THE PENNSYLVANIA STATE UNIVERSITY
SCHREYER HONORS COLLEGE

DEPARTMENT OF GLOBAL AND INTERNATIONAL STUDIES

THE EFFECTS OF ECONOMIC GROWTH AND POPULATION GROWTH ON LAND USE, WATER CONSUMPTION AND WATER CONSERVATION POLICY IN PHOENIX, ARIZONA

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SPRING 2018

A thesis
submitted in partial fulfillment
of the requirements
for a baccalaureate degree
in Global and International Studies
with honors in Global and International Studies

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ABSTRACT

The desire for economic growth in Phoenix, Arizona has promoted the growth of the city's population and the expansion of the city itself. Phoenix has grown from a small desert town into one of the largest cities in the United States. Phoenix's economic development after World War II enabled it to retain its workforce and employers, while attracting new workers and companies.

However, Phoenix is located in the desert of the Salt River Valley in Central Arizona. Phoenix has always had to face the challenge of water security. The emergence and intensification of climate change will force the city to struggle even more in the 21st century as the population increases and demand for fresh water grows, while supply remains scarce.

1) This thesis will argue that population growth and a political system that prioritizes economic growth have been, and will continue to be, the catalysts for Phoenix's increasing water demand. Phoenix's population has grown unchecked because of the desire for economic growth, and the lack of population control measures. 2) This thesis will also argue that Phoenix's city officials have not adequately addressed the threats to water supply that are posed by population growth. 3) This thesis will argue that the city government ultimately bears responsibility for any impending water shortages that the city will face in the 21st century. 4) Finally, this thesis will use historical water consumption data to examine quantities of water that could have been conserved if water demand levels had been lower at earlier times in Phoenix's history.

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ACKNOWLEDGEMENTS

First, I thank Professor Jonathan Abel and Professor Larry Gorenflo for advising my Honors Thesis. Without their help and support, this project could not have been completed.

Second, I thank my parents, Edward and Kathleen, my sister, Anne, my brother, Eddie, and our cat, Penelope. My family has always taken an interest in my education and encouraged me to excel in school. They have pushed me to go further in my academic endeavors, whether this meant attending Penn Charter, studying abroad in Freiburg, Germany or writing this thesis. I am grateful that my family has always supported me and my educational pursuits.

Third, I thank my past teachers, professors and coaches. They too have encouraged me throughout my academic career and they share in my academic success. Everything I have learned in school has shaped me into the person I am today, and the person I will become in the future.

Finally, I thank my friends, peers and classmates. This group has been an integral part of my education and my growth as a person. We share many memories both in and out of the classroom. I am grateful for our past times together and I hope to have more with you all in the future.

I am incredibly thankful that I was able to attend Penn Charter. The school provided me with a priceless education, and values that I will hold for the rest of my life. Going to Penn Charter laid the foundation for my personal growth and success at Penn State.

My time at Penn State has been a personal odyssey of learning, self-discovery and fun. I experienced everything that the university could offer me during my time here. I grew up at Penn State. For that reason, Penn State will always be home.

Chapter 1

Introduction

Since its founding as a farming community, Phoenix has sought to attract newcomers and residents. Economic growth has been the impetus for the city's development since the 19th century. Throughout its history, economic growth has been viewed positively, as an important goal to achieve. Attracting more residents meant that more people will settle land, work jobs, and produce goods and services for the city's economy and tax base. Economic growth has created new jobs throughout Phoenix's history. The creation of jobs has meant that more people must come to Phoenix in order to sustain its economic growth, or even accelerate it. To achieve its goal of growth, Phoenix has marketed itself as an attractive place to live for residents, and as an attractive place to relocate for businesses.

A strong economy can provide citizens with steady employment and income, which will mean that more money will become available for municipal services. However, Phoenix's location in the Sonoran Desert presents a problem to these ideas. Two of the main concerns about living in a desert are water demand and water supply. Phoenix's economic growth, which demands population growth, is in a sense at odds with managing water supply and demand. The city's population growth has expanded the city physically and increased the amount of land used for human activity.

While Phoenix's population was smaller in the 20th century than it is in 2018, the challenge of water conservation was still a major concern considered in some of the city government's actions. However, the city's goal of economic growth is what ultimately guided

Phoenix's city government. Drastic policies to reduce water consumption would discourage growth and negatively impact the city's economy and tax base. Yet within the present context of global climate change, Phoenix's must better balance its economic goals with its water conservation policies. Temperatures are rising in Phoenix and are expected to continue rising throughout the 21st century. Its population is also the largest it has ever been, and is expected to continue growing; while demand for water is also growing.

The city government of Phoenix has never addressed its growth mindset as a potential problem or threat to its citizens' long-term wellbeing as it relates to water supply. What this paper will do is first analyze this mindset, its origins and the outcomes it has produced by examining the city's history of economic growth, population growth, land use and water consumption from its beginnings through the 21st century.

This paper is more historic in nature, rather than economic, although the importance of Phoenix's economic mindset cannot be understated. Phoenix's economy and business leaders have played an integral part in shaping the city throughout its history. The growth and success of the city's economy have been vital to attracting people to the city. Phoenix's emphasis on its economy has been the catalyst for population growth. Population growth has led to more water consumption. To change or eradicate the system of capitalism or free market economics is not the purpose of this paper, although both systems have had a hand in creating this crisis of water scarcity. Nor is the purpose of this paper to propose that Phoenix follow an entirely new economic system.

It seems unlikely that the American economy, the state of Arizona's economy or Phoenix's economy will implement a radically different system so as to achieve sustainable goals like conserving natural resources. This is especially true given Arizona's cultural tendency

towards small government. The current dominance of the Republican Party at both the state and federal levels throughout the United States means that there is small hope for action that would go against the interests of economic growth, given the Republican Party's stances on environmental issues like climate change. The divisiveness and partisanship also indicate that any major change to the American system of capitalism and free market economics would not pass, even if a bill made it to the floor of Congress. Therefore, implementing radical changes to the economy will not be this thesis' focus.

Instead, this thesis will focus on the origins of the modern Phoenix, and the early city leaders who promoted the city as a way to attract more residents. Changes in land use over time stemming from population growth and economic production will be analyzed. Public records of city officials' responses to ideas about water policies will be examined. Phoenix's cultural and political ideals will be discussed as well. Figures for water consumption patterns and water supply will be included. Current water crises in other parts of the world will be shown as potential outcomes that Phoenix could face in the near future. Finally, water demand levels will be compared as a way to demonstrate how much water Phoenix could have conserved if it successfully reduced water consumption rates across different sectors.

Chapter 2

The Foundation of Phoenix and City Growth 1867-1940

"In the late 1890s a severe drought hit the area, forcing thousands of acres out of cultivation, and many farmers and town dwellers, feeling defeated, moved away. Those who remained recognized that progress resulting from growth was doomed unless they solved the water problem. After much debate they decided that a water storage system was the only answer. The idea was not new. For years local leaders had supported the need for a controlled water supply to overcome periodic floods and droughts, but not enough private capital to harness the erratic Salt River could be raised. Because of this failure to accumulate sufficient funds, Phoenix promoters contended that the federal government should undertake the job. Once completed, it was declared, a water storage system would bring "an era of good times such as no region of the West has ever known." [1] - Urban Development in Arizona: The Rise of Phoenix

The quote above, taken from Bradford Luckingham's *Urban Development in Arizona*: *The Rise of Phoenix*, is emblematic of the struggle between conserving water and promoting economic growth in a desert community. Even before the turn of the 20th century, Phoenix had already experienced the unforgiving nature of drought. At this early stage, the city, and the Salt River Valley in general, were small agricultural communities. The harsh desert climate caused some to leave, realizing the danger that drought presented to them and their livelihoods. Yet the

[1] 199-200. Bradford Luckingham, "The Rise of Phoenix", *The Journal of Arizona History*

people who stayed understood that without water, their efforts to improve their community would be for nothing. This passage is telling because it shows that even in 1890, the citizens of Phoenix recognized that water was the key to everything. Water was the thing that was going to allow Phoenix's citizens to survive and the city to flourish. To push onwards into the future without a secure supply of water would be akin to putting the cart before the horse.

In 1890, Phoenix's leaders addressed the challenges presented by future droughts by creating a water storage system. It is also extremely telling that previous efforts to create such a storage system around this time were unsuccessful because there was not enough private funding to support such a project. Phoenix's leaders thought it best to seek federal funding in order to successfully undertake the building of their water storage system. Phoenix would prosper after the project was completed.

People moved to Phoenix before 1890 to carve out a living for themselves. Many of these people were farmers, producing crops for their own subsistence and selling their surplus at the market. People moved to Phoenix at this time to make a living for themselves, to purchase property, to create businesses, to earn money. Yet when faced with drought, a problem endured by all, there were not enough private resources that could be pooled together to ensure the wellbeing of Phoenix's citizens. In 1890, the citizens of this small community needed the federal government to fund a water storage system so that they could continue to live in Phoenix. At this time, Phoenix's population numbered just over 3,000 citizens. The community of farmers that remained in Phoenix recognized the need to have access to water, so they looked towards the government to provide help. In turn, the government built the Roosevelt Dam, Phoenix's citizens gained greater, more secure access to water, and Phoenix continued to grow as a city.

It is worth asking some questions about this series of events. What if this group of farmers left Phoenix collectively, and settled elsewhere? What if their intuition, that progress without water would be for nothing, led them to the conclusion that they needed to move to an area with more reliable sources of water? What if the federal government thought the same way? In other words, what if the federal government refused to provide the funding for the Roosevelt Dam? Without the necessary private capital or federal funding, would these farmers have stayed? Would Phoenix be the city it is today, numbering over 1.6 million in population and sprawling across the Salt River Valley, if the Roosevelt Dam was not built? This line of questioning could continue in perpetuity and postulate any number of different alternate histories for Phoenix. Instead, what follows in this chapter is a chronology of how Phoenix actually changed from its Native American settlement and decline, to its post-Civil War settlement, to the building of the Roosevelt Dam through to World War II.

Phoenix's Beginnings 700 AD; Growth and Development 1867 to 1920

The land on which Phoenix is situated today has roots that date back hundreds of years to the Pueblo Grande ruins.[2] From 700 AD to 1400 AD, a culture, known as the Hohokam, lived in this area, sustaining itself with an intricate irrigation system and series of canals, which helped to make the land more fertile.[3] Drought is believed to be the leading cause of this civilization's demise.[4] In Andrew Ross' book, *Bird on Fire: Lessons from the World's Least Sustainable City*, he writes that the Hohokam's irrigation network was sustaining the civilization by 600 AD with a thousand miles of canals that supported densely planned villages measuring 4,000 square

[2] "City of Phoenix History", *City of Phoenix*
[3] "City of Phoenix History", *City of Phoenix*
[4] "City of Phoenix History", *City of Phoenix*

miles.[5] The population peaked at 40,000, and trade routes went as far west as California and nearly reached the High Plains to the east.[6] However, when resources became scarce, the civilization became isolated.[7] A long drought in 1100 led to migration to other parts of the southwest.[8] A series of seven major floods between 1357 and 1384 led to the end of the Hohokam civilization as people left their settlement.[9] Ross writes that the civilization was rendered "archaeologically invisible by the mid-1400s." [10] Others assert that poor nutrition or immigrant overpopulation led to the collapse of the Hohokam.[11]

The beginnings of the modern city of Phoenix date back to 1867, when the Swilling Irrigation Canal Company diverted water from the Salt River into the existing extensive canal system.[12] A year later, residents moved into the area and began growing crops a few miles east of the city's present location.[13] The city was officially recognized as Phoenix on May 4, 1868.[14] By 1870, increases in population necessitated the choice of an official town site and the construction of said site.[15] Lots were sold in the city at the end of 1870, and by 1880 Phoenix had over 2,000 residents.[16] The city was officially incorporated as Phoenix, Arizona in 1881.[17]

The surrounding towns of Glendale, Mesa, Peoria, Scottsdale and Tempe were each built between the 1870s, and 1890s, as the area expanded its development.[18] The railroad played an

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[5] 46. Andrew Ross. "Bird on Fire: Lessons from the World's Least Sustainable City", *Oxford Press*
[6] 45-46. Andrew Ross. "Bird on Fire: Lessons from the World's Least Sustainable City", *Oxford Press*
[7] 46. Andrew Ross. "Bird on Fire: Lessons from the World's Least Sustainable City", *Oxford Press*
[8] 46. Andrew Ross. "Bird on Fire: Lessons from the World's Least Sustainable City", *Oxford Press*
[9] 46. Andrew Ross. "Bird on Fire: Lessons from the World's Least Sustainable City", *Oxford Press*
[10] 46. Andrew Ross. "Bird on Fire: Lessons from the World's Least Sustainable City", *Oxford Press*
[11] 47. Andrew Ross. "Bird on Fire: Lessons from the World's Least Sustainable City", *Oxford Press*
[12] "City of Phoenix History", *City of Phoenix*
[13] "City of Phoenix History", *City of Phoenix*
[14] "City of Phoenix History", *City of Phoenix*
[15] "City of Phoenix History", *City of Phoenix*
[16] "City of Phoenix History", *City of Phoenix*
[17] "City of Phoenix History", *City of Phoenix*
[18] 5. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*

important part in the greater development of the area as it connected Phoenix to Glendale, Mesa and Tempe, the largest of these outer towns.[19] Available water from the Salt River was an important factor that shaped the city's early development, as the Hohokam irrigation canals were extended.[20] Land development and city growth generally trended towards the northern and eastern parts of the city from the 1880s onward.[21] A railroad was built in the 1880s which ran through the southern part of town near the Salt River.[22] This area of the city was generally developed for more industrial businesses, such as lumber yards, and warehouses, although there was some inexpensive housing built for minorities due to "discrimination and economic factors."[23] Further south, consistent flooding from the Salt River disincentivized development in this part of the city.[24] An important development was the establishment of the Salt River Valley Water User's Association (SRVWUA) in 1902.[25] This organization exercised private control guided the development of the canals and the construction of the Roosevelt Dam, which was built to provide a consistent supply of water to the Salt River Valley, and to reduce the potential for flooding and drought.[26]

The dam was located about 65 miles northeast of Phoenix.[27] Its completion in 1911 was pivotal to Phoenix's early agricultural success because it provided greater stability and control to

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[19] 5-6. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*

[20] 2. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

[21] 5. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*

[22] 5. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*

[23] 5. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*

[24] 5. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*

[25] 2. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

[26] 2. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

[27] 200. Bradford Luckingham, "The Rise of Phoenix", *The Journal of Arizona History*

the city's water supply.[28] The dam's steady supply of water provided the impetus for both local and federal spokesman to promote Phoenix as a new, desirable destination for settlers.[29] Organizations like the Phoenix Board of Trade, the Santa Fe Railroad and the Southern Pacific Railroad marketed Phoenix as an oasis paradise and a fertile agricultural valley.[30] The purported health benefits of the city's climate were also a draw to attract travelers and residents, as long as they had the money to stay in Phoenix.[31] Construction of new medical facilities and hotels were advertised, while those without sufficient funds were warned that their presence was not welcome.[32]

The early success and diversification of Phoenix's agricultural sector was critical to attracting new residents in the city's beginnings. Some of the first surplus crops sold included barley, corn and wheat. [33] As the agricultural sector expanded, fruits were sold, and alfafa production led to the growth of ranching for cattle, horses and sheep. [34] Dairies were later established as well. [35] The Roosevelt Dam's completion also allowed for the production of cotton to expand. [36] Phoenix used its agricultural success and rural image to attract more

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[28] 200. Bradford Luckingham, "The Rise of Phoenix", *The Journal of Arizona History*

[29] 200. Bradford Luckingham, "The Rise of Phoenix", *The Journal of Arizona History*

[30] 200. Bradford Luckingham, "The Rise of Phoenix", *The Journal of Arizona History*

[31] 202. Bradford Luckingham, "The Rise of Phoenix", *The Journal of Arizona History*

[32] 202. Bradford Luckingham, "The Rise of Phoenix", *The Journal of Arizona History*

[33] 2. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

[34] 2. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

[35] 2. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

[36] 2. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

potential settlers to live on the outskirts of the city, and increase city's growth and development. [37]

As development became more constrained to the south, it was also limited in the eastern part of the city, where an insane asylum made the area a less attractive development option.[38] The northern part of the city was a more desirable development location because the presence of the Indian School was viewed as a source of cheap workers, and "a market for Anglo merchants." [39] Although more high-end development began to spread towards the northwestern part of the city, floods from Cave Creek constrained development in this area as well, leading to the northern and northeastern parts of the city gaining prominence and preference for development.[40] Irrigated fields, shade trees and orange groves near the Phoenix Mountains attracted many residents to these parts of the city, as well as the mountain and views and refreshing breezes.[41] However, growth slowed in the northern part of the city as a result of price restrictions placed on deeds, which were intended to prevent the expansion of lower value housing.[42] Higher value development shifted more towards the northeastern part of the city after the construction of the lower valued Sunnyslope community.[43] City growth continued through the 20th century as Arizona officially became a state in 1912.[44] Other planned communities surrounding Phoenix were built between 1910 and 1920, including Chandler, Gilbert, Litchfield

[37] 2. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

[38] 5. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*

[39] 5. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*

[40] 5. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*

[41] 5. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*

[42] 5. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*

[43] 5. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*

[44] 5. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*

Park, Ocotillo, South Phoenix and Tolleson, as well as more informal settlements for agricultural workers like Cashion, Guadalupe, Higley, Laveen and Queen Creek.[45]

The Business Class' Early Influence on Phoenix's Development

One important development that occurred in 1913 was Phoenix's decision to switch to a commission-city manager style of local government. Voters approved this switch in an effort to maintain the idea of Phoenix as a progressive city.[46] This style of local government was prominent in other smaller American cities, and was considered an "efficient, business-like approach to the management of city affairs." [47] This event marks the beginning of the local business class' foray into politics. Important local organizations, like the Arizona Club, the Board of Trade, the City Club and the Merchants and Manufacturers Association were proponents of the city's change in government.[48] The following passage reveals the business class' influence on the city's direction moving forward in the 20th century.

> The business elite that helped bring the commission-manager form of government to Phoenix also encouraged cultural development in the city, for it indicated a sense of urban arrival. They wished to create the image of a "civilized city" by establishing symbols of urbanism, and they promoted and supported schools and churches, libraries and theaters, and other sources of "refinement. [49]

This description of Phoenix's early plans for urbanization stands in contrast to its early roots as a rural, agricultural community. The influence of the business class clearly shifted the vision for Phoenix's future towards an urban city. The language of this passage also indicates

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[45] 5. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*
[46] 202. Bradford Luckingham, "The Rise of Phoenix", *The Journal of Arizona History*
[47] 202. Bradford Luckingham, "The Rise of Phoenix", *The Journal of Arizona History*
[48] 202. Bradford Luckingham, "The Rise of Phoenix", *The Journal of Arizona History*
[49] 202. Bradford Luckingham, "The Rise of Phoenix", *The Journal of Arizona History*

that the city's self-promotion would also shift. Urbanization was not only meant to improve the city. The idea of Phoenix as a cultured urban center was clearly meant to attract more residents and travelers to the city. This passage also indicates that the plan was for Phoenix to develop as other American cities had. It seems that alternate visions for development were cast aside in favor of urbanization and the development of cultural institutions. Additionally, there is no mention of future access to water or the city's climate, nor are there questions raised about the area's carrying capacity for humans. This vision seems to be centered on growth. Phoenix needed to urbanize to attract more people. The idea of "urban arrival" suggests that Phoenix needs to offer the same urban attractions that other cities have. It would follow that the business class supported this direction for Phoenix's development because it saw opportunities to earn greater profits.

Businessman Dwight Heard is an example of how the business class guided Phoenix's early development. Having moved to Phoenix after professional success in Chicago, Heard, along with his wife and friends, began investing in Phoenix's economy and tried to attract other outside investors to their local ventures.[50] Heard owned a real estate company, which led a number of construction projects, and the Arizona Republican, a newspaper that played a role in shaping local Phoenix politics and ideas about life in the city.[51] The Heards supported Phoenix's cultural development and cultural institutions, like the Heard Museum. [52] After his death, Heard was revered for his support of Phoenix and Arizona.[53] However, Heard's deeds, while beneficial to the city, show how one wealthy person can disproportionately impact a city. Heard was an

[50] 203. Bradford Luckingham, "The Rise of Phoenix", *The Journal of Arizona History*
[51] 203. Bradford Luckingham, "The Rise of Phoenix", *The Journal of Arizona History*
[52] 203. Bradford Luckingham, "The Rise of Phoenix", *The Journal of Arizona History*
[53] 203. Bradford Luckingham, "The Rise of Phoenix", *The Journal of Arizona History*

employer in at least two different industries, construction and media. His workers clearly depended on him for their employment, and his control of a newspaper would have allowed him the opportunity to flood public debate with pro-business, pro-growth views. Therefore, it would seem difficult for citizens of Phoenix to go against Heard and his ideas at this time since his ideas permeated throughout public discourse and people depended on him for work. Heard is an example of how the business class was able to create a culture of growth and expansion in Phoenix. This is not to diminish Heard's achievements, but rather to show how the business class achieved power in Phoenix by employing workers and spreading ideas to the masses. In this sense, Heard is not so different from a modern day business leader like Jeff Bezos, who is also a large employer in Seattle, owns a nationally published newspaper, the Washington Post, and is influencing cities' visions for the future with Amazon's contest for its new HQ2 location. One of the big draws for cities to compete for the HQ2 bid is that Amazon expects to hire about 50,000 employees to staff its new headquarters.[54] Even in 2018, this project's notoriety and influence shows the desirability of economic growth, population growth and tax base expansion.

