Water Resource Problems within Pre-Platted Communities in the United States: The Case of Lake Havasu City, Arizona

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Abstract

This paper analyzes water resource-management issues at Lake Havasu City, Arizona, a large, pre-platted community. This amenity-based community is located in western Arizona, where water supply is a major concern. Water resource problems are intensified by poor planning and development decisions made by the original developer. The site chosen for development is an alluvial fan located in an extremely arid and drought-plagued region. To make matters worse, the entire site was platted and sold as rapidly as possible, creating problems associated with a sprawling subdivision and scattered developed. Fortunately, community officials have managed to devise ways to overcome many of these problems by implementing some rather innovative water resource-management techniques. Despite these innovative approaches, more is needed to meet the fresh water demands of a growing population. There is a special need to view water resource issues in a regional context because the demand for water supply is not limited to a single community. Competing demands for limited, potable water supplies require a cooperative effort if communities are to succeed in meeting future water resource needs. This is particularly significant at Lake Havasu City, because their water supply is determined by decisions made by those in charge of establishing Colorado River water use allocations.

Key words: pre-platted communities, potable water supplies, rapid population growth, water allocations, water conservation techniques.

Introduction

WATER SUPPLY IS BECOMING a serious problem in many parts of the world as the demand for fresh water continues to spiral upward. This is certainly true in the United States, where drought and rapid population growth and development have exacerbated the problem. A significant challenge is providing an adequate water supply for residents within pre-platted communities, particularly those that have experienced rapid population growth in recent years. For purposes of the research, a community is considered to be pre-platted if the entire site was subdivided into relatively small lots and sold as potential home sites prior to the installation of basic services such as water and sewer. Developers of pre-platted communities were often motivated by profits from lot sales rather than by creating sustainable communities. A common result was a sprawling subdivision with few, if any, basic services extended to individual lots. When pre-platted communities experience rapid population increases, the demands skyrocket for a wide variety of basic goods and services, including water and waste disposal.

The purpose of this paper is to show how rapid growth within pre-platted communities (lot sales subdivisions) creates a tremendous strain on natural resources, especially potable water supplies. Original developers, rushing to sell lots as rapidly as possible, often failed to provide even the most basic services. It was quite often the individual lot owner's responsibility to provide water and sewer facilities on-site via individual wells and septic tanks. For those subdivisions that grow and become incorporated cities, extending utilities (central water and sewer) to hundreds or even thousands of lots is a significant problem. This paper, by using a case study, illustrates how a pre-platted community is meeting the challenge of providing an adequate water supply for a rapidly expanding population in an extremely dry environment. Coupled with the problem of water supply is an aging infrastructure.

The Setting

Lake Havasu City began in 1963 when Robert McCulloch, a millionaire chainsaw executive, purchased a twenty-six square-mile parcel of barren desert along the western boundary of Arizona. It was the first of eight land development projects built by McCulloch Properties, Inc. (MPI). The 16,700-acre development is located along the eastern shore of Lake Havasu, a federal Bureau of Reclamation dam project (Figure 1) (Stroud 1995).

McCulloch devised one of the most outlandish and expensive promotional stunts ever used by a land developer to promote a project. He purchased the 140-year-old London Bridge for $2.5 million from

