Issues of Aging Infrastructure: The Tucson Experience

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In the latter decades of the 20th century, Tucson Water, like most other utilities around the nation, relied on an infrastructure that was slowly aging. Because Tucson depended on groundwater supplies that were stable in quality over time, the slow deterioration of the pipes went largely unnoticed. Although the utility maintained a relatively modest ongoing replacement program for mains, other system needs often took precedence. When a new water supply was introduced in the early 1990s, deterioration of the water system accelerated and led to a crisis, and became a potent illustration of the importance of an ongoing infrastructure replacement program.

In 1992, Tucson Water introduced Colorado River water into the drinking water supply for about half of its customer base, or approximately 250,000 people. This supply came to Tucson for treatment and subsequent delivery via the Central Arizona Project (CAP) canal system, which conveys Colorado River water from a location near Lake Havasu on the Arizona/California border to municipal, agricultural, and industrial customers in central and southeastern Arizona. This new resource exposed Tucson's extensive water system to water with characteristics very different from the groundwater the city had relied upon for decades. Among these differences were a level of total dissolved solids (TDS) of 650 mg/L, approximately twice that of the average local groundwater, and a more aggressive corrosivity potential, primarily related to a pH of about 7.6 in the treated CAP water compared to an average of 7.9 in groundwater.

My Water is Brown!

Almost immediately following the initial delivery of Colorado River water, the utility began receiving complaints about water that was discolored, smelly, foul-tasting, or contained rust. Analyses showed that the water contained high levels of iron and other corrosion byproducts from metallic water mains and private plumbing. In essence, the aggressive water was releasing existing corrosion and scale from the pipe walls. In a number of cases, the corrosion products had completely replaced the pipe walls. When the rust and scale were removed, pinhole leaks appeared, joints failed, or pipe walls burst under pressure. In 1994, the Colorado River water supply was discontinued and the utility returned completely to using groundwater. By then, more than 14,000 complaints had been received and the utility ultimately had to pay more than $2 million in damages to affected customers.

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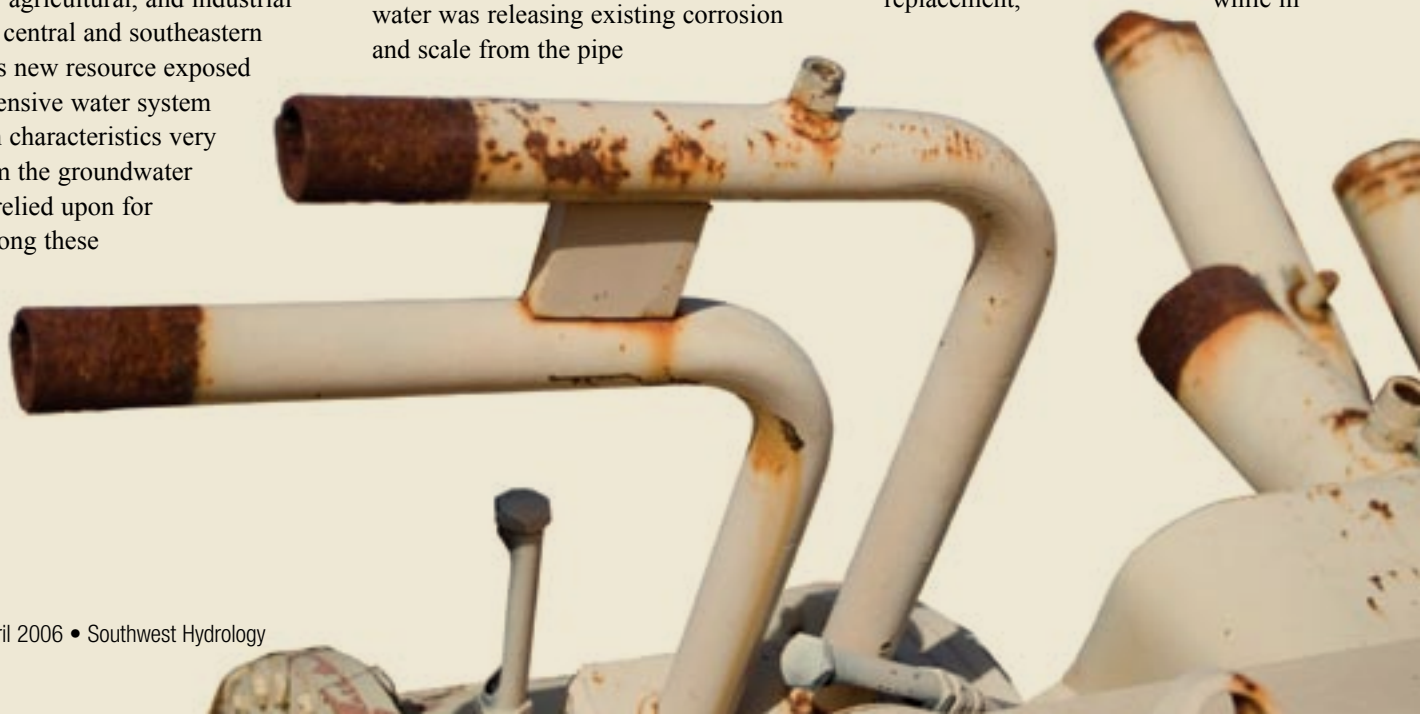
Having learned the consequences of allowing portions of the water system to age beyond its reasonable lifespan, in 1996 Tucson Water began an accelerated replacement program for its water mains. Tucson Water's service area covers more than 300 square miles and contains more than 4,200 miles of distribution and transmission mains. Nearly 220 miles of galvanized steel or unlined cast iron mains were identified and prioritized for replacement or rehabilitation. These water mains were scattered all over the system. In some areas all or most of a neighborhood's mains were in need of replacement, while in



others only half a dozen isolated mains had to be replaced within a square mile.