Land Use Patterns of Phoenix in 1912

The historical map below (**Figure 1**) provides a sense of perspective to the agricultural growth, urban growth and overall land use in Phoenix in 1912, at the root of the city's expansion. The procedures and data sources used to create this map from the Phase I Report on Generalized Land Use must be explained to provide greater clarity. Mapping agricultural land use in 1912 was accomplished by using Salt River Project (SRP) data from irrigation records, specifically

[54] "Amazon Announces Candidate Cities for HQ2", *Amazon.com, Inc.*

when irrigation began on different land parcels.[55] This method was used because irrigation is almost always a necessity for agricultural production in the Salt River Valley.[56] This report used three different categorized data sets to map agricultural land to map an approximation for 1912: 1) lands that were being cultivated in 1910, 2) lands that were being cultivated prior to 1910, but were not being cultivated in 1912, and 3) lands that were not cultivated in 1910, but were being cultivated by about 1925.[57] Urban land use was mapped using United States Geological Survey (USGS) topographic maps from Arizona State University dated from 1906 to 1915, and used a scale of 1:24,000.[58] An urban area was defined as having a regular street grid, and density containing six streets or more in a quarter section.[59] Estimates were made to plot the urban areas of surrounding towns like Alhambra, Glendale and Peoria.[60] Spatial overlaps occurred between agricultural and urban lands, but were manipulated in the final map projections to reflect urban land use, so as to only provide one land use classification for each area.[61] Both agricultural and urban land use were plotted on a map of Maricopa County, while the remaining land was classified as desert land.[62] At this time, no recreational parks had been built.[63]

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[55] 4. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

[56] 4. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

[57] 4. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

[58] 4. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

[59] 4. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

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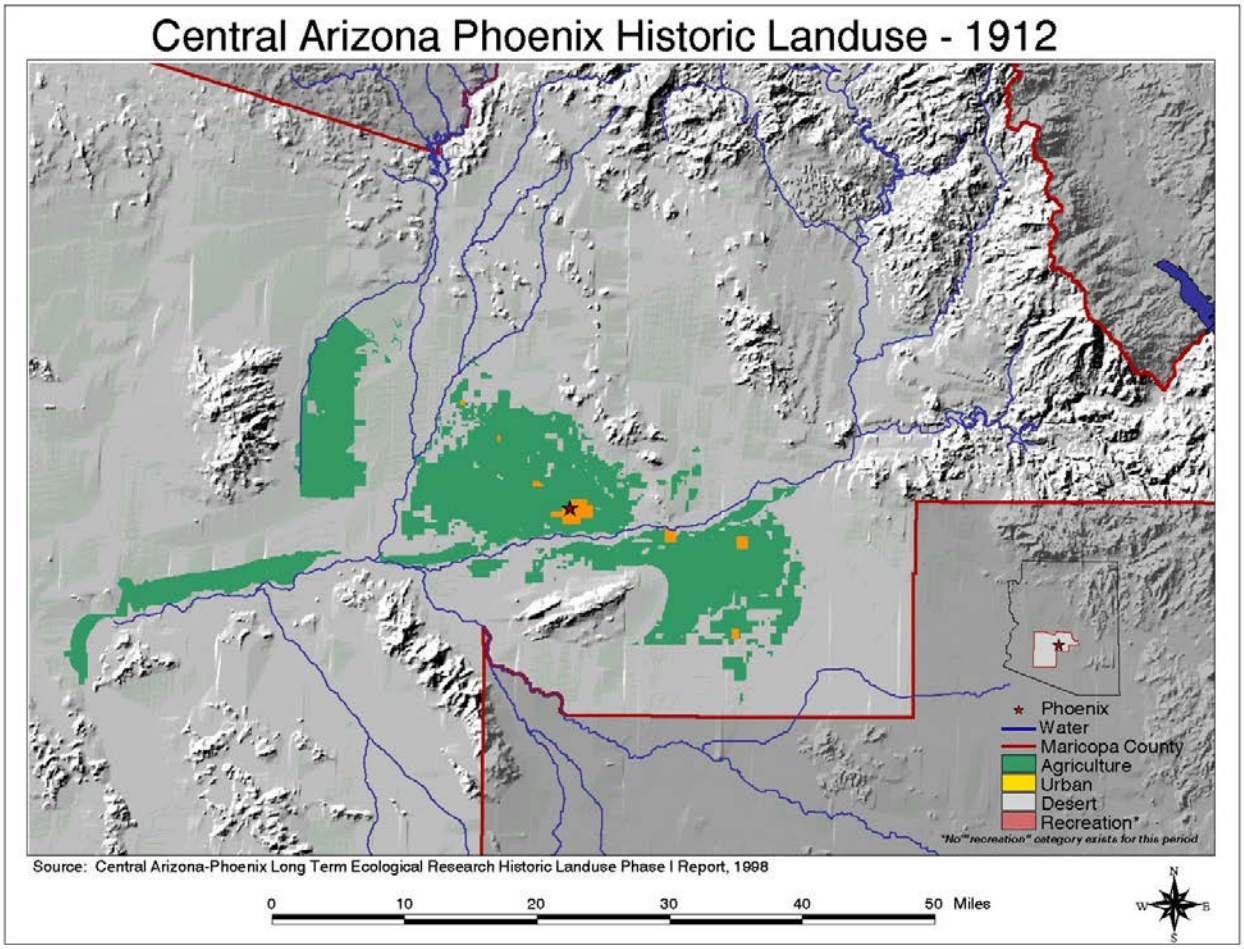
[62] 4. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

[63] 4. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

Figure 1: Central Arizona Phoenix Historic Landuse 1912



[64]

[64] 4. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

The map shows clearly that Phoenix was mainly a farming and ranching community with relatively little urban land use. The remaining land was unsettled desert land not used for human purposes. Proximity to rivers and access to water were obvious needs for the city's early farming communities, as the map reflects. This map also shows the small spread of urbanization throughout the Salt River Valley with small communities to the northwest and the east of Phoenix.

Phoenix's Development and Growth 1920-1945

By 1920, over 29,000 residents lived in the city.[65] Phoenix expanded throughout this decade due to an influx of federal funding projects for bridges, roads, sewer lines and water. [66] Phoenix still faced challenges with water, though. The Great Flood of 1921 inundated land outside of the western downtown area twice in one week, leading to the construction of the Cave Creek Dam in 1922.[67] Phoenix's agricultural sector also faced challenges related to water. Watering crops with surface water caused the groundwater table to rise, which waterlogged the soil.[68] Water pumps were then installed to drain groundwater into the canal system.[69] An auxiliary power generator was added to the Roosevelt Dam to provide electricity to the valley.[70] Water infrastructure continued through this decade with the completion of the Mormon Flat Dam

[65] "City of Phoenix History", *City of Phoenix*

[66] 5. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

[67] 5. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

[68] 5. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

[69] 5. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

[70] 5. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

in 1923, the Horse Mesa Dam and Apache Reservoir in 1924, and the Stewart Mountain Dam in 1930.[71]

The combination of federal investment and private capital led to major increases in the construction industry in Phoenix.[72] The city's downtown skyline began to take shape, while south Phoenix's industrial sector was built.[73] Phoenix's cultural infrastructure was also built in the 1920s, as private funds allowed for the construction of libraries, museums, parks, schools and other buildings for the arts.[74] Travel options were expanded once the Phoenix airport, located near the Salt River, began service in 1927.[75] However, the beginning of the Great Depression in 1929 temporarily slowed the city's construction projects, beginning a period of greater federal investment. [76] Still, Phoenix had experienced considerable population growth between 1920 and 1930, from 29,000 to 48,000 residents.[77]

The Great Depression presented challenges and opportunities to Phoenix during the 1930s. Although the surge in cotton production led to a crash in the 1920s, Phoenix's agriculture sector reverted back to more diversified production in the 1930s.[78] Farmers' decision to sell surplus crops to the government helped keep them in business.[79] Phoenix also changed its

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[71] 5. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

[72] 5. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

[73] 5. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

[74] 5. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

[75] 6. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*

[76] 5. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

[77] "City of Phoenix History", *City of Phoenix*

[78] 5. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

[79] 5. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

marketing strategy to attract newcomers, selling the city's arts scene, fair weather and tourism as its main attractions, as opposed to a rural community.[80] Damming projects for the Salt and Verde Rivers were initially postponed during the Depression, although federal money was used to complete the Verde River's Bartlett Dam in 1939.[81]

Figure 2 shows Phoenix's historical land use from the same Phase I Report on Generalized Land Use as the map from 1912. The map below shows historic land use from 1934. Methods for constructing this map will be explained for clarity. Agricultural land was plotted from irrigation data from areas that were producing in 1912, and those that came into production between 1912 and 1934.[82] Urban land was mapped using aerial photographs with a scale of 1:24,000.[83] The boundaries between agricultural and urban land were delineated where there were agricultural fields adjacent to identifiable street grid patterns.[84] Estimates were made to determine the size of urban land use in surrounding cities like Alhambra, Glendale and Peoria.[85] Overlaps between agricultural and urban land use were converted to urban land use, as is consistent with the 1912 map and data.[86] The only regional park at this time was South Mountain

[80] 5. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

[81] 5. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

[82] 6. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

[83] 6. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

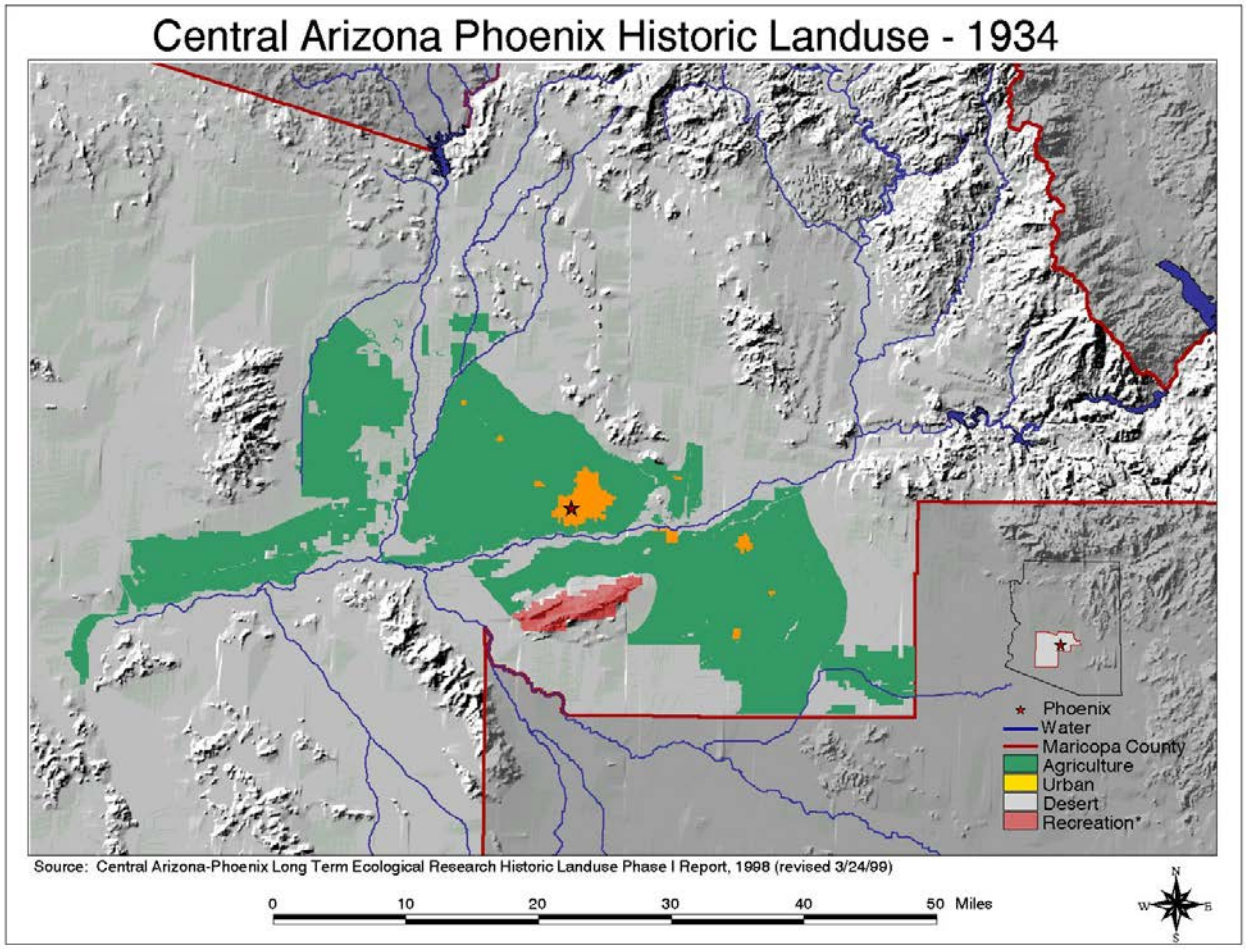
[84] 6. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

[85] 6. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

[86] 6. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

Park, near Phoenix, and the rest of the land was categorized as desert land.[87] This map is categorized within Maricopa County.[88]

Figure 2: Central Arizona Phoenix Historic Landuse 1934



[87] 6. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

[88] 6. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

[89]

While similar to the 1912 Historic Land Use map, the 1934 map reveals the expansion of agricultural land and increasing urban land use in Phoenix. Agricultural land expanded further onto desert land, and surrounded even greater expanses of land near the area's rivers. Phoenix's urbanization can also be viewed, as the city's construction was oriented more towards the northern and eastern parts of the city. Additionally, the pattern of urbanization throughout the Salt River Valley can be seen through the increased urban land use masses to the northwest and east of Phoenix. This map also shows one of the first preservations of land for recreation to the south of Phoenix.

Phoenix's Development Circa World War II

Phoenix experienced growth in the years leading up to World War II, and those that followed. The city used its climate to promote the health benefits of a warm respite from winter.[90] Rebranding the Salt River Valley as the Valley of the Sun, and boasting its status as the Air-Conditioned Capital of the World, Phoenix continued to promote its climate to attract "people of means" to the city.[91] Widespread access to air conditioning was a new draw to promote Phoenix's climate because it would counterbalance the intense summer heat and provide health benefits to residents.[92] Local business leaders like Barry Goldwater fully embraced this type of advertising.[93]

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[89] 6. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

[90] 212. Bradford Luckingham, "The Rise of Phoenix", *The Journal of Arizona History*

[91] 212. Bradford Luckingham, "The Rise of Phoenix", *The Journal of Arizona History*

[92] 212. Bradford Luckingham, "The Rise of Phoenix", *The Journal of Arizona History*

[93] 212. Bradford Luckingham, "The Rise of Phoenix", *The Journal of Arizona History*

Luckingham includes some revealing quotes from Goldwater that illustrate the relationship between prominent businessmen, their interests, the city's economy and the land.

> In 1940, Goldwater declared that "the natural thing to which to turn was the capitalization of our climate, our natural beauties, and the romance of our desert." These "natural resources . . . were subjected to a national advertising program," and the "benefits from it can never be fully estimated." It is "very safe to say that Phoenix would not be in the prominent position which she now occupies, near the top of the per capita spending column of the nation if it were not for the thousands of winter visitors and tourists who call Phoenix their home during a few months of the year." According to Goldwater, "the stimulus from the injection of these tourist dollars into the veins of our economic being have been felt by every person doing business in this area. The farmer has sold more produce. The hotels have filled more rooms. The merchants have sold more goods. It is easy to see, therefore, why businessmen are so unanimously enthusiastic about the continuance and enlargement of a proper advertising program.[94]

The very language used in this passage is indicative of the view that the climate is a resource to be exploited for profit. The word "capitalization" stands out. In Goldwater's view, Phoenix's climate was a good that must be commodified and sold to the masses, and it was. In this context, climate is beneficial because it provides a means for national exposure, which will deliver more income and resources to the city. Goldwater's claim that the gains from the national advertising campaigns cannot be estimated is ironic. One of the challenges in balancing economic and ecological needs is that there are no prices for clean air or access to water. Economic benefits are often quantifiable. Yet Goldwater believed that the exploiting the city's climate for economic gain could not be "fully estimated." It would seem to be more difficult to quantify the ecological impact from the people that came to Phoenix as a result of this advertising program. To even begin such a measure would require a shift in perspective that economic activity can produce adverse ecological effects on a community. Goldwater is only focused on how the city can benefit economically from attracting more people. He even notes the high rate of per capita

[94] 212, 214. Bradford Luckingham, "The Rise of Phoenix", *The Journal of Arizona History*

spending as a measure of the importance of the city's winter tourists. Without the tourists, it is implied that less money would be spent per capita, which would have a negative effect on the city's economy. Due to gains in tourism, more people have purchased more goods and services, and the economy has thrived. The city's businesses want this to continue, so they naturally support Phoenix's continued effort to market itself and attract more people. More people will contribute to more economic activity, which is good because this will produce more wealth and spending in the community. This is an anthropocentric view that neglects to account for the environment in any way, except as a means to accomplish economic goals. The stability of the environment to provide for more people is assumed to be a given. More than anything, this shows the importance of environmental stability to Phoenix's future growth and economic goals. In this passage, Goldwater was implicitly assuming that Phoenix had an adequate supply of water that would be available in perpetuity. Hence, he supports the idea that economic growth and population growth are positive outcomes that should be pursued.

The beginning of World War II led to growth in the city's industrial sector, which attracted more workers and their families to the city.[95] Phoenix even promoted itself as the City of Palms, continuing its self-promotion.[96] Additionally, more people began visiting due to national wartime travel limits that prevented people from foreign travel.[97] In order to better connect both coasts, the federal government invested in Phoenix's infrastructure and built two air force bases that opened in 1941, bringing many servicemen to the city.[98] This led to growth in the aerospace industry in Phoenix.[99] More defense industry investment followed the increase in

[95] "City of Phoenix History", *City of Phoenix*
[96] 214. Bradford Luckingham, "The Rise of Phoenix", *The Journal of Arizona History*
[97] 214. Bradford Luckingham, "The Rise of Phoenix", *The Journal of Arizona History*
[98] 7. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*
[99] 7. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*

military infrastructure.[100] A total of three army bases and six airfields had been constructed around Phoenix by the end of 1942.[101] The combination of defense industry businesses and local armed forces stations produced millions of dollars to the local economy.[102] Phoenix's strategic geographical location and clear skies to prevent air attacks made it an ideal place for the federal government to invest for wartime production.[103] Federal investment in Phoenix during the war produced substantial city growth.[104] However, the city's economy remained largely focused on farming and ranching.[105]

At this time many citizens lived in unincorporated areas of the city, owing to a weaker county government and a historical, frontier preference for greater citizen autonomy and a less powerful government.[106] Land use policies at this time were more laissez-faire.[107] A quote from contractor Del Webb speaks to this fact: "No accurate check has been made to date in the suburban residential areas around the valley, but authorities are convinced the volume of residential construction is at least equal to, and in all probability surpasses, that of the city." [108] Even as Phoenix itself expanded, new residents were coming to the Valley of the Sun and populating the smaller, surrounding towns. This is further evidence of Phoenix's traditions of urban sprawl and population growth. Growth in the outer areas of Phoenix would still benefit the local economy and produce demand for more infrastructure projects to support these new, expanding communities.

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[100] 214. Bradford Luckingham, "The Rise of Phoenix", *The Journal of Arizona History*
[101] 214. Bradford Luckingham, "The Rise of Phoenix", *The Journal of Arizona History*
[102] 214. Bradford Luckingham, "The Rise of Phoenix", *The Journal of Arizona History*
[103] 216. Bradford Luckingham, "The Rise of Phoenix", *The Journal of Arizona History*
[104] 217. Bradford Luckingham, "The Rise of Phoenix", *The Journal of Arizona History*
[105] 5. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*
[106] 5. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*
[107] 5. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*
[108] 214. Bradford Luckingham, "The Rise of Phoenix", *The Journal of Arizona History*

The table below (**Table 1**) provides a statistical visualization for Phoenix's early population growth, as well as the surrounding towns' population growth. This specific table was the third table used in Rex's *Development of Metropolitan Phoenix* research. The table was created to measure specific population levels in Maricopa County in each decade from 1900 to 1998, and to measure the numeric changes in each decade.[109] Population numbers in this table are measured in thousands.[110] For instance, Phoenix's 1900 population in this table would be read as 6,000, while Maricopa County's 1990 population would be read as 2,122,000. The value "NA" means that information was not available for the time period in question, and was not included.[111] This table was created using decennial U.S. Census Bureau counts from 1900 to 1990, as well as estimates from 1998.[112] This table's statistics from 1900 to 1940 are significant when analyzing the history of Phoenix's growth, as well as the greater metropolitan area.