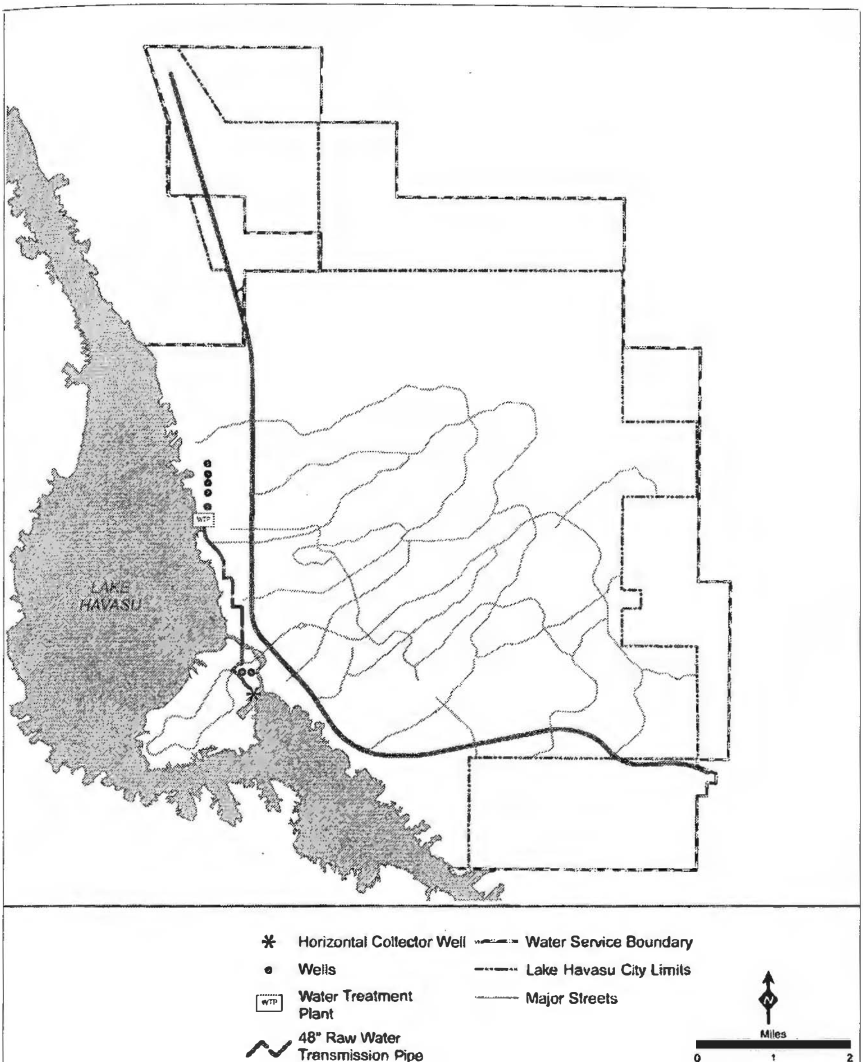

Figure 1.—Map depicting the location of Lake Havasu City, along the shoreline of Lake Havasu in western Arizona. Notice the island that was created by the excavated channel in Lake Havasu. Source: Lake Havasu City, Water Master Plan Update, October, 2007.

the British in 1968 and spent an additional $7 to $8 million to have it disassembled into more than 10,000 pieces of granite, shipped to Arizona, and reassembled along the shore of Lake Havasu under the direction of a British engineer. Reconstruction of the bridge was on dry land, with mounds of sand added to help support the arches during construction. A channel one mile in length was dredged at the completion of reconstruction, to provide water under the bridge. The peninsula known as Pittsburg Point became Pittsburg Island (Figure 2).

Most of Lake Havasu City's environmental problems are directly attributable to McCulloch's choice of site. Sitting on an alluvial fan, Lake Havasu City is particularly vulnerable to flash floods, a problem that is difficult to alleviate. In fact, flooding problems are magnified because the developer did not follow the natural limitations of the land. Although improvements have been made in recent years, many homes are too close to washes and drainage ways, and many roads cross arroyos (washes) without bridges (Figure 3) (Allan et al. 1976).

Despite occasional flooding, a much more serious and long-term problem is water shortages. Water supply limitations are particularly acute at Lake Havasu City because it occupies an inhospitable stretch of desert, where rainfall is minimal and temperatures are extremely hot during summer months. Rainfall averages approximately five

Figure 2.—Ground view of the London Bridge crossing the artificial channel at Lake Havasu City, Arizona. Pittsburg Island, created by the digging of the artificial channel after the bridge was constructed, is visible in the background. Source: Photograph taken by one of the authors, July 2008.

Figure 3.—Ground view of a city street crossing a large wash (arroyo) in Lake Havasu City. Notice the homes near the wash and the city street passing through the arroyo without a bridge. Source: Photograph taken by one of the authors, July, 2008.

inches per year, and summer temperatures often exceed 115 degrees F. This harsh desert climate sustains only widely spaced small shrubs and cacti.

