Drought Vulnerability of Community Water Systems in northern Gila County, Arizona

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EXECUTIVE SUMMARY

An assessment of drought vulnerability was conducted for the “Rim Country” communities of Payson and Pine in northern Gila County, Arizona. Since at least the early 1990s both communities have experienced summertime water shortages, outages, and water use restrictions on multiple occasions. Using a mixed-methods approach of qualitative and quantitative data collection and analysis, the assessment focused on the capacity of both communities to adapt to sustained precipitation deficits (i.e., drought) and increasing water demand due to increasing permanent and seasonal residents and weekend tourists. Assessment results suggest that while drought has had direct and indirect impacts on the productivity of both water systems, it has been overemphasized in popular and official explanations of water shortages, outages, and restrictions. Differences in the occurrence of shortages, outages, and restrictions between the two communities are more likely due to differences in measures taken to adapt to drought and increasing demand. These measures, in turn, reflect contrasting institutional and regulatory structures of public and private water systems, and differing economic incentives of public and for-profit water provision. The assessment concludes with recommendations for state-level programs, policies, and legislation to focus on assessing and building local and regional adaptive capacity, funding more and better interaction between state agencies and local communities, and expanding data collection programs to more closely monitor water systems and evaluate the effectiveness of mitigation programs.
INTRODUCTION

Drought conditions persisted in varying degrees across most or all of Arizona between the mid-1990s and the mid-2000s. In Arizona, conditions were most severe during the summer of 2002, and impacts were considered most significant in rural areas where natural resources and amenities play an important role in livelihoods, local economies, and community welfare. Approximately one hour from Phoenix in northern Gila County (Figure 1, see appendix), residents of the “Rim Country” region experienced a range of impacts including extreme wildfire risk, periods of water shortages (where demand was temporarily greater than supply), water outages (where customers experienced a lapse in delivery of water) and restrictions (i.e., where customers are encouraged or required to reduce demand to mitigate shortages or outages).

During this period, official government statements and local news reports attributed the impacts on community water supplies in the Rim Country to the lack of recharge to the areas aquifers resulting from drought, the “drought-sensitive” nature of the region’s groundwater resources, and to a lesser degree, increasing demand (McKinnon 2002, Parker et al. 2005). As a result, the framing of water scarcity has been in many ways an application of the Malthusian dilemma. During periods of drought groundwater is less plentiful, which adversely impacts the production capacity of community water systems, which in turn results in periods of insufficient water production. But have water shortages during the past several years been driven primarily by the interaction of natural climate and groundwater variability and growing demand? How have community water systems in the region adapted to the stressors of drought and increasing demand? Finally, what kinds of actions are likely to address and mitigate the underlying “drivers” of current and future drought vulnerability?

This report summarizes an assessment of drought vulnerability of community water systems in northern Gila County. The assessment of was motivated, in part, by goals of the statewide drought planning process in Arizona that include identifying sources of vulnerability and proposing mitigation strategies (Arizona Governors’ Drought Task Force 2004). The importance placed on assessing vulnerability reflects planning guidance of the National Drought Mitigation Center (NDMC) (Wilhite et al. 2005) as well as a growing emphasis in the hazards management field of pro-active risk management.

The assessment focused on the two largest communities in the region, Payson and Pine, and more broadly addressed the entire Rim Country region. While not necessarily representative
of the remaining (and smaller) communities in the region, the two communities allow for an analysis of how a public water system (Payson) and private water system (Pine) are affected by drought. Following an overview of the theoretical framework and assessment methods, background is presented on the region’s geography, water resources, and 20\textsuperscript{th} century history. Background is followed by assessment results, including a history of shortages, outages, and restrictions in both communities. The report is completed with discussion of the assessment results and conclusions on vulnerability in northern Gila County and, more broadly, rural Arizona.

THEORETICAL FRAMEWORK


Like much of the contemporary research, this assessment defines vulnerability by adapting a set of three interrelated and overlapping factors: Exposure, sensitivity and adaptive capacity (Smith et al 2003). Exposure refers to susceptibility of the system, region, or population to extreme geophysical stressors and hazard events (e.g., drought, flooding, earthquakes). Sensitivity refers to the relationships between geophysical stressors/hazards and the responses of the coupled human-environment system. Adaptive capacity refers to the ability of individuals and groups to adjust social and economic activities and institutions so as to reduce the impact of geophysical and social stressors. Because communities in northern Gila County have experienced similar patterns of precipitation deficits, the exposure aspect of the vulnerability framework is assumed to be constant for all community water systems and thus is not a focus of the study. Alternatively, sensitivity, and in particular adaptive capacity were critical for
examining differences between Payson and Pine in terms of the production of drought risk and mitigation.

The theoretical framework employed here builds on a subset of the climate and hazard vulnerability assessment literature emphasizing historical, institutional, and political-economic processes in the production of vulnerability (Hewitt 1983, Pulwarty & Riebsame 1997, Pelling 1999, Bankoff 2003, Wisner et al. 2004). In the late 1970s, Marxist researchers critiqued mainstream hazard research for the lack of analysis of political-economic and historical processes in the production of disaster risk (Hewitt 1983). Throughout the 1990s a growing number of researchers began illustrating the importance of political, economic, and cultural processes and institutions in how individuals, populations, geographic regions and economic sectors become more or less vulnerable to extreme geophysical events (Blaikie et al. 1994, Bohle et al. 1994, Varley 1994, Ribot 1996, Mileti 1999). Much of what was marginal in the 1980s and early 1990s has been incorporated into mainstream hazard research perspectives (Mileti 1999, White et al. 2001). The majority of assessment research has been conducted in developing countries where geophysical hazards often lead to significant human deprivation. More recently, however, there has been increasing interest in understanding the production of hazard vulnerability in advanced capitalist settings (e.g., Clark et al. 1998, Finan et al. 2002, Hayes et al. 2004).

