsection); and
- Significant variations in block prices and block volume thresholds among the providers that use increasing block rate structures.

Tucson's 2001 rate structure possesses the steepest marginal price curve in the Smart Water survey. This steepness is attributed to the sizeable incremental increases in each block price, the number of blocks, and the relatively low "volume triggers" for each block. This is an example of an aggressive increasing block rate structure. As discussed earlier, Tucson also possesses the lowest SFR per capita consumption rate in the Smart Water survey (107 gpcd).

Figure 3.15 also illustrates the significant differences between increasing block rates and uniform or seasonal rates. Uniform and seasonal rate structures do not offer a conservation price incentive by charging higher rates for higher consumption levels. However, the increasing block rate is not a panacea: setting block volumes and prices is integral to this strategy's effectiveness. Although the majority of water providers in the survey implemented an increasing block rate structure, many of the block prices in these structures appear to be set too low to be effective. This ineffectiveness is compounded if the incremental price increases from block to block are negligible.

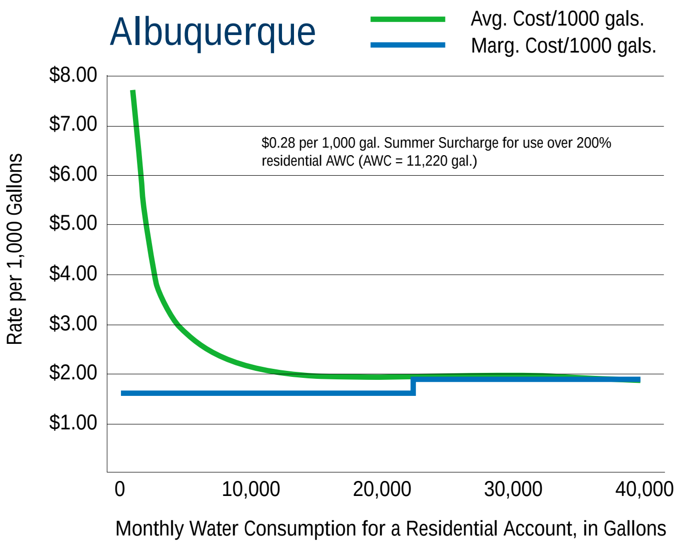
Average Price of Water

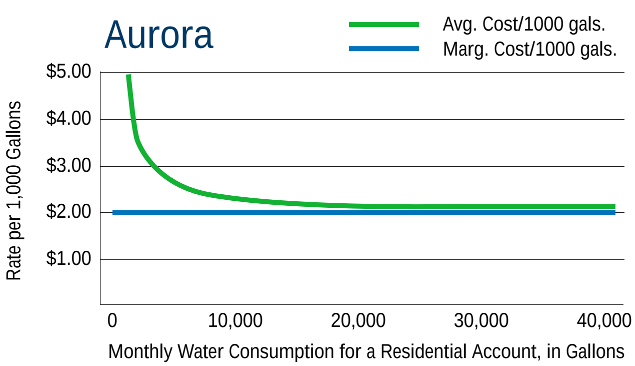
The average price curves in Figures 3.16a through Figure 3.16j show that the majority of water providers in the sampling use price structures that result in relatively flat average price curves as consumption increases, regardless of the chosen marginal price structure. From the perspective of a customer reacting to his/her total bill, a rate structure with declining or flat average costs per unit of consumption does not strongly encourage conservation even on water service systems with increasing block rate pricing (*i.e.*, increasing marginal prices). Although the increasing marginal prices appear to provide a conservation incentive to customers in these service areas, the resulting average price effect isn't much different than that of a uniform price structure (as consumption increases). As discussed earlier, minimal block price increases and high fixed costs (*e.g.*, service charges) typically yield this effect.

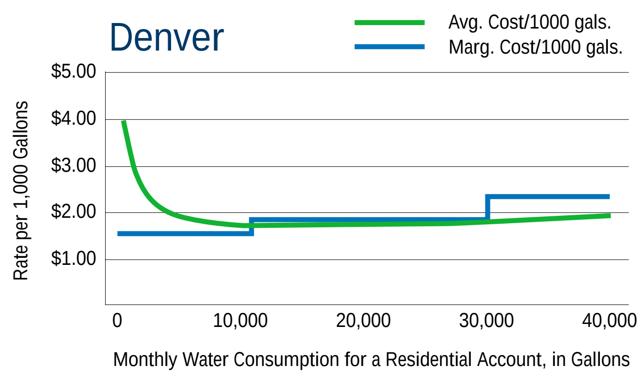
The sampled water providers with average price curves that increase at notable rates as consumption increases are Tucson, El Paso, and Boulder. Significantly, Tucson and El Paso have the two lowest Single-Family Residential per capita consumption rates in the Smart Water Survey, at 107 gpcd and 122 gpcd, respectively. Boulder's SFR daily per capita rate is also below the average of sampled water providers at 140 gpcd. As a wide variety of attributes affect water consumption rates, we cannot provide a statistically significant conclusion on this correlation between rate structures and consumption. Attributes such as other conservation program efforts, societal and cultural values, income strata, and regional climate also have significant effects on consumption rates. However, it is very likely that the distinct aggressiveness of the rate structures in Tucson, El Paso, and Boulder contribute to the relatively low SFR consumption rates in these water service areas.