Lake Havasu City's 16,700 acres have been subdivided into 33,514 lots, most of which were sold within a few years. The city also has multi-family units, motels, mobile homes, and commercial and industrial lots. While growth was slow during the early stages of development, population totals have increased dramatically in recent decades. By 1990, for example, twenty-nine percent of the population in Mohave County lived at Lake Havasu City. According to the Lake Havasu City General Plan 2002, the community nearly doubled in population, from 24,363 to 41,938, between 1990 and 2000. It is now the largest city in Mohave County and provides employment and recreational opportunities and a wide array of basic services. The General Plan projects a build-out population of between 90,000 and 100,000 by the year 2050 (Figure 4) and identifies water availability, transfer of land from public to private use, and infrastructure

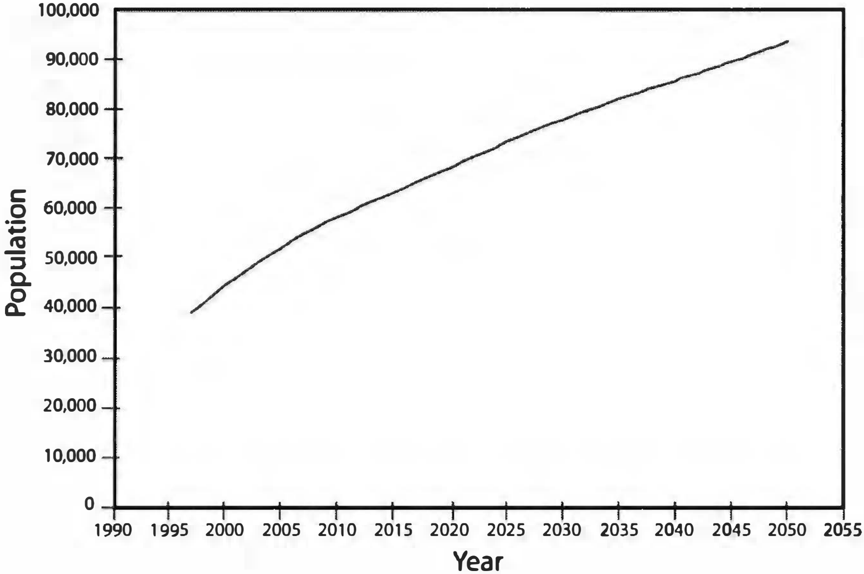

Figure 4.—Graph depicting rapid population growth at Lake Havasu City. Source: Lake Havasu City, Water Master Plan Update, 2007.

as constraints to reaching the projected build-out population (Lake Havasu City 2002, Brown and Caldwell 2000).

During the early stages of development, Lake Havasu City had many of the problems characteristic of land development projects promoted under the guise of new community development. Except for its isolated location, Lake Havasu City was really nothing new and certainly not a model community. Initially, the desert landscape was scarred by a dense network of dirt roads and a confusion of stores and factories, mobile homes, and an irrigated golf course. As the city grew, the roads were paved and services extended to existing homes. While the city has had a master plan from the very beginning, much of the city was allowed to evolve in whatever way was most profitable for the developers (Downie 1974, Stroud 1995). The platted area for the city was designated an Irrigation and Drainage District (IDD) to collect revenue and receive benefits under Arizona State Law (Wilson 2009).

Prior to 1978, Lake Havasu City was an unincorporated recreational area rather than a full-fledged city. Visitors came to enjoy a variety of amenities associated with the lake, primarily water skiing, fishing, and golfing on the newly created golf courses. Until recently, the permanent population was small. Today, the community boasts of having immediate access to the largest body of water on the Colorado River along the Arizona and California border, and a population of over 55,000 with a broad demographic base. The most recent growth boom occurred between 2000 and 2006 and was primarily infill within the Irrigation and Drainage District. Many of the new arrivals during this period of phenomenal growth came from southern California, where they had become dissatisfied with the basic quality of life.