ASSESSMENT METHODOLOGY AND DATA

The assessment is based on a range of data types collected using a variety of methods. Fieldwork involved multiple visits to the region and to state and county government offices, business offices, and research centers in Payson, Phoenix, Globe, and Pine. Primary qualitative data were collected through semi-structured interviews with stakeholders including state, county, and local government officials and representatives, water providers, members of the local and regional real estate community, residents, and local community groups. Secondary and tertiary qualitative and quantitative data were obtained from interviewees and other official sources (e.g., reports, studies, and public records). Historical sources were obtained through archival research of government documents, newspaper articles and previous historical research. Finally, a geographic information system was developed to integrate and analyze quantitative spatial
datasets on land use, jurisdiction, private development and surface and groundwater rights and development.

BACKGROUND

Geography and Water Resources

The Rim Country region is located approximately 70 miles northeast of the Phoenix-metropolitan area in the upper reaches of the Tonto Creek and East Verde River watersheds (Figure 2). The region is immediately south of the Mogollon Rim, the exposed and eroded southern edge of the Colorado Plateau. Elevation above sea level (a.s.l.) ranges from 4,800 feet in the southern part of the region (e.g., Payson) to between 6,000 and 6,500 feet atop the Mogollon Rim. The dominant vegetation is Pinon Pine and Juniper woodlands, with increasing presence of Ponderosa Pine in the upper elevations and on top of the Mogollon Rim.

There are approximately 35 communities in the region. Communities vary in size from isolated gated subdivisions of several homes, to the larger unincorporated communities of Pine and Strawberry (2000 census populations of 1,931 and 1,028, respectively), to the incorporated Town of Payson with a 2003 population of over 15,000 (Arizona Department of Economic Security 2005). The region’s proximity to the Phoenix-metropolitan area and it’s relatively milder climate (Figure 3) have made it a popular summertime tourism destination and second-home area. Using Gila County assessor office records, it is estimated that 20% of the approximately 6,900 housing units in Payson are secondary housing for Phoenix-area residents. In Pine, 60% of the 2,100 housing units are secondary housing for Phoenix-area residents.

The Rim Country is one of the wettest areas of the state despite significant inter-annual precipitation variability (Figure 4). Annual precipitation totals range between 20 and 33 inches, with higher totals closer to the Mogollon Rim. Roughly two thirds of average annual precipitation total falls between October and April, with July-September rainfall representing the other third of the average annual total (Western Regional Climate Center 2005). The Region is part of the larger Central Highlands planning area administered by the Arizona Department of Water Resources (ADWR), in which 50% of developed surface water in Arizona (other than Colorado River Water) originates (Arizona Department of Water Resources 1994). In addition to rain-fed surface water resources, there are numerous springs of varying discharge rates and water
quality along the base of the Mogollon Rim, some of which are the headwaters of perennial streams.

In contrast, groundwater resources in the Rim Country are considered less plentiful, reliable, and predictable than in much of rural Arizona and in particular the parts of the state with basin and range geology. The groundwater system is characterized by multiple and divergent ground-water flow paths, disconnected recharge areas, and shallow water bearing zones beneath sedimentary and igneous rock (Parker et al. 2005). Groundwater storage and flow paths are generally determined by large-scale fracture systems or by karst features in carbonate rocks (Parker et al. 2005). In Payson, groundwater is stored in fracture zones and individual fractures tens of feet thick in the upper 300-600 feet of igneous rock beneath a shallow alluvial unit (Southwest Groundwater Consultants, Inc. 1998). The Town of Payson estimates the amount of accessible groundwater at less than 15,000 acre-feet (Mike Ploughe 2004, personal communication). In Pine, several hundred feet of finely grained siltstone limit storage and transmittal of groundwater to fracture openings in the rock, with no significant storage of groundwater in the pores of the rock (Kaczmarek, 2003, p. 34).

**Post-World War II Regional Development**

The Rim Country was home to Apaches that were forced onto reservations outside the area beginning in the 1870s. By the turn of the century white settlers had settled most cultivable sites and established ranches and small farms. Homesteads totaling 2,158 were established in the Payson area prior to 1933 (Tonto National Forest 2005). Original homestead acreage in Pine is not known but is likely smaller in size relative to Payson. Despite the settlement of non-Indians, Payson was one of the most remote communities in Arizona during the late 1800s and early 1900s, taking 5 days of travel by wagon to Flagstaff and Globe (Trimble 2004). Essentially all economic activity up through and into the 1920s was subsistence farming and ranching. While there were a few small sawmills in the region, only a limited amount of lumber from the surrounding forest was produced for local use (U.S. Forest Service 1972).

The development and populating of the Rim Country has been contingent on its access to the Phoenix-metropolitan area. The Harvey Bush highway, linking Payson with Mesa through a nine-hour drive, was completed in 1937. In 1958, the highway was improved to a 2-lane paved
road and renamed the Beeline Highway (state highway 87). This shortened the nine-hour trip to about five hours (Brown 2001). Between 1960 and 2001 the road was expanded to a four-lane highway. In the early 1970s state highway 260 between Payson and Show Low was paved, and the Beeline Highway became the popular route to the White Mountains (Trimble 2004).

