7.6 2002 MUNICIPAL RESPONSE TO DROUGHT IN THE COLORADO FRONT RANGE

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1. INTRODUCTION

Colorado is no stranger to drought. With its normally arid climate, Colorado has experienced five multi-year droughts in the past 110 years: 1893-1905, 1931-1941, 1951-1957, 1963-1965, and 1975-1978, McKee (2000). Tree ring reconstruction methods indicate that over the last several hundred years droughts of several years duration were not uncommon. The last severe and widespread drought in the state occurred in 1980-1981.

Between 1982 and 2002 Colorado as a whole experienced one of the longest periods of wet weather since 1929. During the same time, Colorado's most populous region, the Front Range—the north-south string of cities east of the Continental Divide anchored by Denver—grew by 42%. This made Colorado the third fastest growing state in the country (by percentage); the Front Range is projected to grow by an additional 37% between 2000 and 2020. Water managers have been understandably concerned about accommodating the water demands of this growing population given the knowledge that drought would eventually return. Additional challenges to balancing municipal water budgets include environmental protection regulations, water quality requirements, interstate obligations, and, over the longer term, predictions that increasing greenhouse gas emissions could result in higher winter temperatures and diminished late winter snowpack, U.S. Global Change Research Program (2002). Any decrease in late winter and early spring snowfall is of particular concern, as stored snowmelt provides the major water supply source for Front Range water users.

a. The Drought of 2002

Following a drier than normal winter of 2000-01, the winter of 2001-02 was also abnormally warm and dry. Precipitation throughout the first four months of 2002 ranged from a high of 73% of average in February to a low of 31% of average in April. Snowpack for the South Platte Basin never rose higher than 54% of average throughout the entire winter. As of May 1, snowpack was 23% of average for the South Platte Basin, and by June 1 only 1% of average snow accumulation remained. Flow at the gaging station near Kersey was 235 cfs in May, compared to a long-term average of 2,486 cfs. A flow rate of 57 cfs on May 2 was the lowest flow recorded at Kersey in over 25 years. Reservoir storage for the basin was 72% of average on June 1 and 53% of average by August 1. The Surface Water Supply Index (SWSI), developed by the State Engineer and the USDA Natural Resources Conservation Service to indicate mountain-based water supply conditions in major river basins of the state, was in the negative range for eight months in a row beginning in December 2001. In comparison the SWSI had been below zero only a total of nine months between January 1993 and November 2001, Colorado Division of Water Resources (2000, 2001, 2002).

By the late spring of 2002, the severity of the drought finally spurred action among municipal water managers in the Denver metropolitan area. The result was a variety of policy responses aimed primarily at reducing summer

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outdoor water consumption through restrictions on lawn watering. In many Colorado communities, lawn watering accounts for over half of summer water use. Restrictions on the time, type and frequency of lawn watering sought to prolong reservoir storage, both for 2002 and, fearing a continued drought, for summer of 2003.

2. METHODOLOGY

a. General Purpose and Research Hypothesis

As part of its ongoing efforts to analyze the vulnerability of water resources in Colorado's South Platte River Basin to the impacts of climate variability and regional growth, the Western Water Assessment* examined the drought response of eleven cities along the Front Range during the summer of 2002. Our central hypothesis was that outdoor watering restrictions imposed in response to drought result in less water being consumed than would normally be expected, given climatic conditions and population growth. The study compared, for each city, water use patterns during summer of 2002 during watering restrictions to earlier periods without such restrictions. This required controlling for all relevant variables affecting water demand except for the suite of policy options described herein as drought restrictions. In most cases, these restrictions included an interwoven set of prohibitions, educational efforts, and/or pricing strategies. An additional, but secondary, research goal was to compare the experience of cities to each other, identifying potential trends between different strategies and different levels of success. Since results for each city are tabulated in this study using a standardized methodology, cross-city comparisons are facilitated—something not otherwise possible since the cities use a variety of approaches internally to estimate levels of success. The general goal of these investigations is to help municipal water managers assess and refine drought coping strategies.

b. Cities Selected for Study

From a water management standpoint, the dozens of adjacent municipalities comprising the Denver Metro area are highly heterogeneous. Many operate independent water systems, based on distinct portfolios of water rights. This study focused primarily on the following municipalities in the Denver Metro region: Aurora, Boulder, Castle Rock, Denver, Fort Collins, Lafayette, Louisville, Parker, Superior, Thornton, and Westminster. These cities were chosen to capture the large variability in municipal water systems.