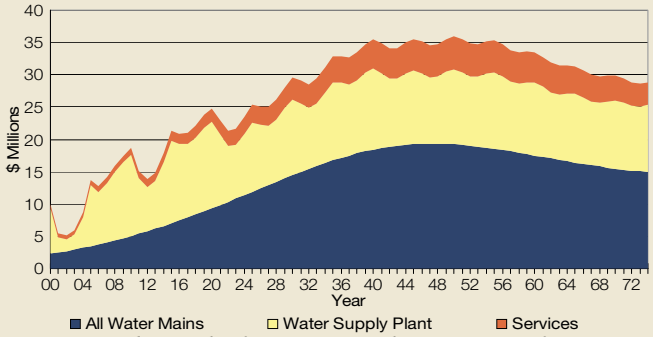
The Problems of Inheritance

Tucson Water's historical pattern of growth compounded the difficulty and expense of identifying and replacing these mains. Tucson Water was first established as the municipal water utility in 1900. Throughout much of the 20th century, the utility's primary method of growth had been to purchase existing private water systems. Information about the material, location, and depth of facilities in these private systems was sometimes missing or inaccurate. Mains were located under busy streets, in unpaved alleys and easements, and some crossed private property. Often, the small utilities that had initially constructed their water systems used inexpensive and occasionally substandard materials, and their design and construction standards were below par. Field verification of water system facilities became necessary before the final design of each main replacement project was completed. Verification methods included either excavation of pipeline segments or "vacuum extraction" potholing, which allows the utility to expose very small portions of the pipeline for examination.

Galvanized steel mains were replaced primarily with PVC pipe, while unlined cast iron mains, most of which were in good shape, were internally scraped and mortar-lined. In addition, the utility discovered approximately two miles of substandard or improperly installed cement/asbestos (CA) pipe, which normally has a life expectancy of about 50 years. Its early failure was not related to the quality of CAP water, but was discovered during the accelerated main replacement program. Ultimately, more than $40 million was expended during the five-year accelerated water main replacement and rehabilitation program, or approximately $40 per linear foot of water main. Since 2001, the utility has expended an average of $3 million per year for continuing main replacement activities, primarily through the sale of water revenue bonds. Some main replacement projects have been financed through low-interest loans provided by the Water Infrastructure Finance Authority (WIFA), an independent state agency that administers the Federal Drinking Water Revolving Fund (DWRF) for drinking water construction projects.

Planning for the Future

The problems associated with the initial delivery of Colorado River water vividly illustrate the importance of an ongoing system replacement and rehabilitation program. But, water quality aside, there are many other reasons why such a program must be included in every water utility's capital improvement planning. The Tucson Water system also contains dozens of major reservoirs and associated facilities, as well as thousands of valves, pumping and pressure reduction facilities, and hundreds of water production wells. All of these facilities, which together make up a community investment of over $1 billion, must function properly in order to provide continuing water service to its 680,000 customers. Without a program to identify and replace aging or failing infrastructure and the necessary funding via water rates and/or water revenue bonds to pay for these critical activities, it would become increasingly difficult for Tucson Water to ensure that service.



Projected annual infrastructure replacement costs for Tucson.

Water main breaks, caused by internal deterioration or by outside forces such as nearby construction activities, are a daily occurrence within the Tucson Water system. Repairing these breaks requires properly functioning valves that allow crews to isolate and de-water broken mains before repairs can be accomplished. In a system that includes 15 different elevational pressure zones, booster stations and pressure reduction facilities provide the means by which proper water pressure is maintained within the system. Ongoing maintenance, and eventual replacement of these facilities, is a necessity.

A nationwide study coordinated by the American Water Works Association (AWWA) in 2001 evaluated the status of water infrastructure in 20 major metropolitan areas. Extrapolating from that study, AWWA estimates that nationwide expenditures for the replacement of drinking water infrastructure will be on the order of $250 billion over the next 30 years. This does not include the cost of replacing wastewater infrastructure or the costs of new treatment facilities intended to meet increasingly stringent water quality standards. The chart at left shows the AWWA study's projected aggregate cost per year for replacement of drinking water infrastructure in the Tucson Water system. The rising wavy shape is very similar to the replacement cost curve of water utilities throughout the nation.

Keeping water affordable while meeting the challenge of maintaining an efficient and reliable water system poses a significant challenge for Tucson Water and the community it serves. For this reason, the utility's Long Range Water Plan integrates both water resource and water management planning with infrastructure planning and construction. By concurrently evaluating our community's need for water supplies and the infrastructure necessary to deliver that water to customers, Tucson Water will be in a better position to meet future water challenges.

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Photo: Mike Buffington