According to Tom Sheridan (1995), it was in the 1950s that the economies of many rural Arizona towns began to change. "Explosive population growth in Phoenix and Tucson drove thousands of city dwellers into the mountains to escape the heat. The biggest boom occurred on the Mogollon Rim" (Sheridan 1995, p. 315). Areas like the Rim Country were also popular destinations for outdoor recreation, hunting and fishing (Gila County Historical Society 1984). During the decade following WW II, Southwest regional Forest Service officials counted 47 subdivisions being developed within the perimeters of the Payson ranger district of the Tonto national forest (Baker et al. 1988). Many of the homesteads established during the late 1800s and early 1900s were being sold, subdivided, and developed as vacation home sites and mountain resorts for Phoenix-metropolitan residents. Gila County government was actively marketing the area as early as the late 1950s as an amenity-rich area for tourism and summer home development for Phoenix area residents (Gila County, 1959). Since then, Gila County government has adopted this model of economic development for northern Gila County (Gila County, 2003).

Homestead-to-subdivision development and lot splitting continued throughout the 1960s, 1970s, and 1980s. More recent development activities in unincorporated areas and communities of the region have consisted primarily of lot splitting and the subdividing of private land for residential uses in Pine, Strawberry, and Star Valley (Gila County, 2003). U.S. Forest Service land exchanges with private investors increased the amount of developable land within the Payson town limits by approximately 8,000 acres between 1930 and 1997. Similar land exchanges in 1964 increased the amount of developable land in Pine by 232.5 acres (Tonto National Forest 2005). Land exchanges helped the Town of Payson become the population and economic hub of the region, with a range of services provided by local businesses and large corporate entities including Wal-Mart, Home Depot, and Safeway. Figure 5 shows development of housing units in the region from 1950 through 2004. Approximately 1200 acres of Tonto National Forest land remains within the Town of Payson limits that could be exchanged at a later
date to accommodate new development. It is unlikely, however, that any land exchanges will occur until the Town finds additional water supplies.

While the permanent population of northern Gila County has grown, Payson is also known as the “Gateway to the Rim Country.” The majority of tourists and second-home owners visiting the region are from the Phoenix metropolitan area, and thus travel Highway 87 to Payson, north to Pine and Strawberry, or east on Highway 260 to Heber-Overgaard, Show Low, and the White Mountains (Figure 1). Figure 6 shows daily absolute difference in 2004 directional traffic counts approximately one mile south of Payson on Highway 87. The magnified plot shows a consistent summertime pattern of net northbound traffic flow on Friday, with the reverse situation on Sunday.

State Water Management in Rural Arizona

Historically, state government in Arizona has played a “hands-off” role in the management of water resources and development in rural areas. Thus, the regulation of land development and management of water in rural Arizona is primarily at the county and local levels. Since 1973 ADWR and the State Department of Real Estate have administered the Adequate Water Supply (AWS) Program. The AWS program was implemented to curtail land fraud and in particular the sale of land without accessible water supplies. The AWS program requires developers to obtain a report on the adequacy of water supplies from ADWR prior to advertising and selling lots. Adequacy is defined as “water of sufficient quality that will be physically, legally, and continuously available for the next 100 years.” If it is determined that water supply is inadequate, it must be disclosed to potential buyers in all advertising material and contracts. The AWS program does not, however, require this to be disclosed to subsequent owners. While water supplies and development in the states major metropolitan and agricultural areas have been increasingly regulated since the early 1980s, the AWS program is the only state-level requirement for areas outside of Active Management Areas (AMAs) that ties development to any notion of adequate water supply.

Between 1973 and 1996 water adequacy statements were issued for about 5,100 lots in Payson, Pine, and Strawberry. ADWR issued determinations of inadequate water supply for 98% of those lots (Arizona Department of Water Resources 1996). While this may initially sound
alarming, it also reflects a loophole in the AWS program. If a developer wants a determination of adequacy, (s)he must produce an engineered study that can cost thousands of dollars. Because of the expense of this requirement many developers immediately request a determination of inadequacy regardless of the actual adequacy of water supplies. The determination and disclosure of inadequate water supply has apparently been of little consequence for new lot development in northern Gila County (Figure 5). Thus, rather than reducing the occurrence of fraudulent land sales and the risk of water shortages, the AWS program has merely absolved the state and developers of liability related to a lack of adequate water and transferred it to the property owner and/or water provider.

Community Water System Development in Payson and Pine

33 of 39 community water systems in northern Gila County rely exclusively on groundwater (Mogollon Rim Water Resources Management Study 2005). The remaining systems rely on surface water and rights established prior to 1910. In 1910 the Kent Decree established rights to normal-flow of the Salt River and its tributaries (including the Verde River) for the Salt River Valley Water Users Association, now the Salt River Project (SRP). These rights were necessary for protecting the water that would begin being stored behind Roosevelt Dam the following year.

Prior to the 1950s, residents relied primarily on individual shallow wells for water supply. As homesteads were sold and subdivided, developers began to include simple water systems to help sell the lots. Some of these systems were organized and operated as small, for-profit water companies (e.g., run by the developer), while others were established by developers and eventually transferred to residents and managed through cooperative agreements or homeowner associations. Regardless of prior experience it was the developer in most cases who initially established and operated the water system with little or any state or county oversight.

The first private water system in Payson was established in 1950. Later in 1965 United Utilities (UU), a holdings company providing water for several other communities in the region, it was purchased the system. In Payson, United Utilities implemented a rather unique requirement that developers drill wells and build distribution systems in order for their subdivisions to be hooked up to the larger system. In 1976, three years after Payson was
incorporated, the water systems of four private water providers (including United Utilities) were integrated into one system. In 1980 the Payson town council established the Payson Water Department, purchased the integrated water system, and began operating a municipal water system. Between 1980 and 2004, the Payson Water Department expanded and improved the system considerably. In 2004 the Payson water system was serving approximately 13,500 people and included 32 active wells with a combined peak production capacity of 4,000gpm, 8.1M gallons of storage capacity, and one groundwater recharge project.