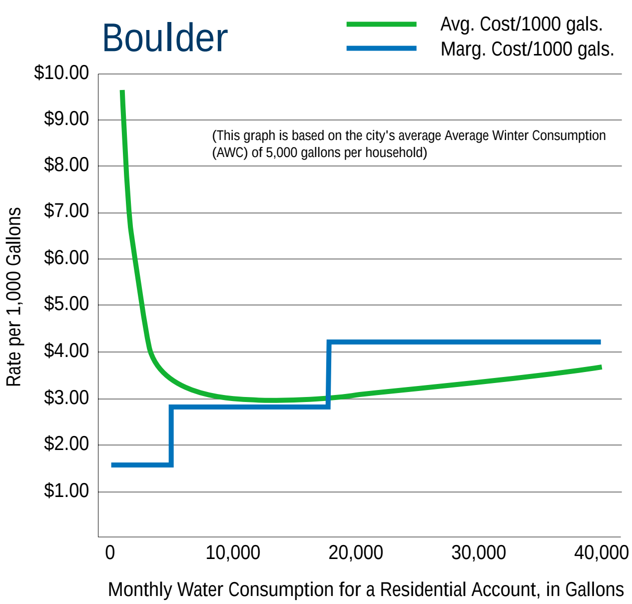
Figure 3.16 a-j

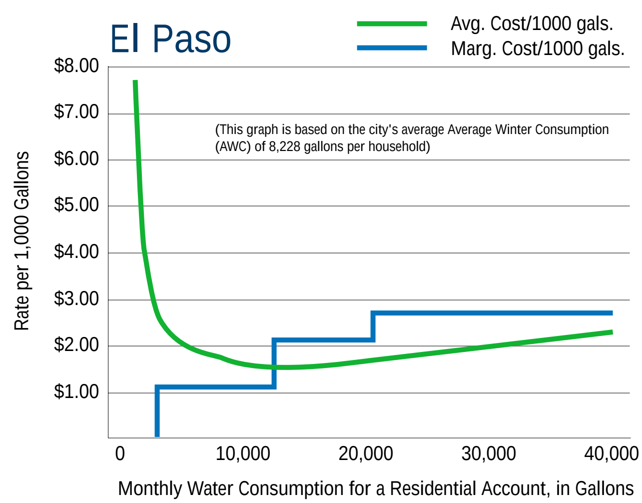
Average Cost and Marginal Cost Curves of Various Water Rate Structures