[109] 15. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*
[110] 15. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*
[111] 15. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*
[112] 15. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*

Table 1: Population of Selected Jurisdictions in Maricopa County 1900 to 1998

Year	Urban Area	County	Phoenix	Mesa	Glendale	Scottsdale
1900	NA	20	6	NA	NA	NA
1910	NA	34	11	2	NA	NA
1920	NA	90	29	3	3	NA
1930	NA	151	48	4	4	NA
1940	NA	186	65	7	5	NA
1950	216	332	107	17	8	2
1960	552	664	439	34	16	10
1970	863	971	584	63	36	68
1980	1,409	1,509	790	153	97	89
1990	2,006	2,122	983	288	148	130
1998	NA	2,784	1,198	360	193	195

Year	Tempe	Chandler	Peoria	Gilbert	Rest of County
1900	NA	NA	NA	NA	14
1910	1	NA	NA	NA	20
1920	2	NA	NA	NA	53
1930	3	1	NA	1	90
1940	3	1	NA	1	104
1950	8	4	NA	1	185
1960	25	10	3	2	125
1970	64	14	5	2	135
1980	107	30	12	6	225
1990	142	91	51	29	260
1998	168	160	87	89	334

[113]

As this table shows, the Salt River Valley had a much smaller population at the beginning of the 20th century than it did around the middle of the 20th century. Phoenix's population increased in each decade between 1900 and 1940.[114] This pattern of population growth between 1900 and 1940 also occurred in Glendale, in Mesa, in the rest of Maricopa County's towns and

[113] 15. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*
[114] 15. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*

in Maricopa County as a whole.[115] This table will be referenced later in this thesis to discuss population growth in the latter half of the 20th century.

Conclusion

This section has presented data and statistics that tell the tale of Phoenix's growth from a small settlement into a burgeoning metropolis between 1867 and 1940. This period of time in Phoenix's history laid the foundation for its continued growth in the latter half of the 20th century, into the 21st century. Phoenix was an expanding city with a growing economy and a growing population. Tourists and new residents were interested in coming to Phoenix. Federal funding for projects was available and accessible during this time. Yet the story of Phoenix during this time is focused on growth. The most prominent local leaders say little about the necessity of access to water. Concerns about water scarcity are not articulated. Expansion is the goal, and the land will support it.

[115] 15. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*

Chapter 3

Expansion of Phoenix Post WWII-1980

To gain a better understanding of Phoenix's attitude towards water conservation and consumption, it is important to examine the changes that the city experienced culturally, economically, demographically and politically between World War II and 1980. It is in this postwar period that Phoenix's population begins to increase dramatically, and its economy shifts more towards industry and technology, laying the foundation for it to become the modern city that it is in 2018. Changes to the city and state governments, city expansion, population influxes and a growing economy shaped how the city was developed and planned, and show what ideas and goals were prioritized in this development.

Understanding how and why Phoenix changed during this period is important to contextualizing the issue of water security in the city after World War II. The previous chapter outlined how the culture of growth was first instilled in the consciousness of the city in the first half of the 20th century. This chapter's aim is to demonstrate how this cultural mindset pushed Phoenix towards an even greater period of economic growth and population growth after World War II. The growth mindset must be related to the ways in which water conservation and water consumption were discussed and debated in this time period.

This chapter will relate the growth mindset to public policies and public debates about water conservation, water consumption and population growth by examining Phoenix City Council meetings and ordinances. Using primary source material from Phoenix City Council meetings provides insight into city leadership in this period, as the city government is the public body which makes local water policy decisions.

Economic Growth 1950-1980

Postwar Phoenix retained its industrial labor force, and by 1950 the city had 105,000 residents, marking a population growth of about 75,000 citizens since 1929.[116] At this time, Phoenix's population ranked 99th in the United States, and the city covered 17.1 square miles.[117] Business leaders in Phoenix helped to cultivate the city's postwar attitude for growth, which has persisted through generations to the present day.[118] The introduction of a new city charter in 1948 helped accelerate change when a group of businessmen took control of the charter government.[119] Sponsored and supported by Barry Goldwater and newspaper owner Eugene Pulliam, the Charter Government Committee (CGC) ticket won each election over the next two decades.[120] The members of the CGC were generally white, educated, affluent males who lived in the desirable north side of Phoenix.[121] Phoenix won two All American City awards in the 1950s under this group's leadership, which helped to achieve its goal of promoting Phoenix's positive image.[122] The new government prioritized the city's economic growth and physical expansion, which was manipulated in favor of the members' private benefit.[123] Some Phoenix businesses, like banks, newspapers and utilities companies were controlled by these same prominent businessmen and were operated essentially as monopolies.[124] With little to no competition, and businesses that lent themselves to servicing the local community, private sector leaders were able to consolidate their power and influence the city's preference and outlook for

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[116] "City of Phoenix History", *City of Phoenix*
[117] "City of Phoenix History", *City of Phoenix*
[118] 7. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*
[119] 7. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*
[120] 226-227. Bradford Luckingham, "The Rise of Phoenix", *The Journal of Arizona History*
[121] 227. Bradford Luckingham, "The Rise of Phoenix", *The Journal of Arizona History*
[122] 227. Bradford Luckingham, "The Rise of Phoenix", *The Journal of Arizona History*
[123] 7. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*
[124] 7. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*

growth.[125] At this time, the charter government was essentially making decisions on behalf of the public that also presented its members with opportunities to earn more money.[126] Specifically, those who owned land were in an advantageous business position at this time.[127] Urbanization, economic growth and city expansion allowed large landholders and those who worked with them to profit.[128]

The business class' influence grew in the 1960s and 1970s.[129] A group of about 40 business leaders, known as the Phoenix 40, strengthened their power and normalized the pro-growth mindset that dominates the city's business attitudes presently.[130] The business class' power was aided by the fact that many of the city's residents were young, preoccupied with their own career goals and families, and were unsure that they would live in Phoenix long term.[131] With little history and connection to the city, many residents did not participate in local politics, specifically those debates which revolved around land use or urban growth.[132] The historical mindset of the West and the frontier also played into an expectation or preference from residents for pro-business policies and small government.[133] Phoenix and its business owners gained even more power when the Arizona State Senate changed its apportionment rules for each county to be represented according to its population size in 1966.[134] With more than 50% of the state

[125] 7. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*
[126] 7. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*
[127] 7. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*
[128] 7. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*
[129] 7. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*
[130] 7. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*
[131] 7. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*
[132] 7. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*
[133] 8. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*
[134] 8. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*

population, Maricopa County gained significantly more seats, and thus increased Phoenix's political capital in state affairs.[135]

The economic changes that Phoenix has experienced since the 1960s have been similar to those experienced by the rest of the United States.[136] The services sector has increased its share of production, while manufacturing's share has decreased.[137] Some of the largest gains in sectoral output have come from "health services, business services, and engineering, accounting, research and management services." [138] However, the economic impact of the Arizona state government and Phoenix's local government have declined below the national average.[139] Additionally, the sectoral share of farming in Phoenix has also declined below the national average.[140] Manufacturing has also generally fallen below the national average for the number of workers employed and average wages earned.[141] The economic areas related to urban planning, such as construction, finance, insurance and real estate, constitute sectoral outputs that are larger than the national average, which is also indicative of Phoenix's pro-growth mentality.[142]

Population Growth and Urbanization 1950-1980

Since 1950, Phoenix's population continued to grow. A large number of former armed servicemen relocated back to Phoenix after World War II.[143] Additionally, many young adults and families have historically moved to the city and contributed to its steady population

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[135] 8. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*
[136] 13. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*
[137] 13. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*
[138] 13. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*
[139] 13. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*
[140] 13. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*
[141] 13. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*
[142] 13. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*
[143] 8. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*

growth.[144] Phoenix has been able to attract in-migrants since World War II owing to the city's warm climate and favorable business policies, which have encouraged employers to expand and relocate to Phoenix, thus improving the job market for workers.[145] Many in-migrants have traditionally been young working adults.[146]

Increases in the city's land area and population growth have coincided with the process of urbanization.[147] Urbanization since the 1950s was targeted within the city as well as outside on the land surrounding it.[148] The proportion of Maricopa County's population that lived in Phoenix in 1950 more than doubled by 1960, from 32% to 66%.[149] In this time period, Phoenix's population quadrupled to 439,000 people, and land area increased from 17 square miles to 190.[150] The construction of tract housing neighborhoods began at this time in order to compensate for the population boom and city growth.[151] Some other urban development projects that continued to urbanize the city were completed in the 1950s: the first high rise built outside the downtown area was finished in 1955, and Phoenix's first shopping mall opened in 1957.[152] Phoenix's main business district shifted north of downtown, while the downtown area itself became a hub for financial, government and legal buildings.[153] Northeast Phoenix became a popular location for resorts and shopping centers in the early 1960s, while northwest Phoenix was developed for many affordable residential housing communities.[154] Planned communities

[144] 12. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*
[145] 8. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*
[146] 8. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*
[147] 9. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*
[148] 9. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*
[149] 9. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*
[150] 9. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*
[151] 9. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*
[152] 9. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*
[153] 9. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*
[154] 9. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*

like Maryvale, Sun City and Youngtown were each built in the northwest of the city in the 1950s.[155] Generally, many new housing development projects in the 1950s and 1960s followed the construction of infrastructure projects like highways or sewers.[156] For instance, southeastern Phoenix expanded more in the 1960s once the I-10 freeway construction was completed and connected to the I-17 freeway.[157] Despite the pattern of rapid growth and urbanization, south Phoenix and southwest Phoenix did not experience this same rate of development, owing to the levels of poverty present in these sections.[158]

Phoenix's economic growth since the 1950s has also influenced its population growth. Increases in the manufacturing of aircraft, electronics and industrial machinery occurred, while the agricultural sector saw decreases in production.[159] Overall, Phoenix's economy shifted towards more urban production than rural production in the 1960s.[160] This change in sectoral production helped to make Phoenix's economy more similar to the national average industrial mix.[161] Phoenix came to be viewed favorably by businesses and industries because of its climate, its position between military markets in California and New Mexico, and its air flights to the Midwest.[162] After the federally funded Fort Huachuca was built in southeastern Arizona, this base became the testing center for new electronic equipment, which allowed for growth in Phoenix's electronic sector.[163] By 1970, the biggest industrial companies were located diagonally from the northwest of the city to southeast of downtown Phoenix, with some located

[155] 9. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*
[156] 9. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*
[157] 10. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*
[158] 10. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*
[159] 8. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*
[160] 8. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*
[161] 8. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*
[162] 8. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*
[163] 9. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*

further outside the city in the valley.[164] Many office buildings were situated in downtown Phoenix, while major shopping centers were located in the eastern part of the city.[165] The state capitol in west Phoenix and Arizona State University in nearby Tempe were also large employers for the city and crucial to the city's economy.[166]

The city's population has been able to grow because it has been able to continually attract a workforce, which has provided an incentive for employers to relocate to Phoenix.[167] However, many of the in-migrants that move to Phoenix tend to be young workers who typically live in the city for a few years before pursuing other career opportunities or starting a family.[168] With little connection to the city, this typically means that new migrants participate very little in their community's affairs and that there are few residents that have lived in Phoenix for many years.[169] This number of young migrants has also played a role in shaping the type of housing that has been built in Phoenix. Young workers in Phoenix typically earn below the median average income, which has created demand for less expensive single family housing.[170] Recently, more Baby Boomers have moved to Phoenix, and with more money, they have created a demand for larger, more expensive single family properties, which have worked to reduce the supply of smaller single family houses, which would seem to contribute to younger workers typically moving out of the city.[171]

However, Phoenix's population growth did not occur without its own challenges. Some public services were improved and kept pace with the needs of the growing population, while

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[164] 9. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*
[165] 9. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*
[166] 9. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*
[167] 12. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*
[168] 12. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*
[169] 12. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*
[170] 12. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*
[171] 12. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*

other areas of concern were not addressed.[172] For all the growth and promotion, Phoenix still had to deal with common urban challenges:

> Traffic jams, high pollution levels, housing shortages, overcrowded schools, ugly commercial strips, soaring crime rates, and a host of other detriments, including unethical business practices, intruded upon the "good life." There were few social-welfare programs for the minority poor, and critics often expressed their disappointment that Phoenix leaders and their followers did not possess a greater social conscience. [173]

This passage is revealing, as it speaks to the number of other problems associated with population growth that the city's elite leadership did not address. First, it would seem that although the city was expanding and becoming more urban, some still struggled to find housing. This is surprising given the importance of the construction industry to Phoenix's economy today, which will be discussed further in the next chapter. Urban pollution seems to be a given with a large and expanding population, especially during the time period when Phoenix was expanding. Environmental regulations were generally more lax at this period of American history, even though environmentalism was slowly entering the public consciousness. The issues of traffic and overcrowded schools also seem logical given a rapidly expanding population. As a newer urban center compared to other American cities, Phoenix most likely did not have the infrastructure available to accommodate its booming period of population growth, whether it be the highway system, public transit system or public school system. The increase in crime rates could be tied to the lack of social welfare programs, and the general preference to expand and develop away from the poorer, mainly minority south side. In their own way, these problems each point to oversights by Phoenix's city leadership, whose goals were economic growth and physical expansion. Citizens faced major problems to their quality of life as a result of this growth-oriented

[172] 227-228. Bradford Luckingham, "The Rise of Phoenix", *The Journal of Arizona History*
[173] 228. Bradford Luckingham, "The Rise of Phoenix", *The Journal of Arizona History*

leadership. So, yes, more jobs and more people were coming to Phoenix, but clearly there were some basic needs that were not addressed in favor of promoting the economy and attracting new residents. Still, Phoenix's problems never slowed its population growth, as its growth rate increased 311% in the 1950s, the highest in the United States.[174]

The annual average increase of the Phoenix metro population has risen in each decade since the 1960s when it was 30,000.[175] In the 1970s, it reached 55,000, only to increase to 65,000 in the 1980s followed by about 80,000 in the 1990s.[176] About 70% of these annual average increases in population can be attributed to net in-migration.[177] Table 1 is useful to refer to as a way to visualize and understand population growth after World War II until 1980.

Population growth from 1900 to 1940 was more modest in comparison to the growth from 1940 to 1980. Phoenix added 42,000 people between 1940 and 1950, and then another 332,000 from 1950 to 1960.[178] Although population growth slowed from 1960 to 1970, 145,000 people were still added to the city's population.[179] Growth increased again between 1970 and 1980, when 206,000 people increased Phoenix's population to 790,000 by 1980.[180] The other surrounding towns generally experienced population growth during this period, though not at the same rate that Phoenix did.[181] These population figures are indicative of the trends described in the passages prior to this section.

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[174] 228. Bradford Luckingham, "The Rise of Phoenix", *The Journal of Arizona History*
[175] 14. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*
[176] 14. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*
[177] 14. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*
[178] 15. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*
[179] 15. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*
[180] 15. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*
[181] 15. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*

Land Use Patterns in 1955 and 1975

Examining Phoenix's economic growth and population growth provides the context to understand the city's land use plans. Phoenix's rapid urbanization took place in the 1950s when America's economy was booming, and millions of people were getting married, having children, buying cars and buying homes outside of cities. There was a preference to own automobiles and drive them, and to own larger homes. Keeping this history in mind, it makes sense that Phoenix's physical development produced lots of low density housing that ultimately changed a large portion of the land.[182] From the mid-1930s until 1955, about 83% of land development occurred on farmland.[183] Still, about 50% of Maricopa County's land was used for farming in the 1950s even Phoenix and its surrounding towns expanded, though the majority of it was used for animal grazing.[184] Yet even from 1955 to 1975, about 40% of development continued to take place on farmland, while the rest spread further out to desert land or unused land.[185] Despite urbanization, the percentage of land used for farming was actually higher in 1975 than it was in 1934.[186] These patterns of land use paint a picture of unchecked, methodical land development increasingly encroaching onto outer land for the benefit of human settlement.

The policy of annexation was another factor in Phoenix's expansion during the postwar period. Annexation was one way for the city to secure its future ability to expand.[187] With outer towns developing, it was necessary for Phoenix to annex them and incorporate them into the city before these towns could become independent communities that could prevent Phoenix's

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[182] 10. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*
[183] 10. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*
[184] 10. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*
[185] 10. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*
[186] 10. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*
[187] 224. Bradford Luckingham, "The Rise of Phoenix", *The Journal of Arizona History*

outward expansion.[188] In the 1950s, annexation allowed Phoenix to grow 11 times larger in physical size, and four times larger in population size.[189] Due to this expansion, Phoenix expanded its tax base and was able to retain constant tax rates in the 1950s.[190]

Below is another map (**Figure** 3) from the Phase I Generalized Report on Land Use that covers some of the years following World War II. The same agricultural irrigation data from SRVWUA was used for this map projection.[191] Areas in production in 1934, and between 1934 and 1955 were plotted.[192] Urban areas were identified as areas with a regular street grid and six or more streets in a quarter section.[193] This projection was mapped using 1:24,000 scale topographic maps from Arizona State's Noble Map Library.[194] To map the northwestern urban areas, maps were used from the Glendale Historical Society.[195] The 1958 City of Phoenix Generalized Existing Landuse map was used to plot Phoenix's central urban area.[196] Overlaps between agricultural and urban land were categorized as urban, just as in previous maps from this collection.[197] Regional parks were included using the MAG Existing Land Use spatial dataset from 1995.[198]

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[188] 224. Bradford Luckingham, "The Rise of Phoenix", *The Journal of Arizona History*

[189] 226. Bradford Luckingham, "The Rise of Phoenix", *The Journal of Arizona History*

[190] 226. Bradford Luckingham, "The Rise of Phoenix", *The Journal of Arizona History*

[191] 9. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

[192] 9. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

[193] 9. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

[194] 9. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

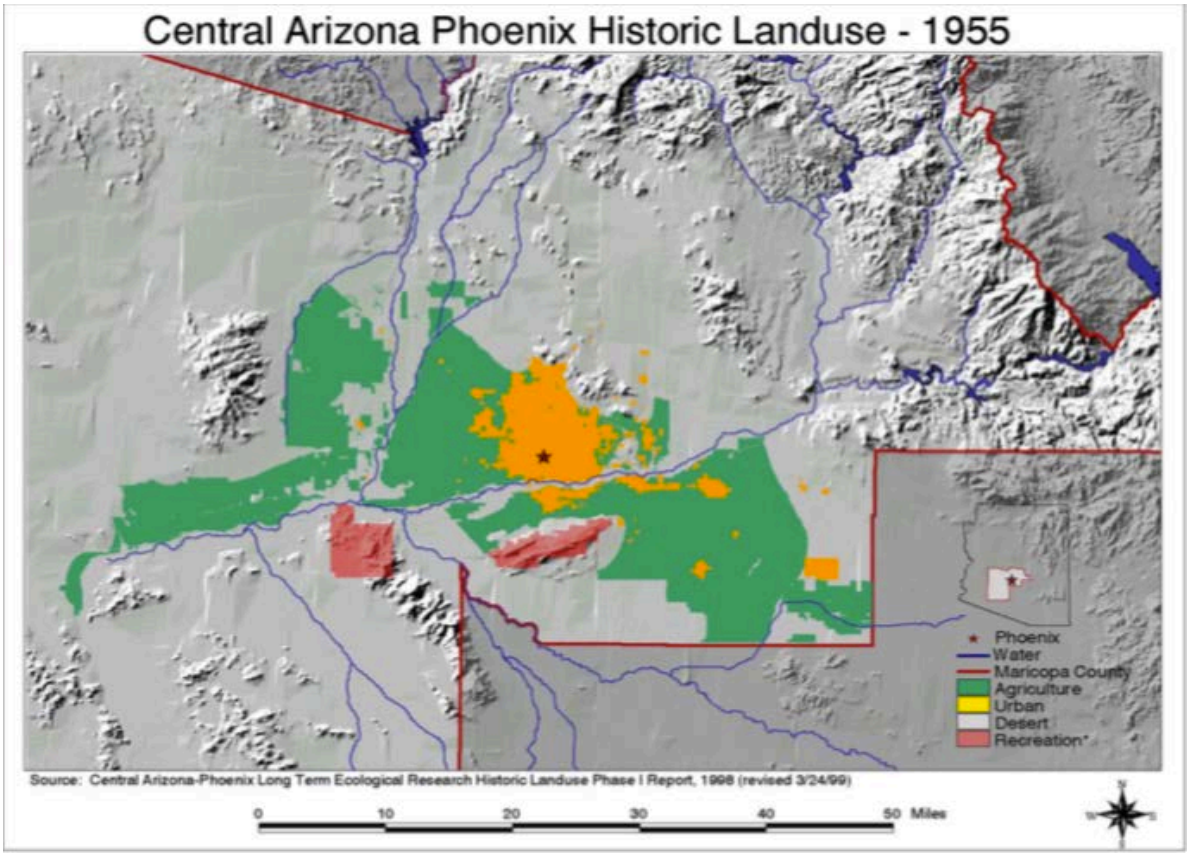
[195] 9. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

[196] 9. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

[197] 9. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

[198] 9. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

Figure 3: Central Arizona Phoenix Historic Landuse 1955



[199]

While the agricultural land in this projection appears identical to the 1934 projection, the amount of urban land increased significantly over this 21-year period. This speaks to the level of urban sprawl in Phoenix, and the Valley of the Sun as a whole. Urban expansion increased to the northwest of Phoenix, and south of the Salt River.[200] While the majority of land that was developed was former agricultural land, a larger share of developed land was formerly desert

[199] 8. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

[200] 8. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

land, around one-sixth.[201] More of the land settled to the north and northeast was on higher terrain without access to irrigation water, which speaks to the city's shift away from its agricultural roots.[202] Estrella Mountain Park was established to the west of Phoenix.[203]

Another land use map from the Phase I Generalized Report on Land Use from 1975 is pictured below to illustrate the extent of urban sprawl in Phoenix and throughout the Valley of the Sun. The report notes that urbanization during this period was dictated more by economics and less by urban planning.[204] Phoenix and its surrounding cities each expanded further into desert land, which was less expensive per acre.[205] Land developers controlled expansion at this time, promoting low-density housing guided by the city's principles of growth and "the good life." [206] The following quote further illustrates these sentiments, and the preference against long term urban planning and regulation.