Despite being a relatively small community, Pine has a complex history of private water provision and system development. Mormon settlers established rights to surface water in Pine Creek and developed the first communal water system in Pine in the late 1800s. Through most of the 20th century other residents of Pine relied on shallow wells. In the 1970s a developer in Pine established E&R Water Company (E&R) to serve his developments and others in Pine. Following shortages, outages, and statewide attention in the summer of 1989, E&R was sold in 1990 to UU. During this time another developer in Pine established the Myers Water Company that was eventually bought by UU and was renamed Williamson Water Works (WWW) sometime before 1995. As a subsidiary of UU, E&R came under pressure by the Arizona Corporation Commission for poor management practices, fiscal irresponsibility, and violating rules on extending the E&R system in 1996. As a result, UU sold E&R, WWW, and 8 other water systems in northern Gila County, to Brooke Utilities, a holdings company based in Bakersfield, California. In its first few years of operation, Brooke Utilities integrated the E&R and WWW systems into one system, renamed it as the Pine Water Company (PWC). An evaluation in 2002 (Arizona Corporation Commission 2003) indicated the Pine Water Company (PWC) system served 1,887 connections, and included 19 wells with a combined production capacity of 226,000 gallons per day and 985,000 gallons of storage. Since 1996, four Domestic Water Improvement Districts (WIDs) have been formed in Pine. Three WIDs (Strawberry Hollow, Pine Creek Canyon, and Solitude Trails) provide water for district residents (i.e., separate from the Brooke Utilities service area) and a fourth WID (Pine/Strawberry) does not provide water, and instead focuses on identifying and developing additional water supplies for the communities of Pine and Strawberry.
VULNERABILITY ASSESSMENT RESULTS

Throughout the 1990s media reports and government officials at state, county and local levels consistently implicated sustained precipitation deficits as the dominant factor in the occurrence of water shortages, outages, and restrictions. To date, however, there has been little critical analysis of this claim. What is the history of shortages, outages and restrictions in each community? How has the interaction of natural precipitation variability, local geohydrology and increasing demand produced water scarcity? Finally, do differences in shortages, outages, and restrictions between Payson and Pine reflect different capacities of adapting to the stressors of drought and increasing demand?

A History of Water Shortages, Outages and Restrictions

A history of summertime water shortages and outages (May-September) in Payson and Pine was reconstructed for the period 1989-2004 (Figure 7). The start year of 1989 was chosen for two reasons: a shift from persistent above-average to below-average precipitation occurred in the late 1980s, and a widely reported outage in Pine in July 1989 in that was blamed on the drought by the local water company and state government officials. Approximately 130 archived articles from The Payson Roundup (the local newspaper in Payson) and the Arizona Republic (statewide) were reviewed. The Payson Water Department, private water system administrators, and customers have used the Roundup as a primary source for announcing water use restrictions and system outages. The Roundup has also acted as a forum for official and unofficial perspectives in the debate over water supply, development, and regional sustainability.

Between 1989 and 2004, Pine residents served by E&R, United Utilities and Brooke Utilities experienced restrictions on water use during 11 out of 16 summers (May-September), totaling at least 545 days. During six of the 11 years outages affected parts of the system, although outages typically lasted only for at most several days and did not affect the entire system. Seven of the 11 summers with restrictions required transport of water from systems or wells outside of Pine to maintain service to customers.

It wasn’t until 1994 that restrictions were placed on customers of the Payson water system. Between 1994 and 2004 Payson residents experienced a total of 158 days of restricted
water use during a total of 6 summers. The Payson water system experienced only one minor outage in late July 1995 that was attributed to a failed pump in a major production well.

In both Payson and Pine, shortages and subsequent restrictions and outages have coincided with the major summer holidays of Memorial Day and Fourth of July. During these long-weekends tourists and second-home owners, primarily from the Phoenix metropolitan area, migrate to the area en masse (Figure 6). When demand exceeds production capacity, storage is consumed to compensate for the deficit. If storage is depleted, outages occur. While weekend visitation remains high into September, it is hypothesized that shortages and outages have occurred far less often later in the summer because of the development of the North American Monsoon (NAM). Between early July and mid-September the NAM results in increased cloud cover and several inches of rain, reducing outdoor watering demand.

A Climate-Sensitive Groundwater System

In addition to drought, shortages and outages in northern Gila County have been attributed to the region’s geohydrology and the limitations it places on groundwater production. Although not entirely well understood (Parker et al. 2005), wells intercept water moving through fractured aquifers. Due to the complex spatial patterns and connectivity of fractures and fractured zones, changes in well productivity can vary significantly over relatively short distances and length of time pumping, contrary to assumptions appropriate for unconfined aquifers where radial flow dominates (Kaczmarek 2003).

