Residential Water Demand Management in Aurora: Learning from the Drought Crisis

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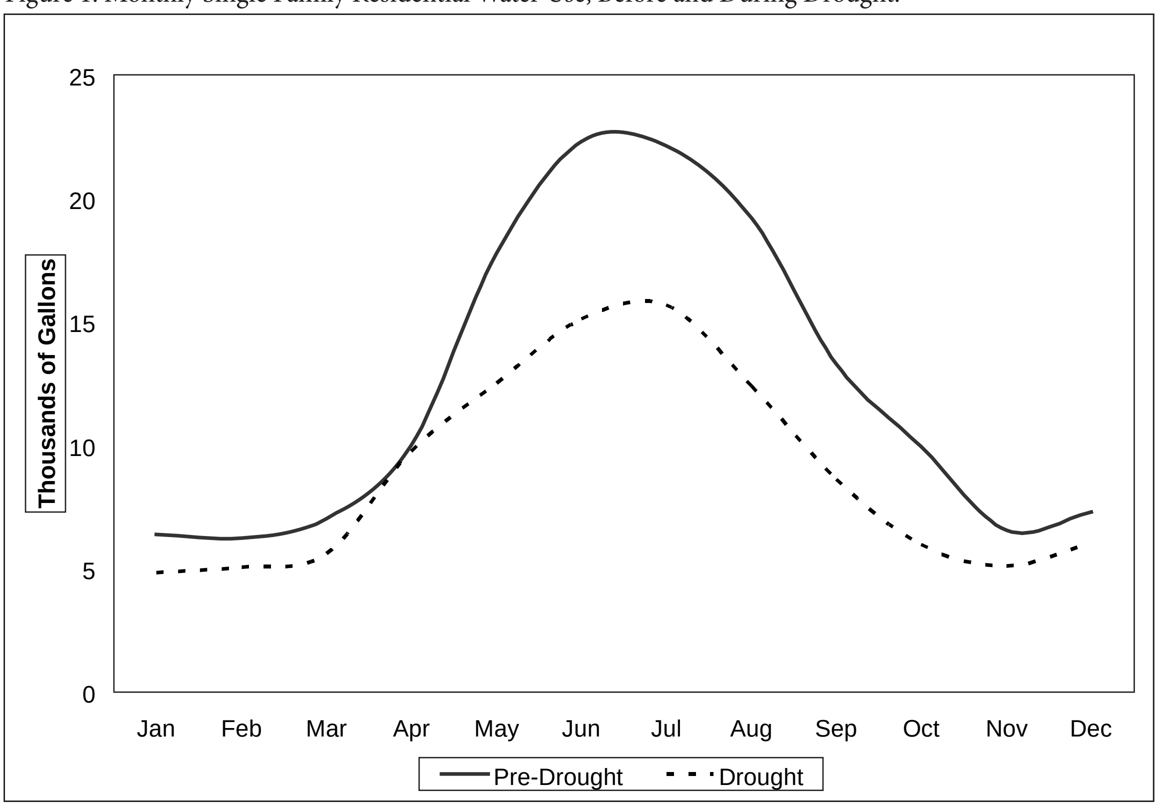
Recent drought years in Colorado have brought many unwelcome burdens and challenges to Colorado's water management community, but have also provided a strong incentive for reform and innovation. One example can be found in Aurora, where drought conditions in 2002 prompted an aggressive expansion and acceleration of a variety of residential demand management programs, aimed not only at surviving the drought crisis but also at reducing long-term per capita demand. Programs have included outdoor water-use restrictions, incentive and rebate programs, and a variety of pricing reforms, all nested within an ongoing public education campaign. By almost any measure, this mix of tools was immediately and hugely successful, with demands in 2003 down 26 percent from pre-drought conditions in 2000 and 2001. Average pre-drought (1/1/2000 to 4/30/2002) and drought (5/1/2002 to 4/30/2005) residential consumption levels in Aurora are shown in Figure 1. Several other Colorado cities have reported similar success stories.