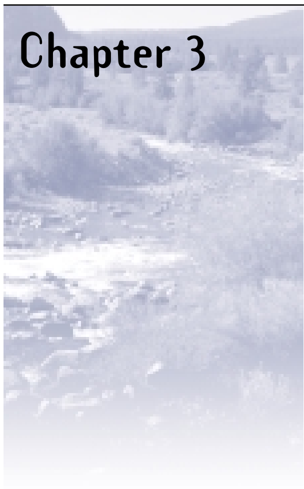


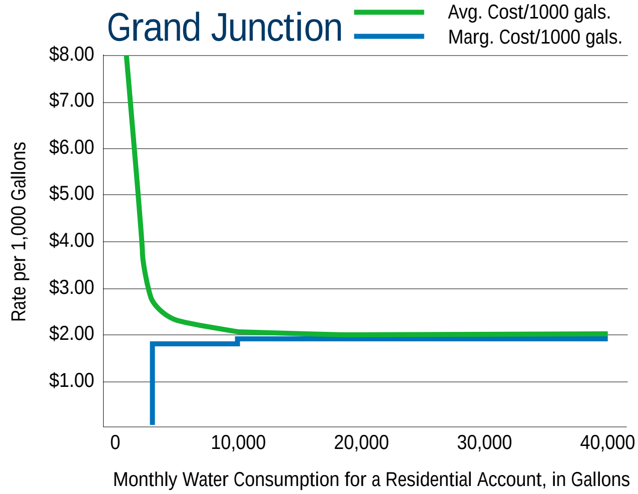


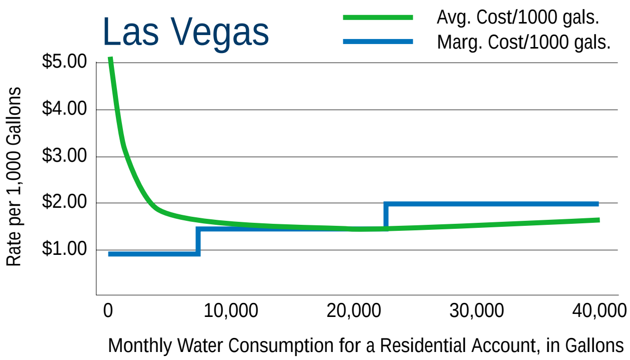


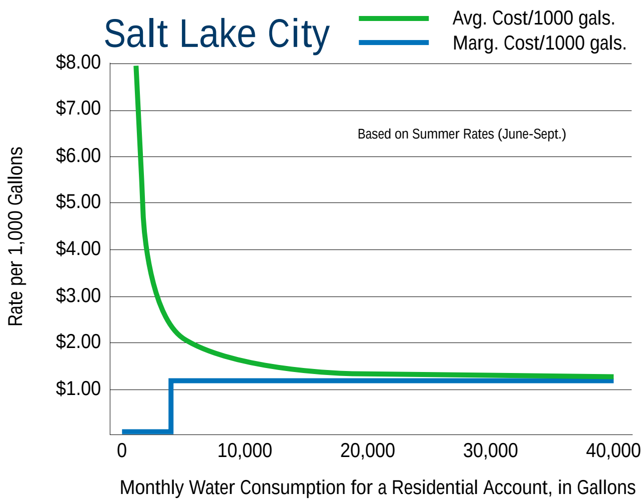


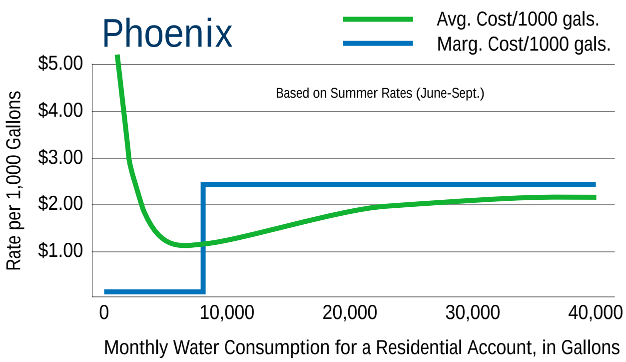


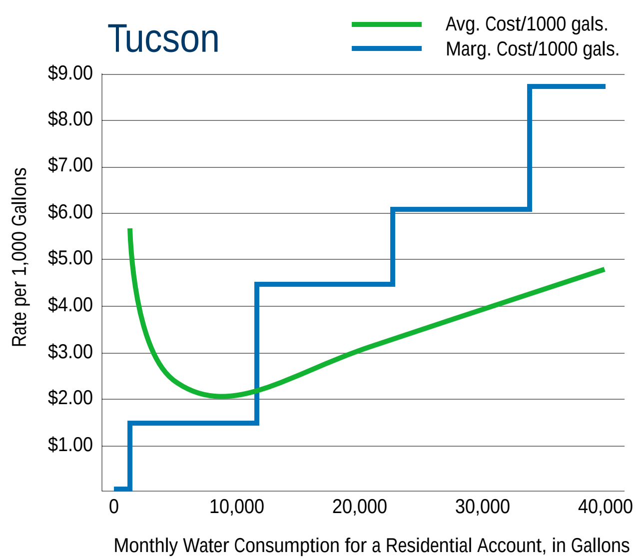



Grand Junction
Avg. Cost/1000 gals.
Marg. Cost/1000 gals.
$8.00
$7.00
$6.00
$5.00
$4.00
$3.00
$2.00
$1.00
Rate per 1,000 Gallons
0
10,000
20,000
30,000
40,000
Monthly Water Consumption for a Residential Account, in Gallons


Las Vegas
Avg. Cost/1000 gals.
Marg. Cost/1000 gals.
$5.00
$4.00
$3.00
$2.00
$1.00
Rate per 1,000 Gallons
0
10,000
20,000
30,000
40,000
Monthly Water Consumption for a Residential Account, in Gallons


Salt Lake City
Avg. Cost/1000 gals.
Marg. Cost/1000 gals.
Based on Summer Rates (June-Sept.)
$8.00
$7.00
$6.00
$5.00
$4.00
$3.00
$2.00
$1.00
Rate per 1,000 Gallons
0
10,000
20,000
30,000
40,000
Monthly Water Consumption for a Residential Account, in Gallons