The relatively shallow and fractured nature of groundwater holdings causes groundwater levels in the region to respond to precipitation variability much more quickly (i.e., annually) relative to other parts of the state. Figure 8 shows depth-to-water measurements for selected wells in Payson from 1995-2005. Some of the well data in Figure 8 show gradual declines in depth-to-water levels during this period when precipitation was below average. Water levels in these wells, however, increased markedly during the winter of 2005, responding to 190% of average precipitation (an additional 17.6 inches) for the period between July 2004 and March 2005. ADWR collects depth-to-water measurements for only two wells in Pine, and Pine Water Company is reticent about providing data. Thus it is far more difficult to identify relationships between precipitation, recharge, and depth-to-water levels in Pine.
During periods of peak demand, municipal wells in Payson and PWC wells in Pine may be pumping continuously for days or weeks to meet demand. At some point, many wells exhibit a dramatic drop in production capacity over a short period of time, a symptom of “overpumping” a well. Once the fractures are depleted, well production is limited by the flow of water through the system of fractures, the amount of water stored in the fractured rock, and the hydrologic conductivity of the fractured rock (Kaczmarek 2003). Other wells tapping into the same system of interconnected fractures may experience similar drops in productivity despite minimal pumping. When this happens, over-pumped wells must be allowed to recover, and other wells must compensate for the loss in production capacity, or water must be brought in from outside the system.

While not easily demonstrated empirically, drought has made it difficult to provide reliable water supply during the summertime. Specifically, drought directly increases demand, and indirectly decreases supply. A significant but unquantified amount of water supply is consumed for irrigation of outdoor vegetation in both communities. On average, peak outdoor watering demand is coincident with maximum potential evapotranspiration in June and early July, and decreases with the onset of the North American monsoon in early July. Below-average winter and spring precipitation prior to this period increases demand, particularly for perennial vegetation (e.g., trees, shrubs).

Drought also affects supply. Over time, decreased recharge to the local fractured aquifers via infiltration of precipitation reduces the groundwater levels. As groundwater levels decrease, wells produce less water per unit of time, requiring longer periods of time to pump the same volume. Additionally, lower groundwater levels reduce the volume that can be pumped before production capacity drops sharply.

**Adaptive Capacity: Long-Term Planning and Reactive Mitigation**

Despite similar exposure and sensitivity to precipitation deficits and increasing water demand, residents of Payson and customers of PWC have experienced significantly different summertime water service. Considering the differences in shortages, outages and restrictions between the two systems, what role has adaptive capacity played in determining the vulnerability of the Payson and the PWC water systems? Do the differences in shortages, outages, and
restrictions between Payson and Pine reflect different capacities of adapting to the stressors of drought and increasing demand?

In general, restrictions in Payson have been shorter in duration and less strict than in Pine (e.g., 20-30% reduction in overall water consumption and restricted outdoor water use). Between 1994 and 1997 restrictions were voluntary and ad-hoc. In 1997 the Town passed the first formal four-stage water conservation ordinance with stages two, three, and four comprised of increasingly strict mandatory restrictions. In 2003, the conservation ordinance was revised, modifying the justification for stage levels. Since 2003 stages are determined by the previous year’s estimated groundwater recharge (rather than current storage levels) and are set for a period of 12 months beginning in March. Stage 3 restrictions were in place in 2003 and 2004. In March 2005 restrictions were eased to stage 2.

During the 1990s the Water Department made a number of supply-side improvements to the town water system. It is unclear exactly what improvements were made to the Payson water system (and when) between 1980 and 1993. In 1980 Payson’s population was 5,600 and the system pumped over 166 Million gallons (81 gallons per capita). In 1993, Payson’s population was over 10,000 and the system pumped over 392 Million gallons (104 gallons per capita). It can be deduced from this growth that system production and/or storage was likely expanded.

In 1995 the Payson Water Department reported it operated 12 wells with a maximum production capacity of 2.35 million gallons per day, and had approximately 3.6 million gallons of storage. In 1996 a groundwater recharge project (Green Valley Park) was completed and is estimated to be recharging local groundwater by as much as 400,000 gallons per day. Also in 1996 the town added approximately 500,000 gallons of storage. In 1997 the town completed a groundwater water treatment project with the Arizona Department of Environmental Quality that decontaminated 140,000 gallons per day that was mixed into the Town’s system. The project was expanded in 1998 to produce between 300,000 and 400,000 gallons per day. New or existing wells brought online in 1997, 1998, and 1999 increased total system production capacity to over four million gallons per day. A new 1.5 million gallon storage tank in 1999 brought storage capacity to over 5.5 million gallons. By 2002 the Town had started to maximize the productivity of the local groundwater system with a production capacity of almost five million gallons per day. As of 2005, the town system includes 32 active wells and over 8 million gallons of storage capacity.
Since 1996 the town has worked with the Tonto National Forest to explore for groundwater on National Forest land nearby Payson. In 1997 Payson drilled exploratory wells west of town (without success). In 2001 Payson applied to drill 21 exploratory wells northeast of town. After significant negative input from residents living nearby the proposed sites, the Tonto National Forest suspended the process indefinitely in June 2004.

In addition to groundwater, the Town of Payson has been actively searching for a surface water supply. In 1973 the town was able to secure a 5,000 acre-feet Central Arizona Project (CAP) allotment but was never able to bring that water to Payson. In 1993 Payson sold its allotment to the City of Scottsdale in exchange for a $4.3 Million water development fund that has been used for, among other projects, the development of Green Valley Park that recharges groundwater levels and provides reclaimed water for outdoor watering of public parks. Since as early as 1998 the Town has been working towards establishing rights to surface water held in Blue Ridge reservoir north of the Mogollon Rim in the Little Colorado River watershed (Figure 2). In 2002 the Town agreed to contribute $150,000 over three years to a regional water study involving the U.S. Bureau of Reclamation, Gila County, and other state and local representatives.