Figure 1. Monthly Single Family Residential Water Use, Before and During Drought.



In order to reap the full benefits of its demand management efforts, Aurora Water identified a need to better understand why their efforts have thus far been successful in reducing system wide demands, as this knowledge is central to answering questions about whether the observed reductions are likely to continue, and which of the policy tools already employed should be prominently featured (or discontinued) in future conservation efforts. This not only calls for investigating the relative effectiveness of the various tools employed, but also for considering how the effectiveness of these tools varies among different types of residential customers. Answering these questions in a rigorous way calls for a quantitative, statistical analysis.

To conduct this research, in the fall of 2005 Aurora Water partnered with researchers at the Western Water Assessment (WWA), a NOAA-funded effort based at the University of Colorado's Cooperative Institute for Research in Environmental Sciences. Aurora Water sought information that would help them with future planning and management exercises, while WWA researchers wanted to better understand the opportunities for residential demand management programs as a tool for adapting to climate change and variability in the West. The following paragraphs summarize some of the findings from the initial Phase 1 of research.

Research Methodology

Many academic studies document those factors known to influence residential water consumption. Prominent among these influences are several factors within the control of the water utility (e.g., price, water restrictions, and rebate programs), and several that are not (e.g., weather and climate, and demographic characteristics of customers). In our research, we utilized a model of water demand that includes both types of factors, while focusing our analysis primarily on those factors that are within the utility's sphere of influence. Fortunately, Aurora provides an ideal case study for examining these factors, as the city has recently experimented with several types of price, restrictions, and rebate programs. For example, over the past 5 years, Aurora Water's water rate structure has evolved from a flat to an increasing block rate (IBR) structure, and from an IBR applied uniformly across the customer base to one that features individual (household level) water budgets. Also significant has been the use of mandatory outdoor water-use restrictions throughout most of 2002 to 2004, and the ongoing use of rebate programs for both indoor and outdoor water-saving technologies.

We have been able to take advantage of this wealth of experimentation by virtue of having household-specific consumption (billing) records going back to 1997, prior to the drought crisis and the imposition of the most aggressive demand management measures. Using a statistical technique known as fixed effects, we have evaluated changes in water-use within more than 10,000 individual households in Aurora, tracking how each household has responded to changes in price, restrictions, and for those that participated, rebate programs. Comparing the responsiveness of individual households to the overall responsiveness of the entire study population allows us to identify important relationships between the demand management tools and the types of customers affected. Specifically, we choose to distinguish between customers that, prior to the drought, were high, medium, and low volume water users. Not surprisingly, the vast amount of system wide water savings achieved in Aurora has come from modifying the behavior of the high-volume water users; thus, understanding how this group reacts to conservation programs is of particular importance.

Preliminary Findings

The most common focus of water demand studies is the determination of price elasticity of demand—i.e., the extent to which consumption drops for a given increase in price. In Aurora, the overall price elasticity of demand is calculated to be -0.60 across the full study period and population, meaning that a 10 percent increase in price reduces demand by 6 percent. This figure, well within the range found in other studies, is a useful finding, but the real insights come from delving deeper. For example, our research demonstrates that the price elasticity of demand is considerably higher among the high water users, in the summer months, and during drought conditions.

Of particular salience to managers is the interaction of pricing tools with water-use restrictions, a special point of emphasis in our research. Pricing tools and water restrictions can both reduce water demand, but they do not operate independently, and their levels of savings are not fully additive since, for any given customer, one or the other (not both) will limit water consumption. In Aurora, enacting mandatory water restrictions reduces the overall price elasticity of demand from -0.60 to -0.37, meaning the effectiveness of price in limiting demand is reduced. To understand this change, one needs only look at the high-volume water user category, whose price elasticity of demand averages -0.75 in periods without water restrictions and -0.24 in periods with restrictions, the decline occurring since restrictions limit water use among these users before any personal price threshold is reached. This observation has many policy implications, perhaps suggesting that managers attempting to control demand of high-volume water users would be wise to focus on pricing tools in non-drought periods (when restrictions are not in place) and water restrictions in drought years. Of course, modifying the severity of the pricing or restrictions policies can alter this conclusion, as can a consideration of the equity impacts of demand management tools on the full spectrum of water users.