> As in other cities of the Southwest, promoters and most residents agreed that it was the best direction to follow, the most desirable form and style of life available. Many new comers to the sprawling sunshine city had moved from decaying, high-density, heavy-industry, massive-problem areas, and they welcomed the change, seeing Phoenix as a better place than the one they left.[207]

Developers and residents wanted greater self-determination and independence as it pertained to land use. Businesses and residents did not want Phoenix to become a thoroughly planned, densely populated city. This was the type of city that many had left. Phoenix's laissez-faire

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[201] 8. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

[202] 8. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

[203] 8. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

[204] 9. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

[205] 229. Bradford Luckingham, "The Rise of Phoenix", *The Journal of Arizona History*

[206] 229. Bradford Luckingham, "The Rise of Phoenix", *The Journal of Arizona History*

[207] 229-230. Bradford Luckingham, "The Rise of Phoenix", *The Journal of Arizona History*

attitude towards city expansion and land use was what people desired, but did not experience in their former communities. New residents wanted to experience this relaxed style of urban planning, while they enjoyed the benefits of more space and single-family housing. These ideas about land use were part of the city's consciousness and identity.

The map below (**Figure 4**) is indicative of the city's land use policy and values. Over 75% of Phoenix's population lived in urban areas by 1960.[208] The Phase I Generalized Report notes that urban expansion led to a decrease in agricultural land.[209] This is also reflected in the city's job placement, as more people worked in urban settings like downtown Phoenix.[210] The map shows the increase in urban land use on the edges of the city, as this is where 60% of urban development occurred during the period between 1955 and 1975.[211] Population growth statistics from the surrounding cities correlate with the expansion of urban land use. Between 1940 and 1970, the cities of Chandler, Glendale, Mesa, Scottsdale and Tempe each increased in population.[212] Although urban expansion occurred on agricultural land, the boundaries of agricultural land actually expanded, and more land came under cultivation in this period than in any previous time recorded in the Generalized Land Use Report.[213] Another important aspect noted is the pattern of leapfrogging previous urban developments.[214] More settlements went

[208] 9. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

[209] 9. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

[210] 9. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

[211] 10. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

[212] 229. Bradford Luckingham, "The Rise of Phoenix", *The Journal of Arizona History*

[213] 10. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

[214] 10. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

farther past the extent of urban boundaries, beyond agricultural lands.[215] This pattern may have emerged due to the real estate industry's land speculations for future development.[216] Maricopa County's parks system also began preserving more land for public use.[217]

To create this map, one dataset was used from the 1974 Land Use Land Cover data compiled by the USGS Geographic Information Retrieval Analysis System.[218] The map used a 1:250,000 scale.[219] Regional parks data from the 1995 MAG Existing Land Use spatial data set was used to map the parks.[220] The Maricopa County Parks and Recreation Department provided estimates for the established dates.[221] To provide each land area with one classification, the area of the parks was subtracted from the 1974 data set mentioned above.

[215] 10. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

[216] 10-11. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

[217] 11. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

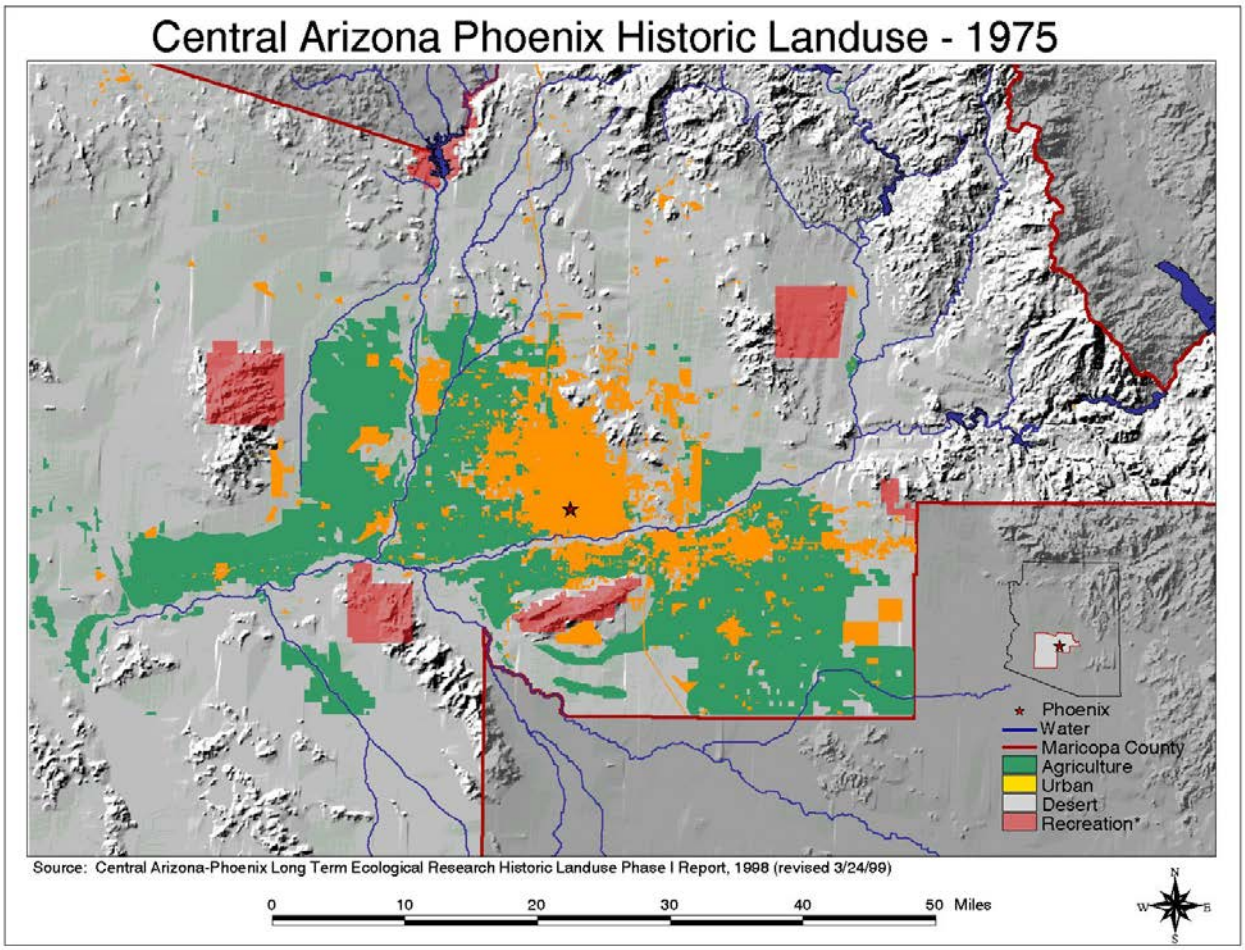
[218] 11. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

[219] 11. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

[220] 11. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

[221] 11. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

Figure 4: Central Arizona Phoenix Historic Landuse 1975



[222]

This map shows the grand scale on which urban sprawl occurred during Phoenix's boom years. The urban areas are significantly larger than in the previous maps shown. The pattern of leapfrogging is also clearly visible outside the large urban area in the center. Leapfrogging occurred in almost every direction across the valley. Some communities are located in remote tracts of desert land. Agricultural expansion also took place across the southern regions of the

[222] 10. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

valley. Even agricultural leapfrogging occurred with some standalone agricultural land visible to the north and west.

Ideas about Water and City Council Actions 1950-1980

The previous sections in this chapter outlined important changes in postwar Phoenix. The economy thrived, the population increased, more in-migrants came to the city and the city itself expanded. These changes are important to understand within the context of Phoenix's water policies and the ways in which water has been regarded throughout Phoenix's history. What these historical events show is that from 1950 to 1980 Phoenix was most concerned with its economic growth and attracting more residents and businesses. However, some water policy actions were taken. The SRVWUA came to be known as the Salt River Project (SRP), and expanded the city's water access to water through the construction of seven dams and a number of reservoirs.[223] These water projects also created hydroelectric power for the entire valley.[224] The city finally paid off the remaining balance of its debt for the construction of the Roosevelt Dam in 1955.[225] Urbanization had the effect of reducing the amount of water used, as it required less water than agriculture.[226]

On the whole, these actions only point to the city's desire for economic growth, which requires a growing population. Expanding the water supply is not the same thing as implementing strict water conservation policies. The urban expansion onto agricultural land was meant for building new residences and places of business, both of which require an influx of

[223] 220. Bradford Luckingham, "The Rise of Phoenix", *The Journal of Arizona History*
[224] 220. Bradford Luckingham, "The Rise of Phoenix", *The Journal of Arizona History*
[225] 220. Bradford Luckingham, "The Rise of Phoenix", *The Journal of Arizona History*
[226] 220. Bradford Luckingham, "The Rise of Phoenix", *The Journal of Arizona History*

more people. Even though there may have been more access to water and a reduction in water usage from agriculture, these actions still indicate an increasing rate of water consumption. Phoenix's policy of annexation also relates to these choices. Annexation automatically increased the number of people who required water services. The expanded tax base created by annexation and the constant tax rates in the 1950s would seem to incentivize residents to move to Phoenix.

Thousands of public records regarding some aspect of water policy can be found on the Phoenix city government website by navigating to the City Clerk section and performing a public records search. Per the Public Records Search page, these records can include the following document types: "City Council meeting results and minutes, agendas, reports, ordinances, resolutions, contracts, elections information including campaign finance reports and documents for political committee registrations and organizations making independent expenditures." [227] This thesis will analyze some of these documents of public record to synthesize the Phoenix city government's water policy actions with the economic growth and population growth that occurred between 1950 and 1980. These public records are used in this thesis because water policy is shaped by local government. Therefore, it is fitting to use these records to gain a deeper understanding of the actions taken by those who legislate water policy in Phoenix. The city government ultimately bears the responsibility for providing adequate access to water to its citizens.

Some public records are useful to illustrate how issues of water conservation and consumption have been addressed, while others relate more to the daily operation and maintenance of the city. For instance, there are many records that approve water main maintenance. While this is a vital part of city water maintenance, records like this will not be the

[227] Phoenix, Arizona City Government, "Public Records Search", *City Clerk*

focus of this section. Instead, records that provide greater insight into the relationships between economic growth, population growth and water policy will be discussed. For this chapter and this time period, the most pertinent public records included range in date from 1977 to 1980. There are certainly more public records related to water policy than those included in this chapter, and more could have been included. The public records chosen for this chapter and for the purposes of this thesis are meant to provide greater insight into the attitudes about water conservation policy, as well as the strategies deemed most effective for such policies.

City Council Report March 30, 1977

One of the more revealing public records between 1950 and 1980 is a City Council Report from March 30, 1977 written by Art F. Vondrick, Water & Sewers Director, sent to Marvin A. Andrews, City Manager, and titled *Water Conservation Measures*.[228] At its outset, the report recommends promoting voluntary water conservation methods, while mandatory water conservation policies are suspended until further research can be completed.[229] The report was made within the context of a potential water shortage in the near future, given "the lack of new gate water credits" and "President Carter's announced decision not to fund the Central Arizona Project [CAP]." [230] CAP is a federally funded project that provides water to Central Arizona. It was noted in the Discussion section of this report that the business side of water conservation could create a situation in which people use less water, but ultimately see their water bills rise in cost because the water providers need to increase their rates to counteract the reduction in water

[228] 1. Art F. Vondrick, "March 30, 1977", *City Clerk*
[229] 1. Art F. Vondrick, "March 30, 1977", *City Clerk*
[230] 1. Art F. Vondrick, "March 30, 1977", *City Clerk*

usage.[231] A similar situation previously occurred with power companies when customers were persuaded to reduce their energy usage.[232] Immediately, this speaks to a clash between business and economics, and water consumption. Water is a public resource that all people are supposed to be able to access. In an effort to reduce water consumption, citizens could agree to consume less water, but would ultimately pay more because of it. The goal of the water providers is to make a profit by providing citizens with water. In this situation, rising costs are a reaction to ensure the financial success of the water providers that simultaneously charges citizens more for consuming less water. This is a byproduct of water conservation, not an intentional financial punishment. This situation demands questioning. Is the financial success of water providers more important than access to water for the public? Could water providers receive supplemental revenue from another source so that citizens would not pay more for consuming less water? For instance, raising taxes on some other good or service could produce the funding to make sure water providers are still financially successful in proportion to water conservation efforts.

The report goes on to say that collaboration with the SRP could provide access to newly drilled wells, and that a winter water storage system could be constructed, while the city awaits new water credits.[233] Here, it is clear that the city wants to expand its water resources, while it implements some water conservation methods. It is then written that water restrictions won't be necessary for two years, until the summer of 1979, and that more long-term issues of water availability will be dependent on funding for the Central Arizona Project.[234] What this passage indicates is more of a "wait and see" approach to managing water resources. Rather than view an

[231] 1. Art F. Vondrick, "March 30, 1977", *City Clerk*
[232] 1. Art F. Vondrick, "March 30, 1977", *City Clerk*
[233] 2. Art F. Vondrick, "March 30, 1977", *City Clerk*
[234] 2. Art F. Vondrick, "March 30, 1977", *City Clerk*

impending water shortage as a crisis to be dealt with immediately, or call for a strategic, long term water conservation policy, the report reassures the city government that action does not necessarily need to be taken for two years, and even then, funding for CAP may not require any further action. This passage shows some contradictory attitudes towards water conservation. Yes, there are some methods that can be implemented to reduce water consumption which are outlined, but since there will not be a severe shortage for another two years, the report gives the impression that stricter conservation measures are not needed in this moment. The tone of the report does not contain a sense of urgency about diminishing water resources because of the possibility of receiving new water resources. Based on the tone, it seems that the chance of receiving new sources of water alters the mentality of the city government. Water conservation becomes viewed as a stricter policy that the city can afford to implement later as a drastic measure since the issue is not as pressing at the moment that this report is written. This is symbolic of a more short-term mentality towards water conservation.

Two methods are then described to save water in the summer: restricting lawn watering by odd or even calendar day and odd or even house number between 4:00 pm and 9:00 pm from May through October, and by installing recirculation pumps on evaporative coolers.[235] It is revealing that the next section of this report, *Water Conservation Measures Put into Perspective*, outlines the difficulty in creating feasible policies. A number of water conservation methods do not save a significant amount of water, either in the volume of water saved or in the amount of money saved by the customer.[236] Methods that fit this description are more part of a public relations campaign to instill water conservation habits into the public's daily consciousness.[237]

[235] 2. Art F. Vondrick, "March 30, 1977", *City Clerk*
[236] 2. Art F. Vondrick, "March 30, 1977", *City Clerk*
[237] 2. Art F. Vondrick, "March 30, 1977", *City Clerk*

For instance, the report asserts that installing a plastic bottle of water into a flush tank could save between one quart and half a gallon of water per flush, possibly three or four gallons per day, but this would only save a customer $0.50 per year.[238] The report claims that the same problem arises with people using low flow shower heads in the shower instead of bathing.[239] Only a shower timer that limited shower times would be able to accomplish the goal of reducing water consumption.[240] Effectiveness is dependent on how long someone actually showers.[241] In addition, the Plumbing Manufacturers Institute warned of the danger of mass installation of water saving devices that could reduce the volume of water, thereby clogging sewers.[242] This report notes that water saving devices are more expensive, which could raise housing prices.[243] The report also doubts the effectiveness of installing such devices to combat a water shortage, while noting the impossibility of regulating people's water usage inside buildings.[244] Implementing these types of conservation methods would be best served in easing the transition towards stricter forms of water conservation.[245] The report recommends that voluntary measures should be viewed as "a desirable means of preventing the waste or overuse of water", and that "a public information program is merited." [246] A list of voluntary measures and mandatory ordinances are provided, which are broken down into four categories: desirable methods, precautionary methods, emergency methods and background or reference information.[247]

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[238] 2. Art F. Vondrick, "March 30, 1977", *City Clerk*
[239] 2. Art F. Vondrick, "March 30, 1977", *City Clerk*
[240] 2. Art F. Vondrick, "March 30, 1977", *City Clerk*
[241] 2. Art F. Vondrick, "March 30, 1977", *City Clerk*
[242] 2. Art F. Vondrick, "March 30, 1977", *City Clerk*
[243] 2. Art F. Vondrick, "March 30, 1977", *City Clerk*
[244] 2. Art F. Vondrick, "March 30, 1977", *City Clerk*
[245] 2. Art F. Vondrick, "March 30, 1977", *City Clerk*
[246] 3. Art F. Vondrick, "March 30, 1977", *City Clerk*
[247] 3. Art F. Vondrick, "March 30, 1977", *City Clerk*

Attached to this same 1977 report, and following the list of recommend policies, is a correspondence from Vondrick to Bob Brunton, Development Services Manager, dated July 13, 1977 and titled *Local Trends in Water Consumption- For Information Purposes*. In this correspondence, Vondrick writes of a problem in California between water conservation and rising water bills.[248] He also attaches water consumption data from various water system service areas of Phoenix compiled between 1974 and 1977.[249] According to the correspondence, there was an 8.8% decrease in water use from 1974, which he writes comes from a 12.5% decrease in residential consumption.[250] Vondrick praises the work of public water conservation education, which has inspired greater voluntary participation in conserving water.[251] However, he notes the potential public backlash if significant rate increases are imposed as a result of widespread water consumption.[252] This highlights the importance of making water conservation policies that are equitable for consumers and prioritize the goal of consuming less water, rather than trying to make the financial side of conservation work for the water providers. Vondrick believes that a 20% to 25% reduction in water use could be achieved via participation in an intensive water conservation program.[253]

The water consumption data included following this correspondence show monthly water consumption measured in 100's of cubic feet by commercial, governmental, industrial and residential sectors, which are broken down further into areas inside the city, outside the city, in Paradise Valley and in Scottsdale.[254] True to the correspondence, residential water consumption

[248] 9. Art F. Vondrick, "March 30, 1977", *City Clerk*
[249] 9. Art F. Vondrick, "March 30, 1977", *City Clerk*
[250] 9. Art F. Vondrick, "March 30, 1977", *City Clerk*
[251] 9. Art F. Vondrick, "March 30, 1977", *City Clerk*
[252] 9. Art F. Vondrick, "March 30, 1977", *City Clerk*
[253] 9. Art F. Vondrick, "March 30, 1977", *City Clerk*
[254] 10. Art F. Vondrick, "March 30, 1977", *City Clerk*

can be seen to decrease in the tables provided.[255] However, while there are decreases in residential water consumption in all four geographic areas, there are differences in consumption patterns for the commercial, industrial and governmental sectors. In direct contrast to residential water consumption reductions, the data provided in this correspondence actually shows that commercial activity's water consumption increased between 1974 and 1977. [256] Governmental and industrial water consumption fluctuated in this period, but also generally increased.[257] While residential reductions in water consumption show progress in the way of water conservation, the other sectors' overall trend of increases are revealing. Water consumption is not only about people using less water in their homes. It is a much more encompassing issue that is interconnected with all forms of human activity. It seems reasonable to think that if Phoenix and the greater Phoenix metropolitan area contained fewer people, there would also be less economic and governmental activity draining the area's water resources, all things being equal. However, it is also possible that a smaller population could have the same effect if per capita water usage was higher.