In addition to water use restrictions, Payson has mitigated growing demand with a variety of zoning and water supply rules and conservation programs. In 1996 the town council passed ordinance #480 that essentially limits new developments to 20 lots or less (regardless of acreage) by requiring larger developments to provide a reliable water supply from outside of the town limits. The town also uses a relatively large lot size threshold to facilitate more zoning change requests to go before the planning and zoning board. This allows for town officials to have more control over the pace of small-scale development such as lot-splitting and small subdivisions.

The Water Department’s conservation programs include education and outreach, leak detection and repair, and requiring new and improved technologies. Free water audits are available to residential and commercial customers. Also, there is a range of year-round and seasonal codes. For example, new turf is prohibited, all urinals in new non-residential development must be waterless, and an outdoor irrigation code prohibits watering between 9am and 6pm from May through September regardless of conservation level. In 2003 the Town Council passed a revised and strengthened conservation ordinance.

Finally, the town has developed revenue streams to fund its water demand and supply activities. In addition to creating a $4.3 Million water development fund, the town council
increased water development impact fees in 1999 from $1,500 per home to $3,700, and $3,800 per 7,500 gallons per month consumption for commercial developments. The town council also approved water rate increases in 1998 and 2000. In 2003 base rates were increased by $1 to fund additional conservation programs.

In contrast to Payson, three different owners and holdings companies have operated what is now the PWC system between 1989 and 2005. In all three cases, the most common approach taken to mitigate water shortages has been to implement temporary restrictions on customer use of water. Restrictions were (and continue to be) implemented as a function of actual storage relative to capacity. Between 1989 and 2005, summertime (May-September) water use was restricted during 11 summers for a total of at least 545 days. During much of this time customers were asked to reduce overall consumption by 30-50% with a total ban on outdoor watering. When system outages were imminent or occurring, water was trucked in or transferred from Strawberry or other nearby water systems. This approach to mitigating outages, however, became increasingly difficult in 2002 when, during an outage July when PWC claimed to be having difficulty identifying a nearby source willing to sell water. Also, Gila County provided a 6,000 gallon water truck for residents in 1996, 1997, and 2002.

Restrictions have been typically implemented in five stages. Stage 5 is a mandatory version of stage 4 restrictions that were enforced with fines and by unhooking repeat offenders. PWC had to receive approval from the Arizona Corporation Commission (ACC) to enforce mandatory restrictions or change rates to recover extra costs of service. The ACC approved all requests by E&R, UU and PWC to enforce mandatory restrictions. The ACC also approved an interim rate increase allowing PWC to charge customers extra to cover the costs of trucking water in 2003.

More permanent system improvements were made in addition to short-term and reactive mitigation measures. Newspaper articles and interviews suggest that the original owner, Ernie Rawls, developed a system fraught with leaks, insufficient in design, and increasingly inadequate to serve the growing number of customers it served. After a weeklong outage in July 1989, E&R was sold to United Utilities. United Utilities reported it had invested $182,000 between 1989 and 1991 connecting new wells and storage facilities, although this amount has not been verified. E&R was sold to Brooke Utilities in 1996 and between 1997 and 2002 PWC drilled five new wells, deepened 2 wells, and added 100,000 gallons of storage capacity. In 2002 the PWC
included 19 wells with a maximum production capacity of 226,000 gallons per day and 985,000 gallons of storage. PWC also improved monitoring of customer use by repairing and replacing meters for over 400 customers. Finally, PWC maintains a CAP allotment of 161 acre-feet per year, but faces significant challenges to using that allotment. Also, PWC officials were required by the ACC in 2004 to participate in a regional study of water supply demand and supply organized by the U.S. Bureau of Reclamation and involving a range of key stakeholders.

**DISCUSSION**

Both communities have very similar exposure to sustained precipitation deficits due to their close proximity. Additionally, both communities have been similarly exposed to increases in water demand from growth in permanent residents and compounded by summertime visitation of Phoenix-area residents. Both systems are considered to be similarly sensitive to precipitation deficits, although similar to a lesser degree than exposure. However, the capacity of each system to adapt to the stressors of reduced recharge and increasing demand is quite different. Focusing on this argument, it is hypothesized that it is the institutional setting within which private water providers have served water to Pine residents, coupled with economic incentives of a for-profit water provider, that has made the system in Pine more vulnerable to shortages, restrictions and outages than Payson.

While the Payson Water Department must follow state and federal guidelines on water quality and production (e.g., well registration), it is entirely responsible for the quality of service provided. The Water Department is accountable to customers (i.e., Payson residents and businesses) via oversight of the Payson town council and Mayor who, in turn, are elected officials who represent the interests of the community. Thus, the structure of local government provides Payson residents with a degree of access to system managers, who are in turn held accountable for their actions through an elected, representative government.

In addition to providing reliable water service in the near-term, the town government must be responsive to local economic interests. The entire region developed as a second-home, tourism and retirement destination, and real estate and development-related business have remained central to the economic future of Payson. Thus it is in the interest of the Water Department and the town council that water supplies in the future will be sufficient to sustain
Payson’s growth-based economy. The importance of this issue is reflected in the efforts of the Water Department to maximize the production capacity of the Payson water system after experiencing shortages in 1994. The town’s efforts to manage growth through regulation of development, however, have been quite controversial and upset some members of the local business community. The Town has actively sought light industry and retail businesses that do not require large amounts of water in an effort to diversify its economy while limiting increasing water demand.

The structure of the Payson government has allowed for a diverse approach to managing demand, investing in system improvements, and research. Because the Town is responsible for planning and zoning, water supply management, and has the power (with public support) to enact policy changes, it can develop a more diverse and comprehensive approach to mitigating the risk of water shortages. The town funded a multiyear geohydrological study in the early 1990s that led to an improved understanding of groundwater supplies and ultimately led to the adoption of a “safe yield” framework for managing water supplies and demand.