Phoenix
Avg. Cost/1000 gals.
Marg. Cost/1000 gals.
Based on Summer Rates (June-Sept.)
$5.00
$4.00
$3.00
$2.00
$1.00
Rate per 1,000 Gallons
0
10,000
20,000
30,000
40,000
Monthly Water Consumption for a Residential Account, in Gallons


Tucson
Avg. Cost/1000 gals.
Marg. Cost/1000 gals.
$9.00
$8.00
$7.00
$6.00
$5.00
$4.00
$3.00
$2.00
$1.00
Rate per 1,000 Gallons
0
10,000
20,000
30,000
40,000
Monthly Water Consumption for a Residential Account, in Gallons

Total Water Bill vs. Single-Family Residential per capita Consumption

Figures 3.17a through 3.17e display the average total water bills for various consumption levels with respect to the actual Single-Family Residential daily per capita consumption rates. Price data points for the average water bill totals in these charts were extracted from the 2002 Water and Wastewater Rate Survey[27] (conducted and reported by Raftelis Financial Consulting, PA), as well as computed via the 2001 rate structures.

Figure 3.17a

Comparison of 2001 Single-Family Consumption and Monthly Water Bills (for 3,740 gal./month consumption)

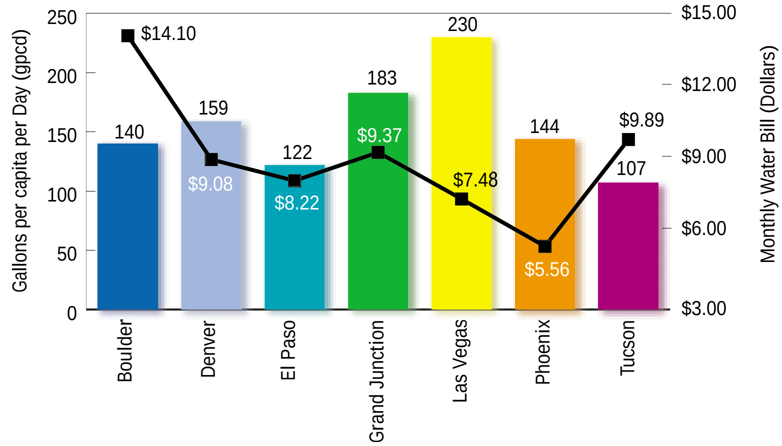
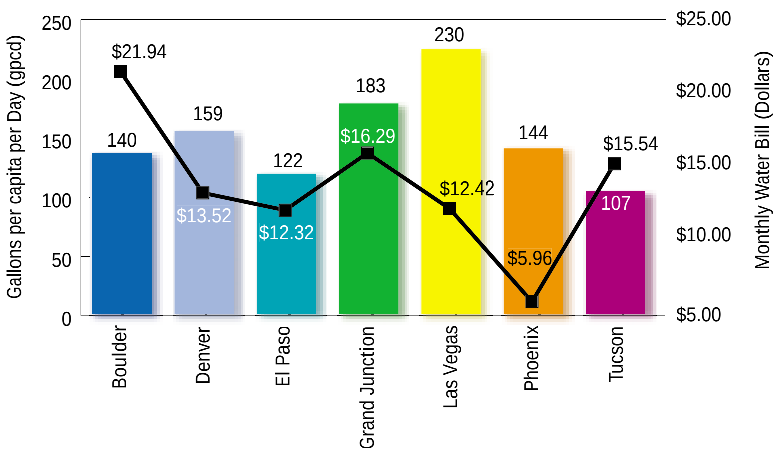


Figure 3.17b

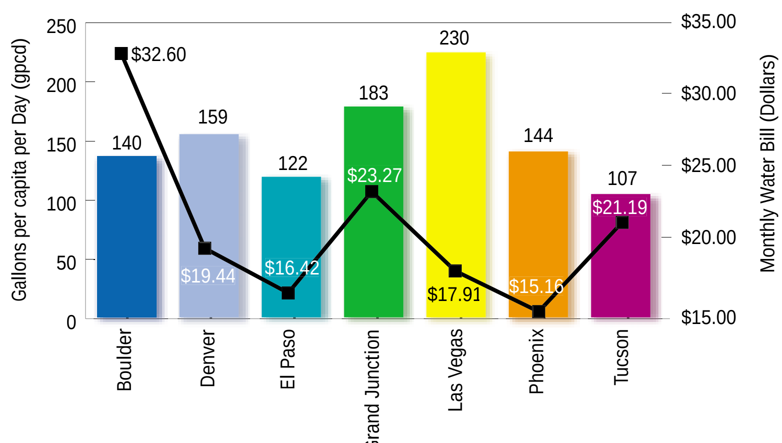
Comparison of 2001 Single-Family Consumption and Monthly Water Bills (for 7,480 gal./month consumption)