Vondrick then includes a report from the Arizona Water Commission sent to Governor Raul H. Castro, titled *Water Conservation in Arizona* and dated June 1977.[258] First, the Water Commission's report cites the importance of conservation to manage the state's water resources, as well as the challenge of water conservation that will exist in perpetuity given the state's climate.[259] The report states, "Essentially all water originating in Arizona or entering the State is consumed in the activities of man or evaporates or transpires from natural areas. This is

[255] 10. Art F. Vondrick, "March 30, 1977", *City Clerk*
[256] 10. Art F. Vondrick, "March 30, 1977", *City Clerk*
[257] 10. Art F. Vondrick, "March 30, 1977", *City Clerk*
[258] 12. Art F. Vondrick, "March 30, 1977", *City Clerk*
[259] 13. Art F. Vondrick, "March 30, 1977", *City Clerk*

evidenced by the fact that essentially no water flows out of Arizona except that obligated to Mexico." [260] The problem could not be stated any more clearly: human activity is the driving force behind the reduction in the water supply if the water doesn't evaporate or transpire. It stands to reason then that fewer people would use less water, and thus it would be easier to manage such a finite supply of water.

One of the more fascinating facts and quotes is given as this report works through the statistics of water consumption in Arizona: "In 1970, the total depletion by urban users was less than 7 percent of the statewide total. Agricultural depletions represented 89 percent, mining 3 percent and steam-electric power and fish and wildlife uses… a little over 1 percent." [261] As a statewide report, these figures do not necessarily represent Phoenix's exact water consumption data. However, given the state's desert climate and the large agricultural presence in Phoenix, these figures should be taken into account when contextualizing the challenge of water conservation. If 89% of Arizona's water in 1977 was consumed in agricultural production, then it would seem that Arizona's farmers represent the biggest challenge to reducing water consumption. This figure of water consumption brings up questions. To begin, why are there are farmers in Arizona if the state is largely desert? Desert, by definition, indicates a lack of water. Therefore, why does it make sense for there to be farmers who are draining the available water resources? Given that humans have not been hunters and gatherers in the 20th and 21st centuries, and given that food has almost entirely been produced via agriculture for centuries, then why would it make sense for millions of people to live in a state that is largely desert, where water is scarce and where agriculture itself threatens water supplies? If agriculture is meant to provide

[260] 13. Art F. Vondrick, "March 30, 1977", *City Clerk*
[261] 14. Art F. Vondrick, "March 30, 1977", *City Clerk*

sustenance, but simultaneously threatens human existence by using the vast majority of water supplies, then why should agricultural production be allowed to continue? In questioning the viability of agricultural production, it would seem that Arizona is not an ideal place for people to live en masse. If producing food in a place is such a threat to water availability, then food probably shouldn't be produced there, and people probably shouldn't be living in such a place. To eliminate the agricultural sector would force Arizona's farmers to leave their homes, and would then require food to be produced and transported from farther away, which would raise the price of food for all in Arizona. Reducing the number of farmers would probably help water conservation efforts, but this would also create a negative impact on Arizona's economy due to the loss of production. This report writes that Arizona's farmers are actually efficient in reducing water consumption, although some improvements could be made.[262] Despite the farmers' efficient use of water, their activity still accounted for 89% of water consumption in 1977. Perhaps if there were fewer people in Arizona who demanded food, or fewer customers out of state, the farmers would not have to produce as much food, and they could then use less water. Agriculture would probably remain the most significant water consumer, but with less people to feed, perhaps less water would be consumed on the whole. The report includes a number of findings and recommendations for improving water conservation, many of which relate to public education, price sensitivity, agricultural management and amending laws.[263]

City Council Report April 1, 1977

[262] 14. Art F. Vondrick, "March 30, 1977", *City Clerk*
[263] 15-20. Art F. Vondrick, "March 30, 1977", *City Clerk*

One City Council report from a Councilman Gutierrez recommended a sliding scale for water rates given the city's efforts to promote water conservation.[264] The report was sent to the Mayor and City Council with the title *Water Rates No. 9 On the Policy Session Agenda for April 4, 1977*, and dated April 1, 1977.[265] To try and work around the issue of raising water rates when citizens consumed less water, a sliding scale approach to water costs was recommended.[266] The report states that the average water user consumes 2,500 cubic feet of water per month.[267] The recommended scale proposed a $0.25 charge plus the current service charge for users that consume less than 1,500 cubic feet, $0.26 plus the current service charge for consuming 2,500 cubic feet or more, $0.28 for consuming 3,500 cubic feet and finally $0.30 for consuming over a monthly average of 5,000 cubic feet.[268] The purpose would be to allow smaller users or water conscious consumers to use less water and not have to pay more because of it.[269] Councilman Gutierrez believed this plan would be the most equitable and the most feasible to implement, in comparison to a plan which would change rates based on the summer or winter months.[270] What this report shows is that it is possible to create a balance between the business interests of water providers and the conservation interests of the city, state and residents.

City Council Report October 17, 1977

A City Council report was made on October 17, 1977 by Lin Hallickson, Intergovernmental Programs Coordinator, sent to the Mayor and City Council, titled *Summary*

[264] 1. Councilman Gutierrez, "April 1, 1977", *City Clerk*
[265] 1. Councilman Gutierrez, "April 1, 1977", *City Clerk*
[266] 1. Councilman Gutierrez, "April 1, 1977", *City Clerk*
[267] 1. Councilman Gutierrez, "April 1, 1977", *City Clerk*
[268] 1. Councilman Gutierrez, "April 1, 1977", *City Clerk*
[269] 1. Councilman Gutierrez, "April 1, 1977", *City Clerk*
[270] 1-2. Councilman Gutierrez, "April 1, 1977", *City Clerk*

Report of the Water Conservation Seminar.[271] The purpose of this seminar was for government officials from Glendale, Mesa, Phoenix, Tempe and Scottsdale to discuss water management strategies.[272] This document's retelling of the seminar is revealing as to the types of strategies and the ways of thinking that were informing water management ideas at this time:

> It was expressed at the meeting that government's responsibility in a sensible, voluntary water conservation program must begin by setting an example for others.
>
> Therefore, it was agreed early in the proceedings that the significant facets of a voluntary water conservation program include: 1) educating both the public and each governmental entities' own employees, 2) community communication, and 3) a personal commitment.[273]

First, even in a greater regional discussion of water conservation, the very idea is thought of as a voluntary measure. This suggests a lack of urgency on government's part to solving the problem of water consumption and scarce water resources. A more proactive approach would view water conservation as a compulsory measure necessary to take in order to protect and promote the wellbeing of the population at large. The idea of "setting an example for others" is well-intentioned, but the policies outlined in the next sentence are indicative of a singular approach to water conservation that does not address the underlying forces of economic growth and population growth which are draining scarce water resources. The governmental mindset towards conservation is focused on public education that is meant to influence individual action, culminating in a collective reduction in water usage. While this approach is a positive step towards encouraging conservation, it does not go far enough. A more radical solution to water conservation would recognize the need to sacrifice some combination of economic growth, population growth, agricultural production, tax base size and greater personal autonomy over

[271] 1. Lin Hallickson, "October 17, 1977", *City Clerk*
[272] 1. Lin Hallickson, "October 17, 1977", *City Clerk*
[273] 1. Lin Hallickson, "October 17, 1977", *City Clerk*

one's water usage to be truly effective. The proposed measures at this meeting are more of the same ideas about water conservation that do not offer any new solutions. Economic success and population growth are not considered as detriments to water conservation efforts. The nature of water conservation in the greater Phoenix area is not thought of as a sign that the land cannot support such a great human population and its accompanying economic activity.

The discussion section of this report suggests further delusion from government leaders as it regards water conservation. In a speech at this conference given by Wesley E. Steiner, state water engineer and executive director of the Arizona Water Commission, it is said that, "Maricopans are using water almost twice as fast as the replenishment rate so that an annual overdraft of slightly over 900,000 acre feet per year results under present conditions." [274] Although this metric is based on county-wide consumption, this speaks to a high level of water demand that the county struggles to sustain. In Steiner's speech, he raises the point that water supply and demand could be balanced in Maricopa County by water from the Colorado River supplied by the Central Arizona Project combined with a 61% decrease in harvested acres.[275] This speech seems to recognize the need for reduced agricultural production, as well as an increase in available water resources. This is the type of approach that should have been followed, and it should have gone even further to recommend a decrease in economic production and population. However, Steiner notes the difficulty in making more water resources available for public use, as water supplies that are part of the SRP and Salt River Indian Reservation are attached to those who own that land, meaning that those who own that land where the water flows own those same water rights, which cannot be moved supply users outside these

[274] 1. Lin Hallickson, "October 17, 1977", *City Clerk*
[275] 1. Lin Hallickson, "October 17, 1977", *City Clerk*

properties.[276] It would seem that this private right to water represents a challenge to implementing water conservation and providing access to more water, as these landowners have autonomy to consume water as they please.[277] The report goes on to say that, "In general, Maricopa County's water problem is not immediate. There is no cause for panic. Fortunately, sufficient groundwater reserves are available to permit a reasoned, planned solution to the problem." [278] These sentiments are exactly the problem with the approach to water conservation in Phoenix. Since there are enough water reserves in the short term, the county can afford to rely on its groundwater for its water supply. Rather than view a future shortage of water as a serious crisis to be dealt with immediately and for the long term, it would seem that government officials were content to enjoy this short term feeling of security that did not require immediate action. This passage from the report reads as governmental procrastination, a willingness to push responsibility and action to a later date for others to deal with.

The report then delves into the dichotomy between agricultural and urban water consumption, noting that 89% of the state's water is consumed by agriculture, while only 7% is consumed by urban users.[279] However, as urbanization increases, urban water consumption will make up a larger percentage of consumed water and water demanded.[280] The report stresses the importance of urban water conservation as the urban population grows.[281] However, nothing is written regarding the need to decrease agricultural water consumption. Given agriculture's enormous share of water consumption, it would seem that the easiest way to conserve water resources would be to decrease the largest category's percentage of water consumed. This is not

[276] 1. Lin Hallickson, "October 17, 1977", *City Clerk*
[277] 1. Lin Hallickson, "October 17, 1977", *City Clerk*
[278] 1. Lin Hallickson, "October 17, 1977", *City Clerk*
[279] 1-2. Lin Hallickson, "October 17, 1977", *City Clerk*
[280] 2. Lin Hallickson, "October 17, 1977", *City Clerk*
[281] 2. Lin Hallickson, "October 17, 1977", *City Clerk*

explored as a possible solution, which seems to suggest that government officials view agricultural production and water consumption as givens. This calls into question the logic of settling millions of people in an area where water is scarce and producing food is accomplished by using 89% of all the water that is consumed. The strain that agricultural production seems to place on water resources suggests that perhaps agriculture is not suited to such an environment, or perhaps the agricultural techniques or the products produced are not suitable to the environment. In any case, the report's focus on the importance of urban water conservation in the future is puzzling, as it such a low percentage of water consumed in Arizona.

Per capita consumption of water is then discussed. At the time of this report, the national average for water consumption from public water systems was 154 gallons per day, which included rural domestic usage and excluded self-supplied industrial usage.[282] Comparatively, Arizona's per capita consumption was 220 gallons per day, the Valley of the Sun's per capita consumption was 200 gallons per day, and the SRP service area's per capita consumption was 300 gallons per day, which included residential and park irrigation.[283] These numbers speak to the level of demand for water. Consumption levels in Arizona were all higher than the national average, and the SRP's consumption was nearly twice the national average. Yet the report finds a way to justify these figures: "However, compared to uses in other areas with climates similar to Arizona, the use rate of 300 gallons per capita per day does not appear exorbitant." [284] Per capita consumption rates per day are then given for California's San Joaquin Valley (338 gallons per capita per day), Albuquerque, New Mexico (250 gallons per capita per day) and Tucson, Arizona

[282] 2. Lin Hallickson, "October 17, 1977", *City Clerk*
[283] 2. Lin Hallickson, "October 17, 1977", *City Clerk*
[284] 2. Lin Hallickson, "October 17, 1977", *City Clerk*

(190 gallons per capita per day), which are all above the 150 gallon per day national average.[285] So, some of Arizona's cities fall across this large spectrum, in some cases using less water per capita per day than other cities.[286] It may seem positive that Arizona does not have all of the highest consumption rates, and that this problem of high per capita daily water consumption exists in other places. However, just because Arizona's cities have similar statistics does not mean that this is good news. If anything, this shows that higher per capita water consumption levels are prevalent in dryer environments, which again calls into question the reasoning behind settling in such areas owing to the scarcity of water.

Ordinance Adopting Water Saving Devices May 27, 1980

The Phoenix City Council adopted an ordinance that codified the installation of water saving technology in new toilets and urinals.[287] The ordinance calls for designs that cap flushing at a maximum of four gallons per flush.[288] Additionally, all shower heads in new buildings would be equipped with low flow technology to limit water usage to a maximum of three gallons per minute.[289] All faucets in new buildings and public spaces would also be equipped with low flow technology to limit water usage to 3.5 gallons per minute maximum.[290] This ordinance shows progress in the way of reducing water consumption for both public and private use. This is a positive measure towards promoting conservation. However, it does not address the growing population or its use of water, nor the agricultural sector's use of water. This could be categorized as a water conservation method that may not save a significant amount of water,

[285] 2. Lin Hallickson, "October 17, 1977", *City Clerk*
[286] 2. Lin Hallickson, "October 17, 1977", *City Clerk*
[287] 3. Phoenix.gov, "May 27, 1980", *City Clerk*
[288] 3. Phoenix.gov, "May 27, 1980", *City Clerk*
[289] 3. Phoenix.gov, "May 27, 1980", *City Clerk*
[290] 3. Phoenix.gov, "May 27, 1980", *City Clerk*

outlined in previous reports. Policies like this seek to address how water is consumed in the household when they require newly constructed buildings to incorporate water saving technology. What is not addressed is the sprawling nature of urbanization in Phoenix and the greater Phoenix area which encourages more construction of houses that will support people who are going to consume water.

Conclusion

It is the argument of this thesis that the attitudes towards water conservation during this time period represent short-term thinking and complacency, while the policies recommended to reduce water consumption levels during this time period did not go far enough to address the impact of economic activity and human activity on water consumption levels. The public records discussed in this chapter present Phoenix's government leaders and other Arizona government leaders as somewhat unworried regarding possible water shortages that could occur several years in the future. There is a prevailing attitude in these records that water shortages are a cause for concern, but do not call for immediate action or planning. The sense given is that these issues can be dealt with in the future.

Little is said about the impact of agriculture on water consumption, while there is an emphasis placed on the growing urban population. It is puzzling that agricultural water consumption is not identified as the major challenge to solve the challenge of water conservation given its disproportionate usage of water throughout the state. Instead, it is mentioned multiple times that urban water conservation will become important in the future as the urban population increases. The public records indicate that the urban population is identified as the thing that must be planned for and held in check. Residential water consumption will come if public education programs are successful and community action is taken. This thinking is backwards

and ultimately harmful because it seemingly neglects the impact from agriculture, while ignoring the questions that arise when contemplating the sense of farming in a state that is largely a desert, and settling in a state where water is scarce.

The attitudes and policies of water conservation at this time are tame. There seems to be no impending sense of crisis from government leaders. Government leaders at this time seemed to take water for granted. There is no mention that perhaps economic growth and population growth must be reduced, or limited, to conserve water. These types of growth are seemingly taken as givens. This suggests that the framework for thinking about public water conservation policies was flawed and centered on the success of the economy.

Chapter 4

Expansion of Phoenix 1980-2000

Population Growth

Between 1982 and 1992, the Phoenix metropolitan area's growth rate was three times greater than the United States average.[291] Between 1980 and 1994, Maricopa County was the third fastest growing county in the United States by population.[292] To put greater historical context to this population growth, Maricopa County's population increase was 564% between 1954 and 1994, whereas the United States' population increase was 72% during the same period.[293] The Phase I Report on Generalized Land Use notes the importance of a "large skilled-labor supply and markets for products" as catalysts for population growth in Maricopa County.[294] Maricopa County's labor force population doubled between 1980 and 1995, while the county experienced a 1.5% lower unemployment rate between 1984 and 1993.[295] A special census in 1995 showed that the Phoenix metro area had a population of 2.5 million with Phoenix's population share declining from 60% to 45% between 1970 and 1995.[296] The

[291] 11. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

[292] 11. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

[293] 11. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

[294] 11. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

[295] 11. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

[296] 14. Tom Rex, "Development of Metropolitan Phoenix", *ASU Digital Repository*

surrounding cities also showed increases: “The population of Mesa jumped to 338,000 in 1995, while Glendale, Scottsdale, Tempe and Chandler each had between 100,000 and 200,000 residents.” [297] This speaks to the level of urban sprawl present in the Valley of the Sun, not just within Phoenix. Economic growth, employers relocating to Phoenix, available housing and the city’s climate have all played a significant role in making the entire metropolitan area an attractive place for residents. It is important to call attention to Table 1 to reiterate the population growth that had taken place from the 1980s to the end of the 1990s.

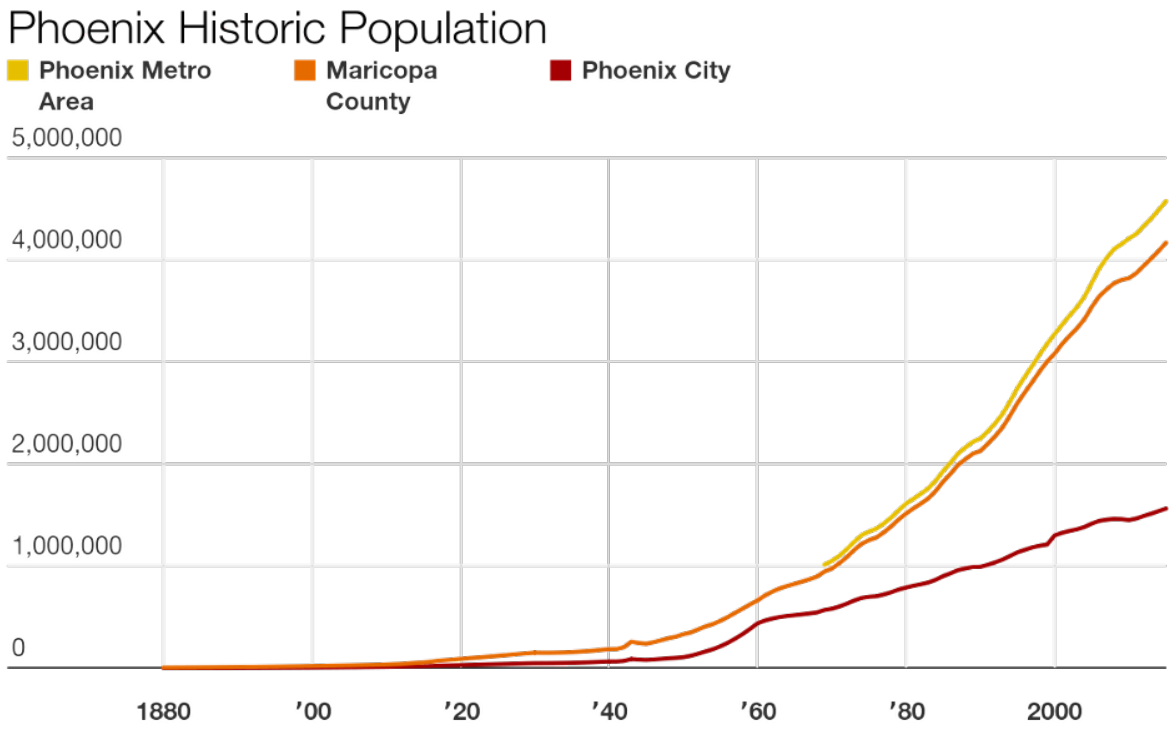
As this table shows, population growth continued in each of the communities surrounding Phoenix in the 1980s and 1990s. The population of Phoenix itself increased by nearly 200,000 people between 1980 and 1990, and over 200,000 people between 1990 and 1998. Phoenix has the largest population of all the individual communities by a large margin. However, population growth still occurred in all of these other towns. These statistics are indicative of the culture of growth and the growth mindset that have been so influential to the Phoenix metropolitan area. It is remarkable to compare Phoenix’s size in 1900 to its size in 1998, as well as each population center’s first and last recorded sizes. Over a century, a collection of once-small towns transformed into urban centers that support thousands or millions of people.