One key point of variability is the location of source waters. As a practical matter, these cities can be grouped in three geographic regions (north, central and south) based on the location of their water sources and the associated water delivery infrastructure, Hydrosphere (1999). Most Denver Metro cities have access to flows coming down the east side of the Rockies, either from the South Platte mainstem or from several tributaries. In the northern and central regions, these flows are augmented by water collected in the headwaters of the Colorado River system west of the Continental Divide. In the northern region, these flows are captured by the federal Colorado-Big Thompson (C-BT) project, which annually diverts over 200,000 acre-feet to the Front Range. Slightly smaller imports are associated with the cities in the central region, which primarily rely on tunnels owned and operated by the Denver Water Department. Cities in the southern edge of the metro region generally lack imported water, and are highly dependent upon large (drought-proof) groundwater reserves that underlie the entire Denver Metro region.

Other important sources of variability include the age and size of the cities, their growth rates, their differing approaches to water management and conservation, and most importantly in this investigation, their different approaches to drought management. While all eleven cities were impacted by the drought, these impacts were far from uniform, and their responses—and their levels of success—were equally varied.

For example, due to severe water supply shortages, Lafayette imposed a mandatory one-day-per-week limit on outdoor watering in order to reduce water consumption by 75%, while fellow northern-region city Superior was

* A joint research project of the National Oceanic and Atmospheric Administration (NOAA) and the Cooperative Institute for Research in Environmental Sciences (CIRES) at the University of Colorado.

content with voluntary outdoor watering restrictions for most of the summer. Similarly in the central region, Aurora implemented strict lawn watering restrictions long before neighboring Denver. These differences reflect important differences in water system vulnerabilities, but also reflect different comfort levels regarding risk, and different belief structures regarding the effectiveness of water restrictions—both voluntary and mandatory.

c. Assumptions

This study relies on three assumptions concerning outdoor water use, which are based on our review of the relevant literature and historical trends. First, population growth leads to an increase in overall water consumption. Second, as average temperatures rise outdoor water use increases as well. Finally, as precipitation declines outdoor water consumption rises. Consequently, given the above average temperatures and below average precipitation for the South Platte River Basin in 2002, we would expect that water use would be higher that year than in years with lower average temperatures and higher average precipitation. However, water use data for 2002 suggest that water consumption was less than average for many municipalities compared to previous years, lending support to our central hypothesis.

d. Data

To examine the effects of watering restrictions on water consumption, it was necessary to control for the effects of population and climate conditions in explaining variance in our dependent variable, water consumption. Therefore, for each municipality in our study, daily water consumption, temperature, precipitation, yearly population, and weekly Palmer Drought Index data (described below) were collected for the peak water demand months of May, June, July, and August for the aforementioned municipalities.

Each municipality's water utility department provided daily water use data. These data are based on *demand* as opposed to *production* to help factor out water loss due to leaks or unauthorized use. Population figures for each municipality for the years 1999 through 2001 were provided by the Colorado State Demographer's Office. However, population figures for the year 2002 will not be available until July 2003. Therefore, this study estimated 2002 population for each municipality based on the previous three-year trend of population growth or decline. Annual population figures were used in combination with daily water demand data to make our dependent variable per capita water use, thus controlling for the effects of population on water consumption.

To control for the effects of climate variability, this study collected data from the Northern Colorado Water Conservancy District (NCWCD), Denver Water, city governments, and the National Oceanic and Atmospheric Administration (NOAA). This study first examined the variable *weather,* which is defined as daily variability in temperature and precipitation, to explain variance in per capita water use. It also examined the variable *climate*, defined as historical weather trends, to explain variance. Therefore, in the first instance we simply controlled for daily temperature and precipitation fluctuations. However, daily temperature and precipitation fail to account for the lag effects associated with such weather conditions. As a result, we employed weekly Palmer Drought Index (PDI) data (provided by NOAA) that includes variables such as temperature, precipitation, potential evapotranspiration, and soil moisture to account for historical weather trends.

Per capita water use for the year 2002 was compared to per capita water use for the previous three years. To test for the effect of watering restrictions on water consumption, each day in which restrictions were in place was treated as a dummy variable. Mandatory restrictions and voluntary restrictions were disaggregated to test for the individual effects of each on water use.

e. Preliminary Results

The initial results suggest that in all of the municipalities examined, mandatory restrictions, regardless of the nature of the restrictions (that is, amount of time per week when watering was allowed, extent of enforcement, pricing mechanisms, etc.) are significantly correlated with lower water consumption than historical trends would otherwise indicate. We expect that the extent of the decrease in water consumption for each municipality will be related to variation in the nature of the restrictions. Voluntary restrictions, conversely, showed varied results across our case study municipalities.

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