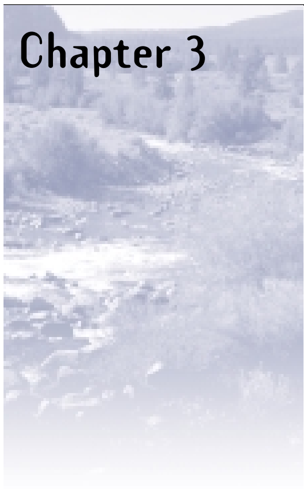
At lower consumption levels such as 3,740, 7,480, and 11,220 gallons (Figures 3.17a, 3.17b, and 3.17c, respectively), the correlation between low SFR per capita consumption and water bill amount is negligible. No trend can be concluded.

Figure 3.17c

Comparison of 2001 Single-Family Consumption and Monthly Water Bills (for 11,220 gal./month consumption)



27 Raftelis Financial Consulting, PA, *Raftelis Financial Consulting 2002 Water and Wastewater Rate Survey*, Charlotte, N.C.: Raftelis Financial Consulting, PA, 2002.



As consumption levels increase to 22,440 and 44,880 gallons (Figures 3.17d and 3.17e, respectively), some possible correlation trends become apparent. For these higher consumption level categories, the SFR per capita consumption rates appear to decrease as the water bill amounts increase, and vice versa. Since the sample size is too small to draw any statistically significant correlations between water pricing and per capita consumption, these results must be viewed in a qualitative manner.

These graphical displays effectively demonstrate the intrinsic objective of aggressively increasing block rate structures. When average costs increase with consumption, consumers that do not use high volumes of water will pay relatively low unit prices for their water (and subsequently have lower total bills), whereas high-end consumers will receive bills that increase significantly with use.

Figure 3.17d

Comparison of 2001 Single-Family Consumption and Monthly Water Bills (for 22,440 gal./month consumption)

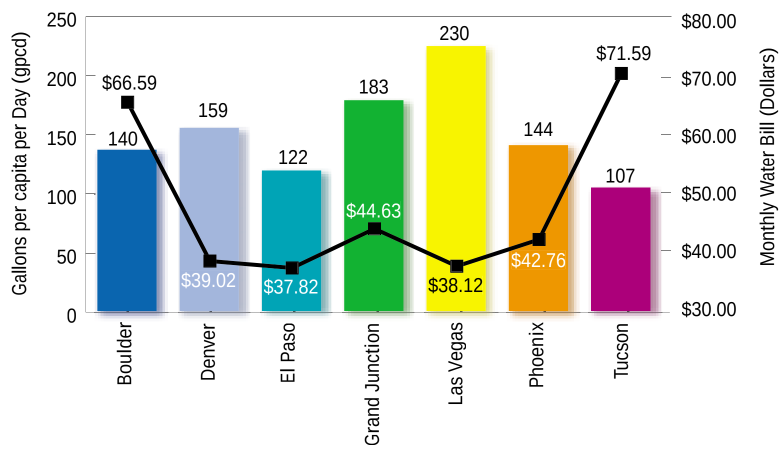
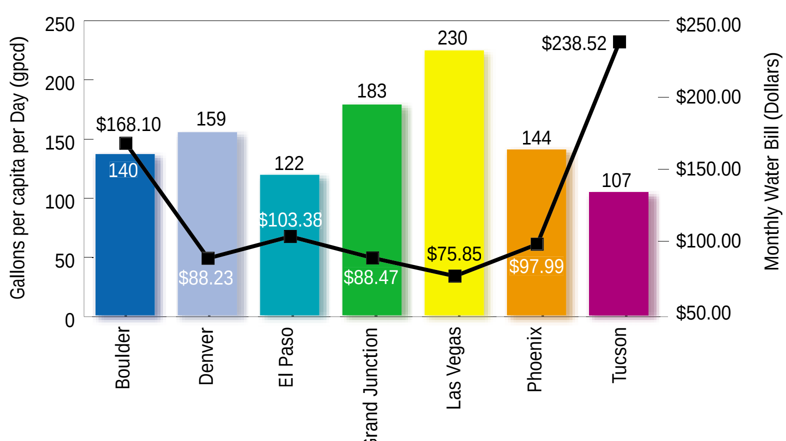


Figure 3.17e

Comparison of 2001 Single-Family Consumption and Monthly Water Bills (for 44,880 gal./month consumption)



2001 Conservation Budgets

The Smart Water survey requested information from providers regarding their expenditures on conservation in 2001. Figure 3.18 displays each water provider's conservation budget with respect to its total budget, as a percentage.[28] Since accounting practices and conservation budget definitions vary for each water provider, the information is not strictly comparable. Regardless, the most notable result of Figure 3.18 is the surprisingly low budget allocation to conservation efforts. This sampling indicates that, on average, only 1 percent of total water service budget funds conservation efforts in our region. Although water service budgets must address a wide range of other operation and maintenance costs, one would expect a stronger budget emphasis on system-wide conservation, particularly given the very limited water supplies and the substantial costs associated with new water supply development projects.