Another way to visualize and understand Phoenix’s changes in population is to plot the population data on a graph. In an article for Medium.com titled *A Population History of Phoenix*, author Lyman Stone creates a number of graphs and charts to illustrate the history of Phoenix’s population growth. The first graph below (**Figure 5**), plots population levels in Maricopa

[297] 14, 16. Tom Rex, “Development of Metropolitan Phoenix”, *ASU Digital Repository*

County, the Phoenix Metro Area and Phoenix City ranging from 1880 to 2015.[298] This graph uses a scale ranging from a population of 0 to 5,000,000.[299]

Figure 5: Phoenix Historic Population



[300]

Stone's data helps to better represent the changes in Phoenix's population over time. The trends in population growth that have been discussed in previous chapters can be seen easily. The first big population growth movement in Phoenix can be seen between 1940 and 1960. From 1960 to 2015, the positive growth trend continues. Phoenix's growth on this graph is modest

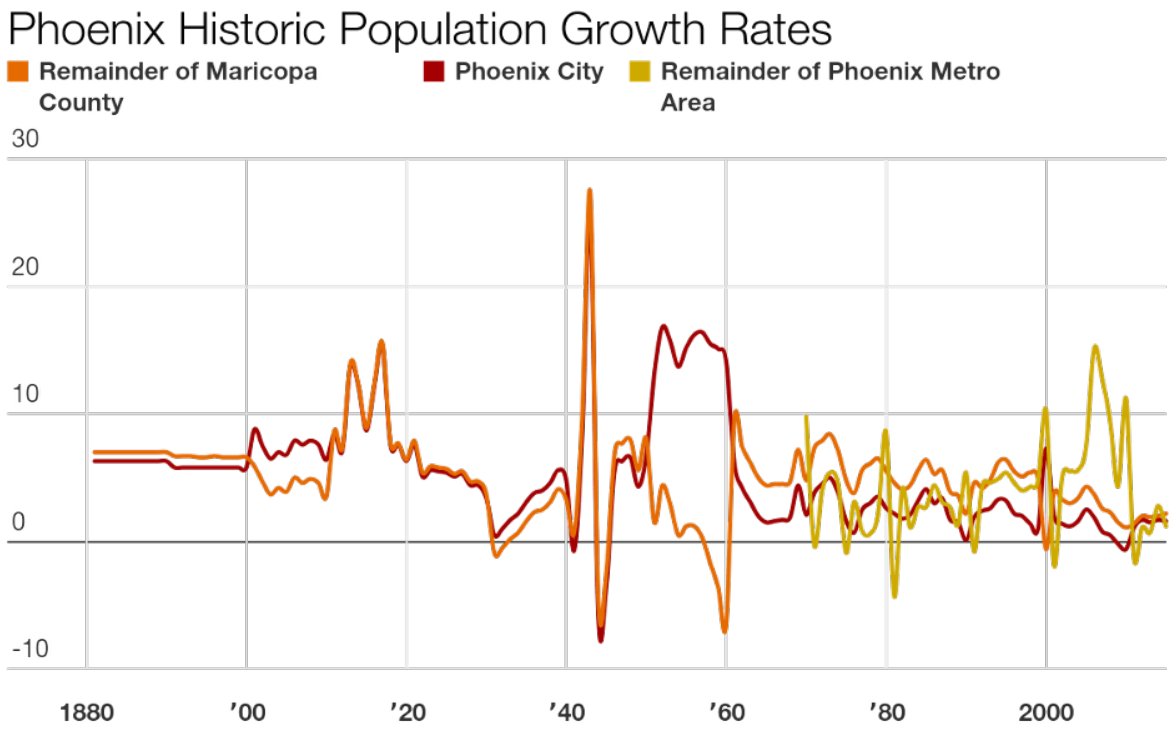
[298] Lyman Stone. "A Population History of Phoenix." *Medium.com.*
[299] Lyman Stone. "A Population History of Phoenix." *Medium.com*
[300] Lyman Stone. "A Population History of Phoenix." *Medium.com.*

compared to the growth of the Phoenix Metro Area and Maricopa County. These two categories have much steeper slopes and higher population numbers than Phoenix. This should be expected given that the Phoenix Metro Area is comprised of other cities that have also had histories of population growth. The divergence between the curves around 1940 indicates the development of these surrounding cities.

Another way to examine population growth is to examine the average annual growth rates, not only the numeric changes in population over time. Average annual growth rates show the change in percentage of the population growth from year to year. Stone also created a graph to demonstrate historical average annual growth rates in Phoenix City, the remainder of Maricopa County and the remainder of the Metro Phoenix Area (**Figure 6**). [301] Stone created Figure 6 by using annual population figures and calculating the change in population by percentage from year to year.

[301] Lyman Stone. "A Population History of Phoenix." *Medium.com.*

Figure 6: Phoenix Historic Population Growth Rates



[302]

If this graph shows nothing else, it shows that Phoenix' population growth has almost always been a positive rate. There are a few instances of negative growth rates in the early 1940s and around the time of the Great Recession in 2008, but other than during these few periods, Phoenix has always had a positive population growth rate. Some of Phoenix's population spikes correlate to the city's marketing and economic growth, which were discussed in previous chapters. Phoenix's growth rate stands out in the early 1900s just after the turn of the century. At this time, Phoenix was using its status as an agricultural community to attract other farmers to the city. It is reasonable to believe the construction of the Roosevelt Dam played a part in

[302] Lyman Stone. "A Population History of Phoenix." *Medium.com.*

producing this early growth spike. The growth spurts before and after World War II correlate with the city's marketing as a desert oasis, and the influx of servicemen and companies to Phoenix. Although the growth rate drops significantly after the growth boom of the 1950s, Phoenix's growth rate remains positive until around 2008. Data for the remainder of Maricopa County and the remainder of the Phoenix Metro Area show more fluctuations that have produced negative growth rates.

Economic Growth

The economy of Maricopa County transitioned from mainly agricultural and natural resource production to a more service-based economy between the 1980s and 1990s.[303] Some of the most important industries included "real estate, construction, electronics, aerospace, retirement, service, and tourism." [304] Some sectors that experienced considerable growth include "information, communications, health, services, aerospace, transportation/distribution, agribusiness and tourism." [305] Written in 1999, the Phase I Report on Generalized Land Use then notes, "Future growth in the area will depend on access to a quality work force, capital availability, competitive tax and regulation environment, accessible technology, advanced infrastructure, housing affordability, cost of living, educational opportunity, and quality of life."[306] This quote speaks to a disconnect between residents in the 1890s and residents in the 1990s. There is no explicit mention of the importance of access to water in perpetuity. The quote

[303] 11. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

[304] 11. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

[305] 11. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

[306] 11. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

used at the beginning of Chapter 2 about the Roosevelt Dam and access to water noted that residents recognized the importance of water to any economic success that Phoenix, or Maricopa County, would have in the future: "Those who remained recognized that progress resulting from growth was doomed unless they solved the water problem." [307] Access to water was seen as the key to future growth. The Phase I Report's quote is more concerned about the economic factors that would create economic growth. Most of the factors required for future growth revolve around attracting new in-migrants or retaining current residents. The "access to a quality work force" can be taken to mean an educated labor force population, which will be made up of people, who will all need access to water. Additionally, this labor force will also need "advanced infrastructure," which could mean a variety of services like highways, roads, public transit, energy infrastructure, plumbing and sewage. Affordable housing will also be an important factor in determining the trajectory of the economy, as the labor force needs an adequate supply of homes for its residents. The cost of living is related to this, as residents must be able to afford their basic necessities outside of their housing. If housing prices are too high and the cost of living is too high, then this would cause people to leave, which could jeopardize the future of the city's economic growth. A strong education system is also a draw for this prized labor force, as higher educational attainment can often lead workers to landing higher paying jobs. More workers who have higher paying jobs will pay more in taxes and contribute more to the local economy, as they will have more disposable income. Lastly, a degree of quality of life implies some level of comfort and some desirable lifestyle for workers. The quote from the previous page echoes all of the sentiments that Phoenix's leaders have pushed since the turn of the 20th century. More people must come and contribute to the economy. More housing an infrastructure

[307] 199-200. Bradford Luckingham, "The Rise of Phoenix", *The Journal of Arizona History*

must be built to accommodate these people. What this quote really means is that the pattern of growth, both population growth and economic growth, must continue. To accomplish this, it would seem that access to water is taken as a given, assumed to be available in the long run.

Sectoral Water Demand Levels 1985 to 2000

Understanding water demand is a critical aspect to contextualizing the challenge of water conservation in Phoenix. In 2008, a report titled *Evolution and Evaluation of the Active Management Area Management Plans* analyzed water demand levels as part of its evaluation of Arizona's 1980 Groundwater Management Act's (GMA) Active Management Area (AMAs) plans.[308] The Arizona Department of Water Resources (ADWR) develops and manages the AMAs.[309] There are five AMAs: Pinal, Phoenix, Prescott, Tucson and Santa Cruz.[310] Industrial, municipal and agricultural demand levels were analyzed, and the findings will be discussed in this section.

In the evaluation of industrial water demand, this research found demand levels for Phoenix in 1985, 1990, 1995 and 2000 (**Table 2**).[311] Industrial demand for water increased in each five year interval, going from 73,485 acre feet in 1985 to 73,767 acre feet in 1990.[312] Demand levels went up again to 83,088 acre feet in 1995, and then to 126,333 acre feet in

[308] i, Sharon B. Megdal, et. al. "Evolution and Evaluation of the Active Management Area Management Plans", azwater.gov

[309] i, Sharon B. Megdal, et. al. "Evolution and Evaluation of the Active Management Area Management Plans", azwater.gov

[310] 1, Sharon B. Megdal, et. al. "Evolution and Evaluation of the Active Management Area Management Plans", azwater.gov

[311] 18, Sharon B. Megdal, et. al. "Evolution and Evaluation of the Active Management Area Management Plans", azwater.gov

[312] 18, Sharon B. Megdal, et. al. "Evolution and Evaluation of the Active Management Area Management Plans", azwater.gov

2000.[313] It is noted that Phoenix has the largest industrial water demand by volume and the most industrial categories that use water.[314]

Table 2: Total Industrial Demand by AMA

Year	Phoenix AMA	Tucson AMA	Pinal AMA	Prescott AMA	Santa Cruz AMA
1985	73,485 ac-ft		4,801 ac-ft		1,393 ac-ft
1987		40,872 ac-ft			
1990	73,767 ac-ft	48,743 ac-ft	5,596 ac-ft	444 ac-ft	1,328 ac-ft
1992				443 ac-ft	
1995	83,088 ac-ft	60,204 ac-ft	6,704 ac-ft	555 ac-ft	1,363 ac-ft
1997				626 ac-ft	
1998		57,500 ac-ft	8,292 ac-ft		
1999					469 ac-ft
2000	126,333 ac-ft				
2005		54,200 ac-ft			

[315]

Figures for municipal water demand follow this page (**Table** 3). Between 1985 and 1998, the Phoenix AMA's municipal water demand rates decreased.[316] In 1985, 308 gallons per capita daily (GPCD) were consumed, but dropped to 301 GPCD in 1990.[317] Decreases continued in

[313] 18, Sharon B. Megdal, et. al. "Evolution and Evaluation of the Active Management Area Management Plans", azwater.gov

[314] 18, Sharon B. Megdal, et. al. "Evolution and Evaluation of the Active Management Area Management Plans", azwater.gov

[315] 18, Sharon B. Megdal, et. al. "Evolution and Evaluation of the Active Management Area Management Plans", azwater.gov

[316] 29-30, Sharon B. Megdal, et. al. "Evolution and Evaluation of the Active Management Area Management Plans", azwater.gov

[317] 30, Sharon B. Megdal, et. al. "Evolution and Evaluation of the Active Management Area Management Plans", azwater.gov

1995 when Phoenix achieved 282 GPCD water demand levels, and then again in 1998 when Phoenix consumed 278 GPCD.[318] This reports notes that the Phoenix AMA has the highest average consumption rate of the AMAs, but also the most potential to reduce its municipal water consumption due to the other AMA's lower GPCD figures.[319] The Prescott AMA had the lowest GPCD levels, with 131 GPCD in 1985, 141 in 1990 and 147 in 1995.[320]

Table 3: Municipal Sector Gallons Per Capita Per Day by AMA over Time

Year	Phoenix AMA	Pinal AMA	Prescott AMA	Santa Cruz AMA	Tucson AMA
1985	308	220	131	178	176
1990	301	228	141	199	169
1995	282	225	147	189	172
1998	278	214	N/A	N/A	172

[321]

The report asserts that there is no clear trend in agricultural demand for each AMA between 1985 and 1998.[322] Changes in agricultural demand can be seen in the table below (**Table 4**). Different factors play a role in fluctuating water demand, presenting a difficulty in assessing the success or failure of agricultural water conservation.[323] Changes in weather affect

[318] 30, Sharon B. Megdal, et. al. "Evolution and Evaluation of the Active Management Area Management Plans", azwater.gov
[319] 29, Sharon B. Megdal, et. al. "Evolution and Evaluation of the Active Management Area Management Plans", azwater.gov
[320] 30, Sharon B. Megdal, et. al. "Evolution and Evaluation of the Active Management Area Management Plans", azwater.gov
[321] 30, Sharon B. Megdal, et. al. "Evolution and Evaluation of the Active Management Area Management Plans", azwater.gov
[322] 30, Sharon B. Megdal, et. al. "Evolution and Evaluation of the Active Management Area Management Plans", azwater.gov
[323] 30, Sharon B. Megdal, et. al. "Evolution and Evaluation of the Active Management Area Management Plans", azwater.gov

how much water is necessary for crop irrigation.[324] This report was not able to discern if water demand levels by acre-feet increased in the mid-1990s due to incentives to plant more acres.[325] These are just two of the potential difficulties to fully understanding the agricultural water demand picture. In 1985, the Phoenix AMA's water demand was 1,363,530 acre-feet, which then decreased in 1990 to 1,023,970 acre-feet.[326] However, demand increased to 1,109,105 acre-feet in 1995, but decreased again in 1998 to 1,021,155 acre-feet.[327] The report mentions the influence of grandfathered water rights to agricultural water demand. Before the passage of the 1980 GMA, during the baseline period between 1975 and 1979, there were high amounts of crops planted and acres irrigated, which resulted in farmers having higher irrigation limits.[328] The report notes that few farms use their entire allotments of water, but that this has led to the agricultural industry gaining more flexibility credits.[329] The agricultural industry has generally been complicit with water conservation policies, but the report states that it is possible to interpret this sector's water conservation efforts as ultimately ineffective.[330]

[324] 30, Sharon B. Megdal, et. al. "Evolution and Evaluation of the Active Management Area Management Plans", azwater.gov

[325] 30, Sharon B. Megdal, et. al. "Evolution and Evaluation of the Active Management Area Management Plans", azwater.gov

[326] 31, Sharon B. Megdal, et. al. "Evolution and Evaluation of the Active Management Area Management Plans", azwater.gov

[327] 31, Sharon B. Megdal, et. al. "Evolution and Evaluation of the Active Management Area Management Plans", azwater.gov

[328] 30, Sharon B. Megdal, et. al. "Evolution and Evaluation of the Active Management Area Management Plans", azwater.gov

[329] 30-31, Sharon B. Megdal, et. al. "Evolution and Evaluation of the Active Management Area Management Plans", azwater.gov

[330] 31, Sharon B. Megdal, et. al. "Evolution and Evaluation of the Active Management Area Management Plans", azwater.gov

Table 4: Agricultural Demand by AMA (acre-feet) over Time

Year	Pinal AMA	Phoenix AMA	Prescott AMA	Santa Cruz AMA	Tucson AMA
1985	754,888	1,363,530		8,960	
1987					104,075
1990	757,376	1,023,970	6,932	11,603	90,849
1995	840,750	1,109,105	9,217	12,884	93,816
1997			7,572		
1998	803,674	1,021,155			94,800

[331]

This section has provided data that point to some degree of success in reducing water demand through water conservation policy from the 1980s through the 1990s. The figures mentioned in this section provide greater context to understanding how much water was actually being used by different sectors.

Land Use Patterns 1995

Phoenix experienced a period of rapid growth between 1975 and 1995. As the Phase I Report on Generalized Land Use notes, "According to our study, the amount of land devoted to urban development almost tripled during these 20 years!" Agricultural land from the southeast and northwest was developed for housing and commercial business, connecting many of the

[331] 31, Sharon B. Megdal, et. al. "Evolution and Evaluation of the Active Management Area Management Plans", azwater.gov

leapfrog communities together.[332] Agricultural land did not expand between 1975 and 1995, which had been a historical land use change in the periods leading up to 1975.[333] In fact, a 30% decrease in the amount of land under cultivation occurred.[334] About 58% of land development took place on desert land, particularly in the northwest part of the valley.[335]

To create this map (**Figure 7**), the 1995 MAG Existing Land Use spatial dataset was used.[336] The Phase I Report reclassified the land use categories from this dataset, and an explanation of their changes can be found Table 3 from this source.[337] Water data from the Arizona Land Resource Information System was used, while the MAG water classification was not used in this projection.[338] Urban centers were mapped by creating a perimeter around small, dense land use area polygons.[339] Rural residences were categorized as agricultural lands, and vacant lands were categorized as urban.[340] However, rural residences were difficult to map, as it was difficult to determine the specific areas used for agriculture.[341] These areas were categorized

[332] 13. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

[333] 13. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

[334] 13. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

[335] 13. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

[336] 13. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

[337] 13. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

[338] 13. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

[339] 14. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

[340] 14. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

[341] 14. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

using the denser land use polygon mentioned above.[342] Buckeye Hills and Adobe Mountain Recreation Area are two recreational parks that are included.[343] At the time of this report, Buckeye Hills was "not yet a formally developed park", while Adobe Mountain Recreation Area was not "a uniformly managed park but rather a gathering of individual concessionaires with no single, known establishment date." [344] This report also implemented the following criteria used to categorize land for this period:

> If a previous year was identified as urban land use, then subsequent years were changed to urban land use
>
> If the land use before and after a middle land use was the same, the middle land use was changed to match the pre- and post-land uses. If before and after land uses were different, then the pre-land use was used. In the case of agricultural/desert transitions, no change was made.
>
> If 1955 land use was urban, but 1934 and 1975 land use were not urban, 1955 land use was changed to equal 1934 land use.
>
> If land use was recreational in 1975, it remained recreational in 1995.[345]

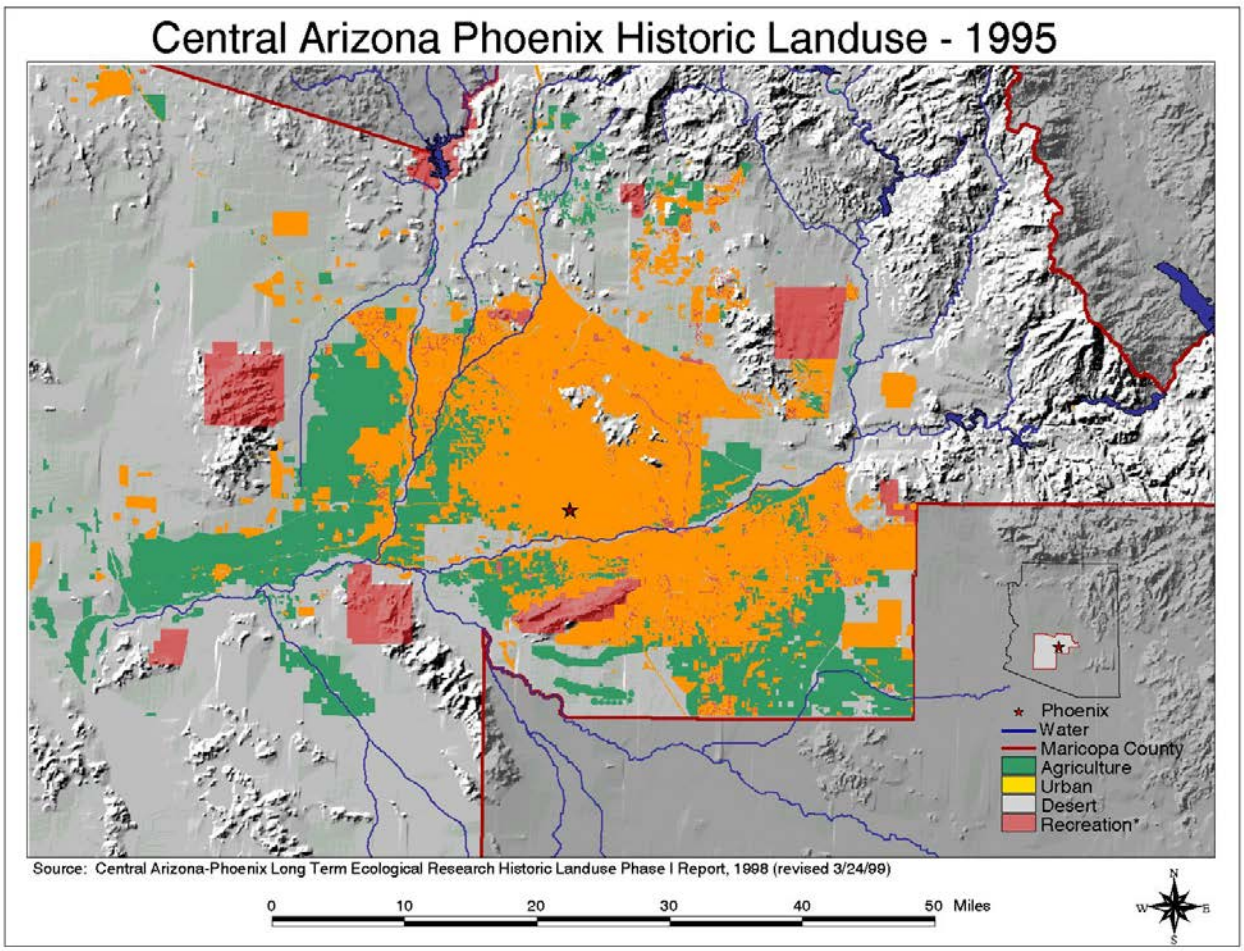
[342] 14. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

[343] 14. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

[344] 14. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

[345] 14. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

Figure 7: Central Arizona Phoenix Historic Landuse 1995



[346]

Each map in this series of maps contrasts differently with the period maps that preceded or followed. However, the increases in urban land between the 1975 map and the 1995 map are visually staggering. For the better part of the century, the collection maps show that agriculture was the dominant land use purpose for people in the Salt River Valley. However, the 1995 map shows even greater increases in urban expansion throughout the valley. Some agricultural expansion can be seen to the north of Phoenix, but the largest changes in land use patterns clearly

[346] 13. Kim Knowles-Yanez, et. al. "Phase I Report", *Central Arizona - Phoenix Long-Term Ecological Research*

came from urbanization between 1975 and 1995. As mentioned, some new regional parks were included in this projection as well. What this final map shows are the ideas and values that Phoenix's prominent business leaders and communities have held throughout Phoenix's history: a large city with a thriving economy and greater self-determined land use.