Compared to Payson, the adaptive capacity of the PWC system remains compromised by marginally effective state regulation, a “mismatch” in state and county regulatory priorities, and economic incentives of a for-profit water provider. The ACC has jurisdiction over the quality of service and rates charged by public service utilities including private water companies. By state law, public service utilities are regulated monopolies given the opportunity to earn a fair and reasonable return on their investments. The ACC aims to balance the customers' interest in affordable and reliable utility service with the utility's interest in earning a fair profit (Arizona Corporation Commission 2005). For example, when a utility seeks to raise rates it must request a “rate case” from the ACC to thoroughly evaluate a fair rate of return.

As a regulated utility, Pine Water Company lacks legal authority to impose pro-active conservation measures and many of the demand management measures employed in Payson. The ACC encourages water utilities outside of AMAs to develop and employ conservation stages and restrictions. The ACC can also grant authority to enforce restrictions with fines and unhooking repeat offenders, but only as a reactive measure based on current water storage. The ACC can also establish a moratorium limiting or prohibiting new hookups and mainline extensions to mitigate worsening shortages. Moratoriums also act as an economic incentive for utilities to
improve service. Since 1989 the E&R/UU/PWC service area has been under some form of hookup and mainline extension moratorium.

While the ACC regulates private utilities, Gila County regulates development in unincorporated areas, and therefore indirectly controls demand for water. The county has been criticized by the ACC and the president of Brooke Utilities, Bob Hardcastle, for approving development regardless of water availability. Hardcastle has also criticized the county for supporting new development and WIDs in Pine despite a history of water shortages. Gila County does require developers to demonstrate that an adequate amount of water can be obtained to serve their proposed subdivisions. Gila County does not, however, require developers to demonstrate that their supply will not adversely affect the supply of existing development. This is significant because new development in northern Gila County primarily results from rezoning and lot-splitting which only increases density. Despite over a decade of chronic summertime shortages in Pine and a poorly understood groundwater system, the county zoning board has not denied a single development due to a lack of water supply. When asked if recent state legislation granting counties the authority to deny development based on inadequate water supply had passed, county officials indicated that it would have had little to no impact on their approval process.

As an unincorporated community, water conservation ordinances and programs can only be enacted and enforced in Pine by county government. Unlike Payson, the county has not implemented a broad conservation strategy. In 2004 the county enacted a conservation resolution that encourages water-saving technologies for new buildings. As of 2005 the county has yet to implement any subsequent ordinances requiring water-conservation practices or technologies.

Gila County has also unintentionally undermined the efforts of the ACC to mitigate shortages. Under state law, counties have the authority to approve water improvement districts (WIDs), which are exempt from ACC regulation. WIDs are intended to provide communities with enhanced local governance and financing options to improve water service within the district. There are five WIDs in northern Gila County, four of which are in Pine. Two of these WIDs were established in the late 1990s by developers seeking to avoid the ACC moratorium on new hookups in the PWC service area (and its possible expansion to all future water providers in Pine). State guidelines on establishing WIDs permit developers to establish districts prior to selling lots. One WID was illegally being served by E&R when it formed, while the other was
within the PWC service area but had not begun selling lots and homes. The first development is essentially built out, while the second is selling lots and building homes as of 2005. While the first development has an agreement to sell surplus water to PWC, it remains unclear if the second system will be able to provide a reliable water supply for all 72 lots.

The motives of for-profit water providers, in part conditioned by state regulation, also increase the vulnerability of Pine residents. PWC monthly rates are comprised of a flat rate and an amount based on water consumption. Since PWC revenues are directly proportional to consumption, conservation results in reduced revenues. This has an effect on the way in which conservation is enacted in Pine, which has been consistently reactive to water storage levels and only during periods when a risk of outage is imminent.

The way in which the ACC sets rates of return for private utilities produces disincentives to invest in system improvements. Profit margins for private utilities are relatively fixed by the ACC during rate cases. When a utility wants to invest in system improvements, it cannot raise capital by raising rates before the investments are made. The ACC only allows utilities to recoup investment costs by increasing rates after investments are made. While this protects customers from “paying for nothing,” it often requires utilities to assume debt in order to make necessary improvements. Furthermore, rate cases require a significant investment of time and resources, and thus are reportedly avoided by small utilities until absolutely necessary. As a result, many small utilities do not adequately invest in infrastructure and thus remain vulnerable to emergencies.

CONCLUSIONS

While broadly addressing the entire Rim Country region, the assessment focused on the two largest communities in the region, Payson and Pine. The assessment employed an assessment framework based on the concepts of system exposure to external stressors, system sensitivity and adaptive capacity. Despite media and official explanations of water shortages, outages and restrictions, the assessment reveals the complex and socially-constructed nature of drought vulnerability. The historical trajectory of the region, in particular post-WWII development, has produced the contemporary scenario. Shortages, outages, and restrictions in
both communities have been exacerbated by ineffective and/or restrictive water and land-use management institutions at the county and state-levels. Local geohydrology complicates efforts to enhance production capacity, and the regional economy drives water demand periodically beyond that which can be produced. Differences in the scarcity of water between the two communities, however, have resulted largely from differences in capacity to adapt to drought and permanent and seasonal population.