Figure 3.18

2001 Conservation Budget, as a Percentage of Total Water Budget

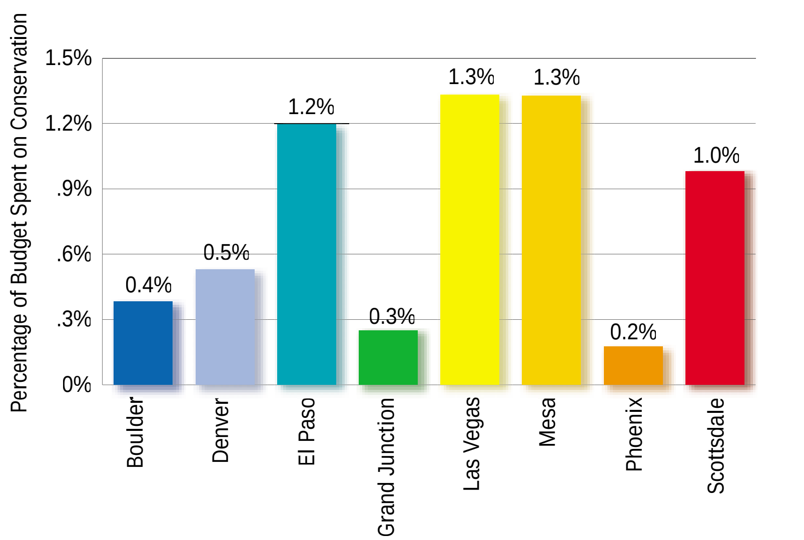


Photo by Jeff Widen.

28 Some of the smaller water utilities do not include "conservation" as a separate budget line item. Instead, conservation program funding is often drawn from the utility's general fund or operations budget in such cases. Therefore, it is not appropriate to include these water providers in the conservation budget comparisons since we do not have the specific dollar amounts allocated to conservation efforts.

2002 Drought Response Measures

Response to the drought in 2002 revealed considerable "slack" in the water system.

The severe drought of 2002 hit nearly every area of the southwestern United States. The drought conditions prompted many urban water providers to pursue immediate, short-term reductions in water use throughout the region through temporary "drought response" measures. In 2002, a large portion of the water savings resulted from outdoor watering restrictions. These watering restrictions, if mandatory, proved to be very effective in lowering system demand. A comprehensive look at water providers on the Front Range of Colorado found savings measured in expected per capita use ranged from 18 to 56 percent.[29] Water providers in the region also implemented a variety of other temporary and permanent conservation measures in response to the drought conditions in 2002, including higher water rates, drought surcharges, public education drives, and appliance and landscape rebate programs to name a few.

Dillon Reservoir during the drought-stricken summer of 2002. *Photo by Denver Water.*

Table 3.6 lists drought response measures and successes for various municipal water providers in Colorado. Of special note is the column reflecting "Savings Achieved" by instituting the various drought response measures. In a very short period, many Colorado water providers were quite successful in achieving large decreases in demand. However, it is unclear whether such demand reductions can be maintained over the long term, or even if they should be. These measures often resulted in brown lawns, among other results. Brown lawns are not an example of efficiency but permanent low water-using landscapes are. In any event, while we point to these results to illustrate the degree of slack in the system, we favor an incentive-based approach to conservation.

During and since the summer of 2002, many water providers discussed or enacted new, potentially more permanent water conservation measures. These program and policy changes involved measures such as water appliance rebate programs, Xeriscape rebate programs, more aggressive increasing block rate structures, lawn watering standards, and landscape ordinances for new development. Some water providers have introduced and maintained these new measures as permanent changes.

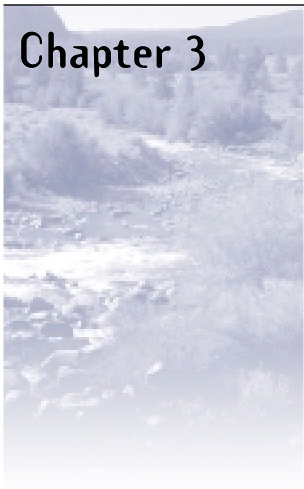
When the drought conditions subsided in some areas in 2003, however, many water providers terminated the conservation programs and measures that were instituted in late 2002 and early 2003 and took other considerations off the table. Some water providers in the region have already gone back to their old ways. This difference in post-drought behavior underscores the very important distinction between short-term reaction and deep-rooted, long-term policy shifts. To maintain sustainable urban water supplies as our populations grow and future droughts occur, we need to pursue long-term policy change.