Ideas about Water and City Council Actions 1980-2000

Actions from Phoenix's City Council from this period show greater urgency to the issues of water conservation and water consumption, but ultimately fall short of addressing the problem of population growth. Similar to the previous chapter, this section will also analyze public records as a way to understand the Phoenix city government's water policies. It is important to keep in mind that the public records analyzed in this section are a selection of public records between 1980 and 2000. Different public records could have been included in this section, which is a limitation for the argument of this thesis. The records that are included are more relevant to understanding the logic behind Phoenix's water policies in this time period. Given the uncertainty and variability of Phoenix's water supply from 2018 onwards, the years between 1980 and 2000 represent two decades where Phoenix's public officials mischaracterized and misunderstood the importance of future water security.

City Council Report February 16, 1990

A City Council report from Michael Gritzuk, P.E. Water and Wastewater Director was prepared for George W. Britton, Deputy City Manager, and dated February 16, 1990. The title of the report was *City of Phoenix Water Conservation Rate Concept for Fiscal Year 1990-91*. In this report, Gritzuk outlines the simplified rates for water consumption, whose goal is to promote

water conservation.[347] This was to be achieved by charging a single rate for all customer classes, charging different rates in the summer and winter months, and implementing a "life-line water supply allocation for each customer to be included in the standard base charge." [348] The report then provides figures for typical monthly bills in January and June, which are broken down into five customer usage categories: low usage residential, median usage residential, high usage residential, commercial and industrial.[349] The report includes a table that shows the price differences between current bills, the proposed conservation rate structure, and the change in cost by percentage.[350] The goal of this proposed water rate change is for customers to pay less in the winter when there is less demand for water, but then pay more in the summer when demand is greater.[351] The report stipulates that the goal is for this rate structure to be "revenue neutral".[352] The profit motive for the water providers is still present in this rate structure, even if customers would be charged less in the winter. The higher summer rates act as an incentive to consume less water in the summer. However, the water providers are meant to break even with this new proposed rate structure. A positive aspect to this proposed rate structure is that commercial and industrial water customers would pay a higher annual rate due to the single block rate offered for their respective customer classes.[353] This policy would act as an incentive for commercial and industrial producers to use less water, which this thesis has identified as an actor whose interests conflict with water conservation. It is asserted that this new rate would lead to an annual decrease in residential water cost rates.[354]

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[347] 1. Michael Gritzuk, "February 16, 1990", *City Clerk*
[348] 1-2. Michael Gritzuk, "February 16, 1990", *City Clerk*
[349] 2. Michael Gritzuk, "February 16, 1990", *City Clerk*
[350] 2. Michael Gritzuk, "February 16, 1990", *City Clerk*
[351] 2. Michael Gritzuk, "February 16, 1990", *City Clerk*
[352] 2. Michael Gritzuk, "February 16, 1990", *City Clerk*
[353] 2. Michael Gritzuk, "February 16, 1990", *City Clerk*
[354] 2. Michael Gritzuk, "February 16, 1990", *City Clerk*

This policy shows progress towards conservation by providing a monetary incentive for residents to use less water, while charging businesses more for their water usage. What this proposal demonstrates is the city government recognizing the need to legislate water conservation that would force businesses to consider their water usage more or be forced to pay more. However, it is unclear if agriculture falls into one of these water rate classifications. As agriculture had been identified as Arizona's largest water consumer by a considerable margin in the 1980s, it would seem that addressing Phoenix's agricultural water usage through this new rate structure would have been an ideal opportunity to reduce water consumption by raising water rates for agricultural producers. It would seem that agriculture could have been classified as high residential or commercial, but with no explicit mention of agricultural water consumption rates in this proposal, all that can be done is speculate.

City Council Report April 23, 1990

Phoenix adopted a water conservation plan in 1986, which was aimed at promoting water conservation in a number of ways. On April 23, 1990, Michael Gritzuk, P.E. Water and Wastewater Director sent a City Council Report to George W. Britton, Deputy City Manager, which was titled *Water Conservation Plan Update*.[355] The report outlines the progress made regarding the 1986 plan's initiatives.[356] One of the most successful initiatives was a plumbing retrofit program, which installed low-flow plumbing retrofits on 40,000 houses.[357] As a number of initiatives had been successful, the report indicates that the Phoenix public wanted greater

[355] 1. Michael Gritzuk, "April 23, 1990", *City Clerk*
[356] 1. Michael Gritzuk, "April 23, 1990", *City Clerk*
[357] 1. Michael Gritzuk, "April 23, 1990", *City Clerk*

action to achieving water conservation, rather than developing new water resources.[358] This shows a more progressive and proactive attitude towards water conservation policies, as the public and city government recognized the need to consume less water, rather than to consume at a constant rate while expanding available water resources. Some of the newly proposed initiatives for the plan's update were an advertising campaign, expansion of the retrofit program, implementation of financial incentives for conservation, and the creation of more water saving programs.[359] While these are positive steps that show a greater public concern for water conservation, there is still no mention of the city's growing population, nor the impact of agricultural, commercial and industrial water consumption. While water conservation still remains the goal, it seems that no one makes the connection between population growth, human activity and water consumption. The report recommends implementing a number of plans to conserve water, but many of these still focus on issues of funding and residential consumption patterns.[360]

While these are positive measures, they ultimately do not go far enough to conserving water. While the mindset of conservation is helpful, this document shows that the framework for proposing and implementing solutions to reduce water consumption was limited. This limitation stems from underlying assumptions of economic growth and population growth. Hence, no solution is proposed that would significantly reduce economic growth or the size of the city's population, as these proposals would also likely reduce the size of the economy. There is no question raised about why water conservation is necessary. The need for water conservation is taken for granted, but never fully unpacked in public record. If the need for water conservation

[358] 2. Michael Gritzuk, "April 23, 1990", *City Clerk*
[359] 2. Michael Gritzuk, "April 23, 1990", *City Clerk*
[360] 3. Michael Gritzuk, "April 23, 1990", *City Clerk*

was questioned and debated, then perhaps someone would have concluded in public record that economic goals are adversarial and often contrary to policies of water conservation.

City Council Report April 23, 1990

Two other public records were written by Michael Gritzuk on April 23, 1990. One will be discussed in this section. That report was titled *Phoenix Water Resources Plan – 1990*, and was sent to George W. Britton, Deputy City Manager. The focus of this report was to discuss the Phoenix Water Resources Plan of 1990 and public opinion, as well as to seek "conceptual approval by Council." [361] The report's discussion section includes some insightful comments that reveal a growing public concern for water conservation.[362] A public meeting about the 1990 Water Resources plan resulted in one comment that Phoenix's approach to water conservation should be more aggressive by requiring graywater reuse systems in building codes and implementing stricter water conservation programs to "prevent the need for groundwater transfers from rural communities in western Arizona." [363] The local Sierra Club chapter advocated for higher water consumption usage charges to encourage conservation, and to use excess funds to finance water conservation initiatives.[364] The report includes other notable comments from this meeting and includes a draft of the 1990 Water Resources Plan.[365]

The first page of the 1990 Water Resources Plan includes a passage describing a public hearing about the 1985 Water Resources Plan.[366] The report reads, "…an elderly gentleman expressed concern that proposed conservation actions and the rising cost of water could force his

[361] 1. Michael Gritzuk, "April 23, 1990", *City Clerk*
[362] 2. Michael Gritzuk, "April 23, 1990", *City Clerk*
[363] 2. Michael Gritzuk, "April 23, 1990", *City Clerk*
[364] 3. Michael Gritzuk, "April 23, 1990", *City Clerk*
[365] 3-4. Michael Gritzuk, "April 23, 1990", *City Clerk*
[366] 5. Michael Gritzuk, "April 23, 1990", *City Clerk*

family to change their long-established Phoenix life-style…He urged City officials to preserve the quality of life that he found synonymous with Phoenix living…" [367] The passage ends with the following question, "Can we change the ways we use water and still maintain the high standard of living that characterizes our city?" [368]

Everything about the introductory anecdote from the 1985 Water Resources Plan public hearing speaks to the issues identified in this thesis. The elderly gentleman who is referenced seemed to understand that implementing water conservation would in fact require lifestyle changes from Phoenix residents. For water to be conserved, people would have to live differently, using water more efficiently. This could mean reducing water usage in any number of ways in one's residence. It could also mean that businesses would be forced to change the way they operate. The cost of keeping the status quo, and not implementing conservation policies, would be to allow water resources to dwindle, thereby laying the foundation for future water shortages. This passage also brings up questions as to what constitutes the "Phoenix lifestyle" that the older man references. Could the Phoenix lifestyle mean having greater autonomy over personal water consumption? If so, perhaps this is also part of the problem. Perhaps the more autonomous land use development and residential choices led people to believe they could use water as they pleased, even irresponsibly and even if it constituted an overuse of water. His concerns about preserving his quality of life speak to a desire for comfort. The availability of water would seem to be of the utmost importance to one's personal comfort. It seems counterintuitive to question the necessity of water conservation, while simultaneously advocating for the protection of quality of life. To address his last question, it would seem that using water

[367] 5. Michael Gritzuk, "April 23, 1990", *City Clerk*
[368] 5. Michael Gritzuk, "April 23, 1990", *City Clerk*

differently would mean losing some of that desirable quality of life. Using less water and giving up a degree of personal control over one's water usage for the common good seems to be the price for being able to live in Phoenix. This entire passage reads as an avoidance of a last resort. Though this man may not speak for all citizens of Phoenix, his comments and questions are revealing. He does not want to give up his high quality of life or his lifestyle.

On one of the following pages, the report gives a breakdown of Phoenix's water supplies and uses.[369] In 1988, 61% of Phoenix's water came from the SRP.[370] The report estimated that by 2010, new water resources would be expanded, which is noted as a necessity, and that the SRP would supply 49% of Phoenix's water.[371] At the time of this report, 68% of Phoenix's water was consumed by residents, while commercial and industrial water usage amounted to 28% and 4%, respectively.[372] These statistics are indicative of the problem of Phoenix's expansion and urban sprawl. They are also reveal the potential to make gains in conservation by focusing on residential policies, which helps to explain why much of Phoenix's water conservation methods were oriented towards residences. It is unclear if and where agricultural water consumption would fit in this data, as it is not explicitly stated as a major water consumer category.[373]

The next section of this report focuses on the stressors to the water supply.[374] The very first threat that is considered is population growth.[375] However, the discussion of population growth in this section is disappointing. The report cites that Phoenix is the ninth largest city by population in the United States, that it continues to grow and that it must supply over a million

[369] 7. Michael Gritzuk, "April 23, 1990", *City Clerk*
[370] 7. Michael Gritzuk, "April 23, 1990", *City Clerk*
[371] 7. Michael Gritzuk, "April 23, 1990", *City Clerk*
[372] 7. Michael Gritzuk, "April 23, 1990", *City Clerk*
[373] 7. Michael Gritzuk, "April 23, 1990", *City Clerk*
[374] 8. Michael Gritzuk, "April 23, 1990", *City Clerk*
[375] 8. Michael Gritzuk, "April 23, 1990", *City Clerk*

residents with water.[376] The water service area is then described, with 200 square miles within the SRP which receive SRP Water, and 400 square miles that are not entitled to SRP water.[377] The report notes the high rate of settlement and population growth in the lands outside the SRP over the previous two decades, but expects this activity to level off in the subsequent 50 years, by 2040, even though the population living in this area will reach one million.[378] In this same 50 year period, population growth and industry will demand more water, as agricultural water consumption approaches zero.[379] While it is positive to see population growth viewed as a stress to the water supply, this section offers no solutions or ideas to stem the growth of the Phoenix service area. Rather than looking at the root causes of this growth or questioning its value, the report only lists its future projections and statistics.

The report mentions other stresses to the water supply, but similarly offers no solutions to alleviating them.[380] Next, the success of conservation initiatives are discussed, followed by the expansion of the water supply.[381] The section following provides information about the future of the water supply.[382] It is estimated that by 2040, Phoenix will be 195,000 acre feet short of being able to supply the amount of water needed annually.[383] The Salt River is supposed to have enough water to supply those who are entitled to receive its water in the future.[384] The rest of this report details the needs for conservation, and a number of other plans to acquire more water resources while conserving water, in order to ensure that there is a water supply in the future.[385]

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[376] 8. Michael Gritzuk, "April 23, 1990", *City Clerk*
[377] 8. Michael Gritzuk, "April 23, 1990", *City Clerk*
[378] 8. Michael Gritzuk, "April 23, 1990", *City Clerk*
[379] 8. Michael Gritzuk, "April 23, 1990", *City Clerk*
[380] 8-14. Michael Gritzuk, "April 23, 1990", *City Clerk*
[381] 15-17. Michael Gritzuk, "April 23, 1990", *City Clerk*
[382] 17. Michael Gritzuk, "April 23, 1990", *City Clerk*
[383] 17. Michael Gritzuk, "April 23, 1990", *City Clerk*
[384] 17. Michael Gritzuk, "April 23, 1990", *City Clerk*
[385] 20-34. Michael Gritzuk, "April 23, 1990", *City Clerk*

While these potential action plans show progress in the government's attitude for water conservation, there is no questioning of population growth and economic growth. Growth is the assumption. People will suffer from water shortages the most during droughts, but they will still remain and Phoenix will still be a city. No one questions why the city has such a large population, sprawling across the Salt River Valley. This source represents a chance to implement stricter water policies that ultimately missed the mark in changing the trajectory of Phoenix's water conservation strategies. There is some change in mindset, but ultimately more of the same thinking dominates the discussion.

City Council Report April 23, 1990

A third City Council report was made by Michael Gritzuk, P.E. Water and Wastewater Director, and sent to George W. Britton on April 23, 1990, which was titled *1989 Per Capita Water Use*.[386] The report says that per capita daily water use in Phoenix's service area was 259 gallons, which would mean that Phoenix was out of compliance with the Arizona Department of Water's requirement of 251 gallons.[387] Phoenix's per capita consumption in 1988 was 253 gallons.[388] The estimates for this report were based on a 1989 population count, which estimated that Phoenix had just over one million residents.[389] The report cites the increase in annual average temperature as a leading cause in the uptick in water usage, as 1989 "…was again the hottest year on record, exceeding the previous hottest year, 1988, by over one degree Fahrenheit…". [390] Increases in temperature impact water demand; "As water demand modeling

[386] 1. Michael Gritzuk, "April 23, 1990", *City Clerk*
[387] 1. Michael Gritzuk, "April 23, 1990", *City Clerk*
[388] 1. Michael Gritzuk, "April 23, 1990", *City Clerk*
[389] 1. Michael Gritzuk, "April 23, 1990", *City Clerk*
[390] 1. Michael Gritzuk, "April 23, 1990", *City Clerk*

for the Phoenix service area has shown, a one degree increase in temperature can result in an increase in water of as much as 7 GPCD [Gallons Per Capita Daily]." [391] Water demand increases when temperatures rise because people, animals and plants need to consume more water to remain healthy.[392] Additionally, higher temperatures can lead to the evaporation of more water sources, like snowpack, which further reduce the amount of water available for consumption from rivers or groundwater sources.[393] In 1990, Phoenix had a population just over one million, which would mean that a one degree Fahrenheit increase would lead to an additional seven million gallons consumed daily.

This thesis has identified population growth as a challenge to water conservation policies. What this comment from the report shows is that increasing temperatures, the result of global climate change, also play a part in shaping water demand. This means that there are greater forces outside of Phoenix's control which contribute to the problem of water scarcity for its expanding population. The nature of increasing annual average temperatures should have been interpreted as further evidence that Phoenix is not an ideal place for over a million residents. Water conservation policies were challenging to implement before this report. The data given here shows that residents were consuming even more water as a result of higher temperatures. This situation would be less of a problem if Phoenix's population was significantly smaller or if its population was decreasing, but that was not the case.

The report also mentions turf facilities as water consumers that were using too much water. The conclusions in this report advocate for the initiatives from the 1986 Water Conservation Plan, highlighting the importance of water rates that prioritize conservation,

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[391] 1. Michael Gritzuk, "April 23, 1990", *City Clerk*
[392] Nick Bradford, "The Increasing Demand and Decreasing Supply of Water." *NEEF*
[393] Nick Bradford, "The Increasing Demand and Decreasing Supply of Water." *NEEF*

plumbing retrofits and low flow standards for plumbing, and limits for turf water consumption.[394] This report indicates that there was belief that the 1986 Water Conservation Plan would produce favorable outcomes for water conservation efforts. Yet there is no further questioning about the increasing temperaturesThere seems to be some recognition that climate change is occurring, as evidenced by the increasing temperatures, but there is no sense of urgency in this report. Faith is placed in the 1986 Water Conservation Plan to better conserve water, and there is no worry that annual average temperatures could continue to rise, which would put further stress on the water supply through increased water demand.

It is worth noting that the next year an update was provided as to Phoenix's per capita water usage figures, which showed a decrease in water usage.[395] This City Council report was dated April 24, 1991, and was prepared by Michael Gritzuk and sent to George W. Britton.[396] A study of Phoenix's water conservation initiatives was funded, which yielded results indicating that Phoenix achieved a 9.3% reduction in water use in 1990, resulting in 234 gallons per capita used daily.[397] About 2.2% of this 9.3% reduction was due to cooler temperatures, while the other 7.1% reduction was the result of conservation efforts.[398] What this report shows is the success of conservation efforts, as well as the importance of climate and annual average temperatures in relation to water conservation efforts. A cooler year led to less demand for water, resulting in less water usage. However, global climate change has largely caused temperatures to rise across the globe since 1990. While there was progress made towards reducing water consumption in

[394] 2. Michael Gritzuk, "April 23, 1990", *City Clerk*
[395] 1. Michael Gritzuk, "April 24, 1991", *City Clerk*
[396] 1. Michael Gritzuk, "April 24, 1991", *City Clerk*
[397] 2. Michael Gritzuk, "April 24, 1991", *City Clerk*
[398] 2. Michael Gritzuk, "April 24, 1991", *City Clerk*

1990, it would seem logical that increasing annual average temperatures after 1990 would counteract these gains.

City Council Report April 19, 1991

An important focus of this chapter has been the Phoenix city government's policy responses to address the city's scarce water resources and high rates of water consumption. It is the contention of this thesis that these policies do not go far enough to addressing population growth and economic activity as stressors to the water supply. Public records indicate that some members of the Phoenix city government were able to make the connections between these problems, but that the prevailing attitudes and discussions sought to address residential consumption patterns.