Water Supply

One of the most-significant problems that had to be addressed by city officials was the dramatic increase in the demand for water that largely corresponded with the city's growth. Unfortunately, the city's entire water supply is limited to a water allocation established by the Bureau of Reclamation for use of Colorado River water. The City is allocated 25,180 acre-feet, or 8.2 billion gallons, of water per year. This amount of water, while being crucial to Lake Havasu City, pales in comparison to the 550,000 acre-feet that is allocated to Los Angeles and San Diego via the Colorado River Aqueduct, and the 550,000 acre-feet to Phoenix and Tucson via the Central Arizona project that was completed during the 1980s. These figures illustrate the significance of Colorado River water to several cities, and point to a need for regional, comprehensive water resources planning. Problems associated with supply are likely to intensify as the demand for water continues to increase, particularly in those cities experiencing rapid population growth. Fortunately, the consumptive trend at Lake Havasu City depicts a slight decline, particularly since 2002 (Figure 5). Nevertheless, the current level of use is a concern in view of limited supplies and the continued drought that plagues the region. Projections indicate that water demand may exceed the current allocation if Lake Havasu City continues to experience population growth in the future (Wilson 2008).

Although the term *groundwater* is often used, all the wells at Lake Havasu City are pumping water from the Colorado River aquifer, a supply that is sustained by recharge from the Colorado River. Consequently, the water taken from wells is included as part of Lake Havasu City's allocation. Even the new horizontal well (Raney Well) that is now the sole source of the city's supply is technically taking water from the river via a 16-foot-diameter, 100-foot-deep groundwater well located at London Bridge Beach on Pittsburg Island in Lake Havasu (Figure 6). One reason the city changed from a series

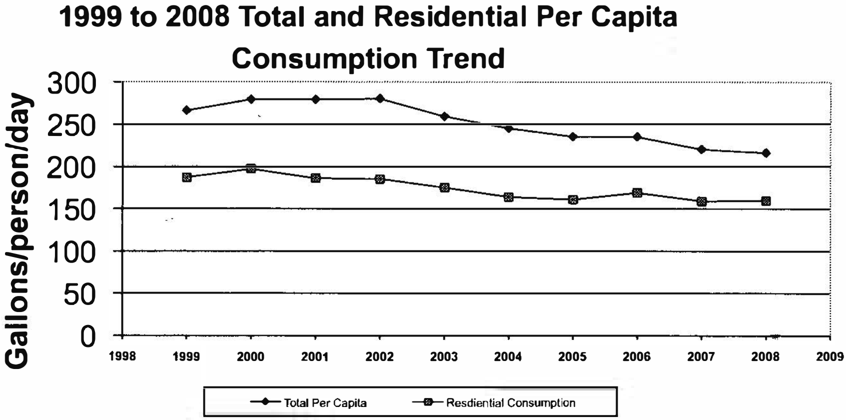

Figure 5.—Water use trend at Lake Havasu City since 1999. Source: Lake Havasu City, Water Master Plan Update, 2007.

of small wells to one large (Raney) well was in response to a State Department of Environmental Quality mandate to reduce nitrate levels in the water supply. The older wells fell short of producing enough water to meet the needs of a growing community, and they had elevated nitrate levels due to seepage from septic tanks. The new, smaller wells had high levels of naturally occurring manganese. Water containing manganese stains plumbing fixtures and clothes, and leaves a black powdery residue that can ruin surfaces and clog parts (Rudolf 2007, Brown and Caldwell 2001).

Lake Havasu City hired Burns and McDonnell, an engineering firm, for help in dealing with their water resource problems. In 1997, the firm helped develop and begin the implementation of a master plan to replace a patchwork of rural septic tanks with modern sanitary sewers, and to reduce the nitrate levels that are seeping into the groundwater. The firm also began work on a system designed to enhance Lake Havasu City's water supply. The city worked for seven years to install sewer lines and a new, state-of-the-art sewer-treatment plant to mitigate the problems associated with water quality. When the project is finished in 2011, approximately ninety percent of the city will be connected to a central sewer system, at a cost of $423 million. Since the state and federal governments are paying only $3 million of the cost, the citizens of Lake Havasu City are responsible for the bulk of the expense; base monthly sewer charges could exceed $100 in the next few years. If this does occur, the Lake Havasu City sewer rate would be one of the highest in the United States (Wilson 2009).