29 *See* Doug Kenney and Roberta Klein, "Use and Effectiveness of Municipal Water Restrictions During Drought in Colorado" (2003).

Table 3.6 2002 Colorado Front Range Drought Restrictions

Water Provider	Savings Goal	Savings Achieved	Effective Dates	Watering Days	No Watering Hours	Watering Time Limit	New Landscaping	Variances	Car Washing	Other
City of Aurora	20% of outdoor use from 2001	20% of outdoor, 7% overall	May 15-Aug. 31	every 3rd day	9 am-6 pm	no limit			on watering days	water rate surcharge
			Sept. 1-Oct. 14	every 3rd day, not on Sun.	7 am-7 pm	1 hr. per day	none allowed	n/a	on watering days	
			After Oct 15	lawn watering banned	n/a	n/a	n/a		no home car washing	
City of Boulder	25% of avg. use based on 2000 & 2001	28-30%	June 5, 2002	2 days per wk. (includes all outdoor watering)	9 am-6 pm	15 min. per zone	none allowed		w/bucket or hose nozzle	no washing hardscape, fill kids pools 1X/day
Colorado Springs Utilities	20% of outdoor use in 2001	18% of outdoor use, 9.5% overall	Jun. 11-Aug. 27	every 3rd day	9 am-7 pm	no limit	by permit: sod-6 wks., seed-8 wks.	alternative management plans, large properties	on watering days	
			Aug. 28-Sep. 30	2 days per wk. (includes all outdoor watering)	9 am-7 pm	3 hrs. per day	by permit: sod-24 days, no seed	alternative management plans, large properties	on watering days	water rate surcharge
			Oct. 1-Apr. 1	once per month	3 pm-9 am	no limit	by permit: sod-14 days (install by 10/15)	hardship, additional savings	on watering days	
Denver Water	30% of expected use	27%	July 1-Aug. 31	every 3rd day	9 am-6 pm	3 hrs. per day	by permit: sod-3 wks., seed-4 wks.	hardship, large properties	on watering days, w/bucket or hose nozzle	serve water on request, shut off fountains, no washing hardscape
			Sep. 1-Sep. 30	every 3rd day, not on Sun.	9 am-6 pm	2 hrs. per day	none allowed	sports playing fields	on watering days, fleet washing 1X/wk.	water rate surcharge, hotel sheet washing every 4 days
			after Oct. 1	lawn watering banned	n/a	n/a	n/a	sports playing fields	home car washing w/ bucket (not hose), fleet washing 1X/wk.	water tap surcharge
City of Fort Collins	10% of average use based on 2000 & 2001	9.5%	July 22-Sept. 26	2 days per week	10 am-6 pm	no limit	3 wks. sod, 4 wks. seed	medical hardship, multiple address, >4 acres	no limits	none
			after Sep. 27	1 day per wk.	10 am-6 pm	no limit	4 wks. sod, 6 wks. seed	medical hardship, multiple address, >4 acres, religious objections	no limits	none
City of Greeley	15% of Sept. 2000	13%	May 1-July 2	every other day	1-5 pm	no limit	sod & seed exempt	none	no limits	
			July 3-Oct. 1	every 3rd day	10 am-6 pm	no limit	by permit: sod-4 wks., seed-6 wks.	medical hardship, multiple address, >4 acres	on watering days, w/bucket or hose	no washing hardscape, public plumbing fixtures
			Oct. 15-Apr. 15	lawn watering banned	n/a	n/a	by permit: sod-4 wks., seed-6 wks.	none	no waste allowed	considering inclining block rate or budget
City of Lafayette	75% outdoor, 35% overall			1 day per wk.	7 am-8 pm, 10 pm-5 am	2 hrs. per day	none allowed	none		
City of Loveland	20%		June 6-Nov. 1	2 days per wk. (includes all outdoor watering)	10 am-6 pm	no limit	sod & seed exempt	none	no limits	none
City of Thornton	15% of Sept. 2001	23.7%	Sept. 1	every 3rd day	none	3 hrs. per day	by permit: only front yards in new construction	medical hardship	on watering days, w/bucket or hose nozzle	none
City of Westminster	20% of average use based on 2000 & 2001	25%	Aug. 1-Sep. 9	every 3rd day	9 am-6 pm	2 hrs. per day	no turf, trees & shrubs w/drip	hardship, large properties	no limits	
			Sep. 10-Sep. 30	2 days per wk. (includes all outdoor watering)	9 am-6 pm, 10 pm-5 am	2 hrs. per day, 10 min. per zone	no turf, trees & shrubs w/drip	hardship, large properties	no limits	water rate increase
			Oct. 1	lawn watering banned	n/a	n/a	no turf, trees & shrubs w/drip	none	no home car washing	

Source: Compiled by City of Fort Collins Utilities.