Other findings with significant management implications involve those programs promoting technology upgrades for indoor water-using fixtures, namely toilets and washing machines. Aurora residents participating in the indoor rebates programs reduced consumption by 10 percent, a finding that is consistent with other studies. This is a water savings that is likely to persist. Less intuitive were findings regarding the use of Water Smart Readers, devices Aurora Water customers can purchase (at a subsidized price) that allow them to track their water-use in real time. Without these devices, individuals only learn of their consumption when their bill arrives, a full month after the water-use decision were made. Individuals with Water Smart Readers tend to increase use (by 16 percent), an initially surprisingly finding that makes sense only when it is observed that these individuals use the knowledge obtained from the Readers to take full use of water allotted to them in the lower priced tiers while avoiding the upper tiers with more punitive pricing policies. Presumably, without a Water Smart Reader, users wishing to avoid the higher priced tiers would err on the side of caution, using water sparingly and thus not using the full allotment of the lower priced water.

Looking Forward

As is typical in research endeavors, our improved knowledge in some areas has only highlighted our need to better understand other factors. For example, demographic statistics regarding our customer base suggest that high-volume water users tend to be wealthier, older, and live in newer and larger homes than other customers (Table 1). These observations have potentially important implications both for conservation programs and for forecasting changes in long-term demand, but there is much more to be learned. Better understanding how customers actually make water-use decisions, for example, is a pressing need, but one that will require obtaining additional data about matters such as the irrigation system and cooling system technologies employed in these households. This is information that utilities rarely collect. Addressing these and related deficiencies in our preliminary analysis of residential water demand is likely to be the subject of a Phase 2 of research.

Additional Information
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To access this article in its entirety, please visit: http://wwa.colorado.edu/resources/water_demand_and_conservation/WaterDemandAurora.pdf

Table 1. Summary Statistics by Type of User.

	Household Type		
Variable	Low	Middle	High
	Average		
Average Monthly Consumption	4.90	9.34	14.80
Economic-Demographic (census-block)			
Household Income	50,680	53,967	58,928
Median Age of Homeowner	33.66	34.33	36.35
Persons Per Household	2.81	2.87	2.82
Percentage of Homes Built After 1960	77%	84%	92%
Number of Bedrooms	1.40	1.44	1.46

Demonstration of the Colorado Agricultural Meteorological Network COAGMET for Improved Irrigation and Pest Management

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Agriculturalists have long understood that weather events and patterns greatly influence their chances for establishing, growing, harvesting, and often marketing a successful crop. Thus, farmers and ranchers have always depended upon weather information to aid in making a variety of production decisions. However, the information or data available for these decisions and the methodology used to interpret this data has not always been sound. Fortunately for the present-day crop producer, agricultural scientists have found ways to utilize meteorological data to develop tools that have the potential to improve and enhance the farmer's management decisions. The need for this information has led to the installation of weather station networks to gather and report basic meteorological data.

Colorado producers have had access to decision support information produced from a weather station network called the Colorado Agricultural Meteorological Network or CoAgMet for over a decade. The CoAgMet network was established in the early 1990's by Plant Pathology extension specialists at CSU and USDA's Agricultural Research Service Water Management Unit, after they discovered that they had a mutual interest in collecting localized weather data in irrigated agricultural areas. Plant pathologists used the data for prediction of disease outbreaks in field crops such as dry bean and vegetable crops such as onion and potato, and ARS specialists used almost the same information to provide irrigation scheduling recommendations. Two information products that resulted from this collaboration are daily crop evapotranspiration (ET) rates and disease forecasting. These products are supplied by the web pages of the Colorado Climate Center (www.coagmet.com) and at www.colostate.edu/Orgs/VegNet/Resources at Colorado State University.

AVRC weather station.

The information supplied by this network can be