Northern Gila County is expected to remain a popular place to visit, recreate in, and own a second home, particularly with Phoenix-area residents. Estimates of a recent regional water demand and supply options study (Mogollon Regional Water Resource Management Study 2005) suggest that in a full “build-out” scenario, the region’s demand for water could increase to as much as 400% of current demand by 2040. Current land and water management policies and institutions will be largely ineffective at mitigating future shortages. In Payson, there are currently about 1500 buildable lots that are already zoned for residential development and thus beyond the regulatory “reach” of the governmental regulation. In all 1500 cases the town is obligated to provide water service. Given the Town’s limited groundwater supply, it is unclear how this growth will be accommodated. In August of 2004 Water Department officials stated that in a worst-case scenario of continued drought, peak summertime demand would begin to exceed production capacity by as early as 2009, requiring the town to rely on storage during busy holiday weekends to satisfy demand.

Despite the growing problem of water scarcity, recent federal legislation has created the potential to provide surface water sufficient for future growth expectations. In December 2004 President Bush signed the Arizona Water Settlement Act that included the authority to transfer rights to the water in Blue Ridge Reservoir from Phelps Dodge to the Salt River Project. The act stipulates that SRP will lease approximately 3,000 acre-feet of surface water from Blue Ridge to communities in northern Gila County. SRP officials have indicated that it will likely take 10 years for the water to actually start flowing to Phoenix and the Rim Country. In the meantime Payson is the only community planning to utilize the water given the costs associated with bringing the water to the other communities in the region.

The Pine/Strawberry Water Improvement District, one of four districts in Pine, is also progressing on finding a reliable water source for both communities. Rather than water provision, the district focuses on identifying new sources of water for both communities as well
as evaluating costs associated with maintaining or expanding present and potential sources. The
district was established in 1996, and has since funded several reports aimed at identifying and
developing a reliable, long-term groundwater supply for both communities. Members of the
board participate in the ongoing regional water study, and are confident that they will develop a
deep well capable of supplementing existing systems and providing an adequate water supply for
both communities.

In addition to local efforts and statewide policy reports, federal and state legislation in
2004 and 2005 show increasing attention to the water supply problems in rural areas like
northern Gila County. In April of 2005 Pete Domenici (R-NM) introduced the Rural Water
Supply Act of 2005 that would establish a program within the U.S. Bureau of Reclamation to
support water supply planning and development in small rural communities in reclamation states.
In the 47th session of the Arizona legislature (2004/2005), a total of three house bills were
introduced that addressed rural water supply. HB 2169 would have required medium size towns
and counties to include in their growing smarter plans details of water supplies and how future
demand would be met. HB 2173 would have amended the water adequacy program by providing
towns, cities and counties with the authority to deny qualifying subdivisions (i.e., with greater
than 5 lots) approval to develop, or allow development with “conditions.” Both bills did not
make it to the floor. A third bill, HB 2277, was signed by the Governor in April of 2005. The
bill, now law, requires community water systems (public and private) outside of AMAs to
provide an updated water supply plan, a drought preparedness plan, and a water conservation
plan to ADWR every five years. It also requires water systems to supply annual information on
amount of water delivered, number of customers, and general use of water. Considering there is
currently a lack of data on these issues, it is a significant step for the state in terms of assessing
rural community water supply vulnerability statewide.

Finally, this assessment adds valuable insight, context and guidance for future efforts of
the Arizona Governor’s Drought Task Force (GDTF) (Jacobs, Morehouse and Garfin 2005) and
State Legislators. GDTF efforts to date have focused on establishing local and regional
monitoring networks to more accurately determine drought conditions. This assessment,
however, suggests that information on drought conditions is not as critical for reducing the
drought vulnerability of community water systems. Rather, this assessment suggests a more
effective trajectory for mitigating community water system vulnerability would be to develop
and implement policies and programs addressing the lack of integration between development and sustainable water supply at state, county and local levels outside of AMAs. It is also recommended that future efforts of the GDTF and the State Legislature focus on assessing and building local and regional adaptive capacity, funding more and better interaction between state agencies and local communities, and expanding data collection programs to more adequately address the political ecology of water scarcity in rural Arizona.
Figure 1. Arizona, Salt River Project watershed, and northern Gila County.
Figure 3. Climagraph for Phoenix and Payson.
Figure 4. Precipitation anomalies (inches) for Payson, 1950-2004.

1950-2004 average = 21.4 inches
Figure 5. Housing unit development in northern Gila County.
Figure 6. Daily absolute difference in directional traffic counts on highway 87, south of Payson (2004).

Source: Arizona Department of Transportation
Figure 7. History of summertime water shortages, outages, and restrictions

Monthly Precipitation Anomalies* (Payson) and Water Shortages and Outages in Payson and Pine

*anomalies based on 1950-2004 monthly averages for Payson

- Payson: (July 4 weekend) (4) (1)
- Pine: (July 4 weekend) (60)
- (late June) (30)
- (mid June) (45)
- (late June) (50)
- (late May) (3)
- (July 5th) (7)
- (late June) (14)
- (mid-June) (120+)
- (late May) (60)
- (late June) (45)
- (July 4 weekend & late July) (1)
- (mid-June) (2)
- (July 4 weekend & late July) (4)
- (June) (3)
- (early June) (90+)
- (late May) (6)
- (late June) (15 days in July)
- (mid-June) (90+)
- (late May) (6)
- (late June) (7)
- (June) (120+)
- (July 5th) (7)
- (late May) (90+)
- (late May) (6)
- (late June) (70)
- (June) (90+)
- (June) (6)
- Water hauling occurred.

Inches

restrictions implemented (# of days)  outages experienced (# of days)
Figure 8. Selected Town of Payson well monitoring data, 1995 - 2005.
REFERENCES


Gila County, 1959. *Prospect for adventure in the wonder country: stake your claim in Gila County*, pp. 4. Publisher unknown.