Chapter 3

Observations and Conclusions of Comparative Analysis[30]

The Smart Water survey and data analysis yielded the following conclusions:

- Water use efficiency, as measured by per capita use, varies substantially between cities.

- There is a large potential for improving urban water efficiency throughout the Southwest. A comparison between Single-Family Residential consumption rates, outdoor and discretionary use rates, and Unaccounted For Water (UFW) percentages reveals much room to improve water use efficiency. An "efficiency target" water provider exists in almost every variable category, setting the benchmark toward which others can strive. These benchmarks hint at a vast potential for water savings.

- Little or no correlation exists between municipal water consumption and climate conditions. Intuitively, we'd expect that water providers in hot, dry areas would need more municipal water to sustain urban landscapes. However, water service areas in hotter, drier areas of the region do not necessarily use more water per capita. The water providers with the lowest SFR per capita consumption rate in this study experience very similar climate conditions as the water providers with some of the highest SFR per capita consumption rates in the study.

- Outdoor, or elective, water consumption accounts for a large proportion of total water sold to municipal customers, offering the biggest target for future water savings.

- Rates of Unaccounted For Water (UFW) vary substantially between water providers. Collectively, the 13 Smart Water survey participants lost track of nearly 39 million gallons (119,000 Acre-feet) of water in the region in 2001 (real and apparent losses). Although some UFW will always exist (due to fire fighting, system flushing, etc.), a substantial potential exists for minimizing or eliminating both real losses (*e.g.*, leaks) and apparent losses (*e.g.*, faulty metering, accounting errors, etc.). The effectiveness of a water provider's conservation message to customers may be compromised if the water provider itself is "losing" significant amounts of water.

- Increasing block rate structures that communicate to their users that avoidable costs increase as consumption rises are effective in promoting cost-based water use efficiency among consumers, as long as the price increases are steep enough to get the attention of water users. Rate structures that yield inclining marginal price curves *and* average price curves tend to be most effective in promoting water use efficiency among consumers. Increasing block rate structures also tend to be fair, if they are established to charge high-volume users for the provider's avoidable costs of serving discretionary, outdoor use.

"Any river is really the summation of the whole valley. To think of it as nothing but water is to ignore the greater part."
-Hal Borland

From "This Hill, This Valley"

30 The observations and conclusions that follow represent the position of Western Resource Advocates and not necessarily those of the individual water providers who participated in this study.

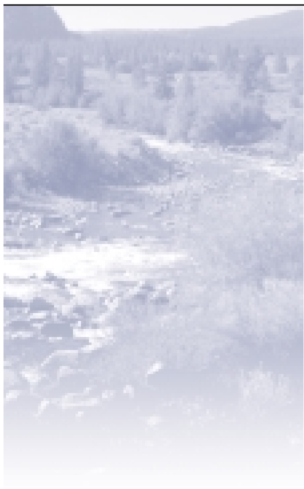
- Many water providers throughout the Southwest are beginning to take a multi-dimensional approach to planning and implementing a conservation program. This appears to be the most effective means used by providers to affect demand-side water use efficiency. Since every water customer may have his/her unique response "trigger" or "motivator", providers must consider a wide array of conservation opportunities and incentives (*i.e.*, via rate structures, rebates, education, and regulation).

- The majority of water providers have not assessed the cost-effectiveness of their particular conservation programs. Although detailed benefit/cost analyses are often conducted to justify structural water supply improvements, this level of analysis for water use efficiency measures is virtually non-existent.

- Regionally, customer self-monitoring could be improved. Water customers are more likely to become more efficient if they have a better, up-to-date understanding of their current consumption patterns. Some examples of such opportunities include distribution programs for direct-use meters (*e.g.*, for self-monitoring of landscape irrigation) and interactive billing websites that provide real-time consumption rates for customers. For some water providers, the transition from bi-monthly billing to monthly billing will also improve customer awareness and reaction.

- The preferences and expectations of a developed urban landscape appear to vary considerably throughout the Southwest. Some urban areas are embracing the concept of Xeriscape designs in most new developments (and actively retrofitting existing developments with Xeriscape), while other urban areas are still encouraging widespread use of non-native bluegrass lawns. These differences become very apparent when the makeup of a city's urban landscape is compared against its surrounding natural landscape. Some cities are adjusting their urban landscapes to fit the arid or semi-arid climate and landscape, some are not.

- On average, only 1 percent of total water service budget is allocated to conservation efforts in our sampling of water providers in the region.



Space for Notes