Figure 6.—Ground view of the small building housing the Raney Well on Pittsburg Island in Lake Havasu. Source: Photograph taken by one of the authors, July, 2008.

Initially, a first-of-its-kind system was created. It included the 100-foot-deep horizontal collector (Raney) well with a capacity that is adequate to meet current demand (Foster 2008). The city is also actively working to select an appropriate location for a second collector well that will not only provide enough water for the build-out population, but will also provide the flexibility to continue service if the first collector well is temporarily taken out of service for maintenance. The nine older conventional wells will be used as reserves (Wilson 2009).

After extensive research into manganese removal options and the use of a test well, a pilot plant complex was designed to evaluate the biological purification method, along with a conventional membrane filtration and three other conventional oxidation filtration processes for manganese removal. All the different processes were tested based on effectiveness and cost. It was concluded that not only was the biological method effective in removing manganese, but it would save $1 million to $2 million in plant construction and reduce annual operating costs by $600,000 to $700,000 compared to traditional methods (Burns and McDonnell 2002).

The water supply system pumps water from the collector well into a filtration plant with filters containing a granular medium and naturally occurring microorganisms that catalyze oxidation of the manganese. Chlorine is also added, but in smaller amounts than conventional methods would require. Additional benefits of the biological filter process are improved taste and color of the treated water. These benefits are accomplished by removing organic matter and other pollutants. Fortunately, the new system creates another flowing source of water in addition to the Colorado River. The source is effluent, the water recovered from flushed toilets and drained bathtubs. This treated effluent will increase from one million gallons per day to about fourteen million gallons per day in the near future. This is being accomplished by the expansion of two existing wastewater treatment plants and by the building of a new one. For a city that receives less than five inches of precipitation per year, reclaimed water can be an extremely valuable resource. As would be expected, the effluent is to be treated to meet State of Arizona standards.

Lake Havasu City uses the effluent to irrigate the growing number of golf courses, green spaces, and landscaping along Highway 95, which runs through the city. Another planned use of reclaimed water is to recharge the Colorado River aquifer that runs beneath Lake Havasu City. The feasibility of aquifer recharge is not fully understood. Water management officials will know more after additional testing has been completed (Wilson 2009). The Lake Havasu City Water Management Plan also includes important strategies to obtain additional water and efforts to increase conservation. Conservation and reuse are extremely important because the number of additional supplies or new sources of water are indeed limited. These efforts, many of which are included in the city's plans for the future, will do much to move the city toward water resource sustainability (Lake Havasu City 2006).

Water Conservation Measures

Conservation measures include the elimination of the use of lake water to irrigate golf courses, the reduction of the overall demand for irrigation, the promotion of the use of water-saving devices such as low-flow toilets and no-flush urinals, the investigation of the feasibility of directing evaporation-cooler waste into the sewer system or to individual irrigation systems, the feasibility of subsurface injection of excess effluent to create a storage reservoir accessible for later recovery, and the continuation of public education on water consumption practices.

Fortunately, Lake Havasu City has taken an active role in reducing the consumptive use of water. The most dramatic reductions in water use are considered to be a direct result of pricing structure revisions and pricing increases. Prior to the introduction of the increased scale-rate structure, water was relatively inexpensive. Total usage per capita began to decrease between 2002 and 2003, and it continued to decline to approximately 220 gpcd (per capita use in gallons per day) in 2008 (Figure 5). This decrease is attributed to the cumulative effects of the closing of the McCulloch manufacturing plant (a former user of large amounts of water) and a pricing structure that charges higher rates as water use increases. Fortunately, residential use, which is seventy percent of the city's total consumption, decreased to below 170 gpcd in 2004. With the exception of a slight increase in water use in 2006, levels at or below 170 gpcd continued through 2008 (Figure 5). New ordinances mandating additional rate increases in the future are being implemented to help create additional water conservation. Other conservation measures include landscaping requirements and low-flow plumbing fixtures. The city has instituted a "no-turf" policy for commercial, multi-family, and industrial uses. The "no-turf" policy is not applicable to single-family residential property. Even so, it is a water savings method that many residents are using (Figure 7).

Finally, the city has established short-term water conservation goals for the five-year period from 2006 to 2010 (Lake Havasu City 2005). The general goals that extended through 2010 were as follows:

- Decrease the total water consumption rate to between 240–220 gpcd through the five-year conservation period.
- Target the residential user group with specific programs designed to reduce overall usage.
- Increase public awareness of the water deficit that Lake Havasu City will experience in the coming years due to population growth and projected Colorado River water shortages.
- Reduce summer-season water usage by ten percent or more.
- Implement the "Slow the Flow" campaign.
- Increase wastewater reuse to keep pace with increased effluent availability.

The steps listed above to meet the growing demand for a limited resource are indeed necessary and expensive. To cover a large portion of the cost, local residents voted to support issuing a $463 million bond to fund a new central sewer system. The first phase of the project began with a $2.2 million contract that was approved by the Lake

Figure 7.—Ground view of no turf in use at single-family home site at Lake Havasu City. Source: Photograph taken by one of the authors, July, 2008.

Havasu City Council in 2002 (Burns and McDonnell 2002). While the central system is a necessary step, it will not solve the water resource problems for this city with a history of rapid population growth. This is particularly true if flows from the already overtaxed Colorado River are less in the future. It also makes conservation and the use of reclaimed effluent even more important. Whether or not adequate water supplies are available in the future depends in part on rates of population growth and on the success with which the goals outlined above are implemented and adhered to by the general population (see, for example, Lake Havasu City 2005).

Conclusions

Even communities with a poor layout and design and a history of inefficiency are now beginning to realize the importance of conservation and the need to preserve natural resources, especially fresh water. The community examined in this research is making or has already made significant changes in the way in which water supplies are obtained, and in the way in which water is used. A new well was installed to enhance water supply, and steps have been taken to remove manganese from drinking water. In addition, plans are underway to utilize reclaimed effluent, as an important means to generate a new water source for irrigation, for replenishing Lake Havasu, and for recharging the underlying aquifer.

This article illustrates the importance of making provisions for water supply within pre-platted communities. Potential problems for the future include competing demands on already limited supplies, the degradation of existing sources of supply from unexpected pollution sources, or a substantial rise in the demand for water from rapid population growth. These and other potential problems highlight the importance of water resources planning and management that includes protection of existing sources and an ongoing search for new sources of supply and innovative conservation techniques.

Located along the Colorado River, Lake Havasu City must compete with faraway metropolitan areas such as Los Angeles and Tucson for river water. Fortunately, the community of this study has initiated a major water-conservation program. The situation at Lake Havasu City provides an indication of the need to view water-resource issues in a regional context. This is extremely important because population growth in cities such as Las Vegas could impact water availability in the Lower Colorado Basin if greater volumes of water are diverted to upstream users.

It is abundantly clear that societies around the globe must switch from the one-time use of water to disperse human and industrial waste. The technology is available to eliminate the practice of using vast quantities of water to wash away waste material. The "flush and forget" system must be replaced by a much more efficient system (Brown 2008). One important option is the composting toilet, which converts human fecal matter into soil-like humus. Interest in ecological sanitation is increasing as water shortages intensify. Fortunately, several options remain available for communities that continue to use their water-based waste-disposal system. These water-saving techniques designed to be used at the household level include water-efficient showerheads, flush toilets, dishwashers, and clothes washers. As water costs rise, the appeal of water conservation will become increasingly more attractive to individual homeowners and to communities as a whole.

The severity of the situation is illustrated at Lake Havasu City, where residents have few options for obtaining fresh water if the flow of the Colorado River diminishes, if the city exceeds its allocation of

25,180 acre-feet per year, or if the federal government reduces the allocation to Lake Havasu City. As a means to cope with this very serious situation, city officials are working to obtain additional water rights, increase water conservation, and increase the use of reclaimed water. Since water supplies are so limited, these efforts and more are needed to ensure adequate water supplies in the future.

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