One of the more informative public records as to the city government's attitudes towards population growth was written by Karen O'Regan, Environmental Programs Manager, and sent to George Britton, Deputy City Manager, on April 19, 1991.[399] The title of this report is *Zero Population Growth (ZPG) Environmental Stress Index*.[400] The purpose of the report was to inform the City Council that Phoenix received one of the worst scores, a 4.0 out of 5, from ZPG's Environmental Stress Index.[401] A score of 4 indicates "danger" according to the index.[402] This index measured air quality, water quality, water availability, toxic releases, sewage and population change.[403] A city's population was correlated with its environmental stress, indicating that larger cities would have greater stress, leading to worse scores.[404] Phoenix was previously

[399] 1. Karen O'Regan, "April 19, 1991", *City Clerk*
[400] 1. Karen O'Regan, "April 19, 1991", *City Clerk*
[401] 1. Karen O'Regan, "April 19, 1991", *City Clerk*
[402] 1. Karen O'Regan, "April 19, 1991", *City Clerk*
[403] 1. Karen O'Regan, "April 19, 1991", *City Clerk*
[404] 1. Karen O'Regan, "April 19, 1991", *City Clerk*

rated a 5.0 in 1988, and was the worst city according to ZPG's environmental measurements.[405] The Phoenix city government's response was to contact ZPG and question the data used for the measurements. [406] ZPG was using data from the 1983 U.S. Geological Survey, which did not include Phoenix's progress in a number of different policy areas like water conservation.[407] The report goes on to mention that in correspondence with ZPG, some data used to rate Phoenix's environmental health were subjective and not standardized.[408] As a result, the city of Phoenix disputed its rankings based on ZPG's methodology, especially given its progress in water conservation policies.[409] Believing that ZPG's index was flawed and did not properly rate Phoenix, the city government seemed to disregard its poor environmental score.[410]

ZPG's measurements and methodology may have been flawed, but rather than question the index's measurements, this report would seem to have been an opportunity to discuss the state of a number of environmental problems in Phoenix. Instead, city leadership sought to attack ZPG's credibility so as to preserve a better environmental image publicly, while promoting progress in different environmental policy areas. Even if ZPG's measurements and methods were flawed and used outdated data, such a poor environmental health rating by any measurement would seem to be a cause for serious alarm. ZPG connected population growth to other environmental issues in its index, indicating that environmental problems are exacerbated when a large human population is present. What this represents is an opportunity where Phoenix's leadership could have questioned the nature of its large and expanding population. This report was an opportunity to ask why so many people live in Phoenix. What draws people to Phoenix?

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[405] 1. Karen O'Regan, "April 19, 1991", *City Clerk*
[406] 2. Karen O'Regan, "April 19, 1991", *City Clerk*
[407] 2. Karen O'Regan, "April 19, 1991", *City Clerk*
[408] 2. Karen O'Regan, "April 19, 1991", *City Clerk*
[409] 2. Karen O'Regan, "April 19, 1991", *City Clerk*
[410] 3. Karen O'Regan, "April 19, 1991", *City Clerk*

Is this right? Should population growth be allowed? What would the city be like if there were fewer people, or more people? Does a large population in an urban area present a threat to a city's environmental health? More questions could have been asked, but seemingly were not. The focus is to dispute ZPG's findings, rather than wonder if their index makes a valid point about Phoenix as a city and shape policy accordingly.

Citizens' Water & Wastewater Rate Advisory Committee Summary Minutes April 20, 1995

Meeting minutes from the April 20, 1995 Citizens' Water & Wastewater Rate Advisory Committee reveal the importance of growth to the city government's plans. Although economic growth and population growth would require more water to be used, the discussion of this meeting shows the city government's desire for growth. This meeting's minutes were centered on "discussion, presentation and possible action on the status of the planning department program for growth." [411] The discussion for this meeting takes place within the context of water rates and city growth.[412] In this discussion, it is noted by Mr. David Richert, Planning Department Director, that Phoenix competes with nearby cities and communities to provide housing for residents, which ultimately impacts city growth and the tax funds that flow into the community.[413] Richert says that housing is expected to expand in Chandler and Mesa, which could lead to losses in sales tax revenue for Phoenix since people often shop near their homes.[414] The prospect of losing employment is a challenge to be dealt with because it impacts potential

[411] 1. "April 20, 1995", *City Clerk*
[412] 1. "April 20, 1995", *City Clerk*
[413] 1-2. "April 20, 1995", *City Clerk*
[414] 2. "April 20, 1995", *City Clerk*

new residents' skills, which in turn influences where employers choose to locate.[415] The availability and growth of jobs impacts the amount of funding available for municipal services, and available housing is also a factor in attracting workers to an area.[416] Safety and successful schools are also part of the equation to attracting a workforce.[417] There is discussion about housing development in different parts of the city, and its impacts on the water services department and water service rates in low density housing areas at end of the meeting.[418]

Overall, the minutes of this meeting show that the motivations for population growth and housing development are to increase revenues for the city. These revenues allow the city to provide more services to residents. There is no questioning of whether this is right or ethical, especially given Phoenix's goal of water conservation. Scarce water resources, a growing population and rising temperatures would seem to indicate that increasing development and available housing is not the proper course of action for the city to take. Instead, the city's leadership should have asked about ways to reduce the population so as to prioritize the goal of water conservation. The opposite is being done in this meeting. Growth is welcomed because it will bring more money. Nor does anyone question the systems of taxation and the economics in Phoenix. The city leaders think and legislate in a limited mindset that does not seek to find creative solutions to increase revenues, while limiting the size of the population and level of water consumption. The culture of growth informs this committee's ideas and actions, while they legislate growth policies on behalf of the citizens, thus perpetuating the cycle of growth. Economic growth and population growth are goals at odds with the policy of water conservation.

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[415] 2. "April 20, 1995", *City Clerk*
[416] 2. "April 20, 1995", *City Clerk*
[417] 2. "April 20, 1995", *City Clerk*
[418] 3. "April 20, 1995", *City Clerk*

In this record, it is clear that Phoenix's city government is prioritizing its economy over long term access to water.

City Council Report January 13, 1999

A City Council report from January 13, 1999 was prepared by Michael Gritzuk, P.E. Water Services Director, titled *Update and Adoption of Phoenix Water Conservation Plan*, which was sent to George W. Britton, City Manager.[419] The report notes the success of Phoenix's water conservation methods since the 1980s, beginning with the 1986 Water Conservation Plan's initiatives, but calls for the implementation of new methods to advance the goal of water conservation as most of the initiatives cannot be repeated.[420] The point is made that Phoenix receives average rainfall totaling 7.5 inches, and that the city's water supplies will be sufficient for its current usage rates until 2025, and potentially in the years that follow, which means that water users have few incentives to invest heavily in water conservation.[421] The beginning of the third Water Management Plan in 2000 would mean that Phoenix would most likely not be able to comply with the Arizona Department of Water Resources' goals and limits for gallons per capita per day, which is what necessitates new water conservation strategies.[422] The focus of this program was to emphasize water conservation as "the right thing to do", rather than promote the cost-saving benefits.[423] One quote from this report stands out:

> Water conservation cannot be imposed on people except for a short time in a crisis situation. It must be voluntarily and willingly accepted and be a shared responsibility between the City and the citizens of Phoenix. Only when citizens embrace and practice a

[419] 1. Michael Gritzuk, "January 13, 1999", *City Clerk*
[420] 1. Michael Gritzuk, "January 13, 1999", *City Clerk*
[421] 1. Michael Gritzuk, "January 13, 1999", *City Clerk*
[422] 2. Michael Gritzuk, "January 13, 1999", *City Clerk*
[423] 2. Michael Gritzuk, "January 13, 1999", *City Clerk*

> conservation ethic and adopt water conservation as a part of their southwestern lifestyle, can the City succeed in meeting its long-term water supply goals.[424]

This quote is significant for several reasons. First, there is the admission that the government cannot impose water conservation unless there is some type of emergency. This can be taken to mean that the Phoenix city government recognized that it could not regulate how people use water in the privacy of their own homes. Water conservation programs and initiatives are ultimately only successful relative to citizens' level of participation. This is the Phoenix leadership admitting that they cannot force people to adhere to policies of conservation. Citizens will always have a degree of independence over their own water usage. The fact that water conservation can only be imposed during emergency times is indicative of the Phoenix mindset towards water usage. People want the freedom to do as they please, to consume water as they please without the regulation of the government. The need for water conservation to be successful should be thought of as a crisis in and of itself.

Thinking of water conservation as a voluntary policy that the public should willingly accept is also the wrong approach. To provide water to the population in perpetuity, the current population should have to adhere to strict water conservation and consumption policies. Economic activity and land development should be reduced. Harsh monetary fines and penalties should be imposed on those who violate consumption limits. These are the types of approaches that the Phoenix leadership should have sought to take. What is more important, protecting the Phoenix lifestyle or ensuring that water will be available to residents in the future? Water conservation demands personal, cultural and economic changes that the Phoenix city government seems unwilling to adopt in this report. The government is in control of legislating water policy,

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[424] 3. Michael Gritzuk, "January 13, 1999", *City Clerk*

and it has a responsibility to provide citizens with clean drinking water. Thus, it should recognize that is has the authority and the responsibility to take action to fulfill this obligation. To that end, if economic goals and personal lifestyles are prioritized and protected by the government, then it becomes necessary to question the purpose, the function and the nature of a government if it is unwilling to impose strict water conservation policies to protect water reserves. If citizens do not want to live in a city or state where water conservation laws are strict, then they should live elsewhere, preferably somewhere with more water and rainfall. This is the crux of the issue. People want to live comfortably in Phoenix and businesses want to thrive there, but the lack of water resources and the high rate of water consumption should signal that Phoenix may not be the location for these activities. Perhaps Arizona is not the place for it either. People should practice water conservation everywhere because it is the right thing to do. What people should not do is live in a place where it is absolutely necessary in order to protect water supplies for the future. This is indicative of a poorly planned community.

Conclusion

This section has sought to contrast Phoenix's economic growth and prosperity with its responses to water consumption levels. While positive steps were taken to promote water conservation, Phoenix's water conservation policies were limited in scope and focus. These policies did not radically alter lifestyles in Phoenix or address the underlying forces driving population growth. There was also a limit to how far Phoenix's city government was willing to go in order to implement water conservation policies. Some degree of respect from the city government for residents' control over their water usage was apparent. Phoenix's solutions in the period between 1980 and 2000 represent surface level solutions.

Chapter 5

Current Water Projections, Potential Outcomes, Policy Challenges

The purpose of this section is to propose policies that the city government of Phoenix could take in order to implement water conservation that would address Phoenix's large population and economy as threats to the future of the city's water supply. However, there are some facts to mention before these recommendations are made.

Phoenix's population has continued to grow since 2000. Phoenix's population numbers 1.6 million according to data from 2016, and it is the sixth largest city by population in the United States.[425] In one of the public records in the previous section, Phoenix was ranked as the ninth largest city in the United States in the 1990s with a population of just over one million.[426] This indicates that population growth has continued in spite of the danger presented by drought, lack of rainfall and dwindling water resources.

The policy recommendations made in this chapter each relate to reducing the size of Phoenix's population. More people require more water supplies for personal and residential consumption. Commercial and industrial activity also require the use of water. Therefore, policies should be aimed at reducing personal, residential, commercial and industrial water consumption. The best way to achieve this is by reducing the size of the population. It is not realistic for the population to grow while reducing water consumption, as there is some amount of water that all people must consume or use to function. Capping the population size at its

[425] "Phoenix Population 2018", *World Population Review*
[426] 8. Michael Gritzuk, "April 23, 1990", *City Clerk*

current level does not do enough to promote water conservation, as consumption levels would most likely remain somewhat constant or fluctuate around a certain amount. Therefore, the problem to address is how to best reduce the size of the population. This challenge requires more radical ideas and solutions that may not be realistic to achieve but may alter the conversation surrounding water conservation and water consumption levels in Phoenix.

Recent Water Supply Estimates

A study was published in 2006 with the purpose of determining Phoenix's regional water supply, titled *Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity*.[427] This study states that Phoenix did not have a "current, publicly accessible statement of its water supply from which to evaluate options for growth", which was the impetus for the conducting the study. [428] The study asserts that without this clearly defined and stated water supply, disagreements about economic policy and water management policy occur, which also makes it challenging to fully assess the costs and benefits of "development proposals or the underlying assumption that new water sources are needed for growth." [429] This research also identifies that differing water management philosophies emerge.[430] The more optimistic position desires "realistic strategies for that accept the water supply "as is" and quantify what population it can be expected to support." [431] This side wants to protect existing supplies of water while

[427] Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[428] 925. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[429] 926. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[430] 926. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[431] 926. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

encouraging an ideal amount residential growth.[432] Citing past successful policies, the more pessimistic side believes it is best to finance endeavors to find and acquire new water supplies, while aiming to provide water for the expected residential demand under current policies for growth and water.[433] An additional problem identified is the competitive nature of municipalities, which do not hold a positive view of regional cooperation to shape growth policies and water policies together.[434] Municipalities compete with each other for their own individual growth, as municipal water supplies are used to win funding development projects and expansion.[435] The position of the research paper is as follows: "The article argues that metropolitan Phoenix needs new water supply policies, not new sources, to better plan for economic growth and to achieve sustainable water management. Current policy relies on state regulations and subsidies that are rigid, ineffective, and inequitable. More importantly, these regulations promote full utilization of supplies rather than sustainability." [436] By identifying the philosophical disagreements and systemic challenges to shaping water policy, this research paper lays the foundation to examining the size of Phoenix's water supply.

Phoenix receives about half of its water supply from the subbasins below the Salt River, Agua Fria River and Gila River.[437] These basins are part of Phoenix's AMA.[438] Phoenix receives

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[432] 926. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[433] 926-927. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[434] 927. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[435] 927. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[436] 927. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[437] 929. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[438] 929. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

surface water from the Salt River and Verde River canal and reservoir systems, which are run by SRP.[439] According to this report, these sources are being overdrawn.[440] However, the report notes that its data suggests SRP is contracted to deliver more water than is actually available.[441] A discrepancy in reporting is then mentioned: "Whereas many published reports describe the annual Salt/Verde system yield at one million acre-feet, in actuality data from SRP show a significantly smaller yield between 1983 and 2002, 0.87 ± 0.2 million acre-feet in median annual diversion. Furthermore, Salt/Verde deliveries were augmented in all years with median annual groundwater withdrawals of 84,000 ± 95,000 acre-feet." [442] This report's findings call SRP's water management of the Salt River and Verde River into question. During this 19-year period, this report found that these rivers yielded less water on average than was being reported by SRP, although more water was ultimately being diverted for human use. These shortfalls in surface water supply were offset by using groundwater sources. A 2002 drought forced more groundwater to be supplied, as 276,500 acre-feet of aquifer water was included in SRP's water delivery.[443] The report calls for deeper investigation into the practice of using groundwater to supplement surface water supplies because the region's changing hydroclimatology could consistently produce even smaller yields in the future.[444] The diversion of surface water from the Agua Fria River, Salt River and Verde River has reduced the flow of these rivers, which has had

[439] 930. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[440] 930. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[441] 930. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[442] 930. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[443] 930. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[444] 930-931. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

a greater negative impact on the greater Colorado River ecosystem, as reduced water flow has changed flooding patterns and many plants and animals have been unable to adapt to conditions with less water.[445] Slower flow has had serious impact on the Salt River since the 1940s, but the Verde River has been affected more recently by dewatering.[446] SRP provides 300,000 acre-feet on average from the Verde watershed to Phoenix, but this supply is threatened by the expansion of water pumping in the upper and middle parts of the Verde River Valley.[447] At the time of this report, "Growth in the Verde Valley has doubled the number of wells, 40 percent of which are located near the mainstem or its tributaries." [448] Additional planned upstream pumping in the Prescott AMA was also expected to reduce the river's flow and impact nearby forest loss, which would in turn reduce biodiversity and streamflow, ultimately reducing Phoenix's water supply.[449]

The report states that government officials have claimed progress in reducing annual groundwater mining levels from 1.8 million acre-feet prior to 1980 to .94 million acre-feet in 1998.[450] However, this research disputes those figures with its own data that found, "Groundwater withdrawals averaged 0.97 ± 0.16 million acre-feet between 1983 and 2002 and showed little variation from the mean. This indicates a steady withdrawal of around one million acre-feet annually and is consistent with agency projections of future withdrawals between 0.6

[445] 933. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[446] 933. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[447] 933-934. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[448] 933-934. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[449] 934. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[450] 929-930. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

and 1.1 million acre feet in 2025." [451] This research found that withdrawal levels were slightly higher than reported, but ultimately in line with estimates for future projections.

The consequences of groundwater withdrawals are then discussed. Impacts of groundwater withdrawal are frequently experienced many years into the future, after decades or centuries.[452] By lowering the water table through groundwater withdrawal, other impacts are felt, such as "increased pumping costs, reduced groundwater quality, land subsidence, disconnection with surface water ecosystems, and permanent loss of aquifer storage." [453] Subsidence can also occur, which is when land moves downward relative to sea-level.[454] This can leave areas prone to flooding and damage to buildings and infrastructure.[455] The report notes that of the Phoenix AMA's seven subbasins, five "have experienced serious declines in water table and land surface", and that these areas will remain in danger of economic losses sustained from damage due to further groundwater withdrawal.[456] The report asserts that regional aquifer management has been "inadequate", and also that recharge projects for urban supplies have the potential to further damage aquifers, even basins that are more distantly connected outside the Salt River Valley. [457]

[451] 930. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[452] 932. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[453] 932. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[454] 932. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[455] 932. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[456] 932. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[457] 932-933. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

The paper proposes that policies must incentivize the sustainability of the water supply, mandate regional plans for integrated cooperation in order to receive funding from the state, and to create market incentives to shift water entitlements." [458] Regarding sustainability, this report criticizes Arizona's water policies and definitions of sustainability, which it asserts has led to mismanagement of water resources.[459] The report argues that these definitions mischaracterize what sustainability means for a water supply, focus narrowly on achieving socioeconomic goals and promote sustainability based on their practices as opposed to the results.[460] Additionally, the report claims that Arizona's water planners misunderstand what safe yield and sustainable yield mean: "The Arizona Revised Statutes define safe yield as "attempts to achieve and thereafter maintain a long-term balance between the annual amount of groundwater withdrawn in an active management area and the annual amount of natural and artificial recharge in the active management area."" [461] However, the report notes that there is ongoing debate about safe yield as a sustainable extraction of aquifer water.[462] U.S. Geological Survey scientists believe that the concept of safe yield does not account for the interconnectedness of groundwater systems to surface water systems, specifically, the capture of discharge from groundwater flows, surface flows and transpiration from vegetation.[463] Aquifers attempt to reach equilibrium after large-

[458] 928. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[459] 934. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[460] 934-935. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[461] 935-936. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[462] 936. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[463] 936. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

scale pumping by capturing recharge from other water basins.[464] This means that what constitutes safe yield groundwater withdrawal could have the effect of reducing surface water supplies and their ecosystems.[465] Additionally, groundwater sources and surface water sources have become disconnected in Phoenix because the flow of surface water is controlled by the canal and reservoir system.[466] The report also mentions that nearly every groundwater withdrawal is legally permitted, but not required to be reduced even though there are clearly groundwater overdrafts.[467]

The Phoenix AMA water supply was measured in this study by analyzing the regional water system before and after water delivery has taken place.[468] This includes "available supply, consumption, return flows and reclamation." [469] The research conducted used the U.S. Geological Survey model to calculate regional water supply, which includes the concepts of gross water supply and renewable water supply.[470] Gross water supply is defined as the theoretical amount of available water, which is calculated by adding all available water sources and subtracting water that cannot be consumed.[471] Renewable water supply is defined as the theoretical supply of water available permanently, which is calculated by subtracting "supplies

[464] 936. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[465] 936. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[466] 937. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[467] 937. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[468] 938. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[469] 938. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[470] 938-939. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[471] 938. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

that cannot maintain a constant averaged volume." [472] The renewable water supply figure is meant to be a maximum threshold of water that can be consumed consistently.[473] The U.S. Geological Survey has different definitions for renewable groundwater and surface water sources: "A renewable groundwater supply does not deplete aquifer storage. A renewable surface supply is that volume of regulated flow that can be withdrawn in 49 of 50 years." [474] This research paper also incorporates imported water supplies as part of the renewable supply in its data from 1983 to 2002.[475] Additionally, this study included water supplies likely to be available to the year 2035 as part of its renewable water supply measure.[476] This study defines opportunity cost as the difference between the gross water supply and the renewable water supply, and economic carrying capacity of the renewable supply as the renewable water supply divided by the water delivery per unit.[477] These definitions also include the following conditions: "…carrying capacity is operationalized as the maximum number of households the water supply can support without triggering a decline in the standard of living of those households. Opportunity cost is measured as that water supply and associated housing development that would be foregone in order to limit water supply to a sustainable level." [478]

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[472] 939. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[473] 939. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[474] 939. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[475] 940. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[476] 940. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[477] 940. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[478] 940-941. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

The study's findings are as follows: the median gross supply of water for metropolitan Phoenix was 4.1 million acre-feet.[479] This supply trended downward between 1983 and 2002, indicating less water was available over this period of time.[480] However, two potential causes are given: temporary drought cycles or permanent changes resulting from climate change or the over-development of water resources.[481] Gross supply was highest in 1993 with a supply of 8.4 million acre-feet, while it was lowest in 2002 with 3.5 million acre-feet.[482] Groundwater supply was correlated with both surface water supply and precipitation levels.[483] 1.6 million acre-feet was the median for annual temporary water supplies, which was made up from CAP's access to one million acre-feet of Colorado River water, as well as groundwater pumped to excess.[484] Both figures were subtracted from the total gross supply so as to calculate the supply of renewable water resources.[485] The figure for renewable water supply was found to be 2.5 ± 0.2 million acre-feet.[486] This supply came from the following sources: "locally extracted ground water, surface supplies from three tributaries of the Gila River, imported water from the Colorado River, and water reclaimed from public systems and reused." [487] The Colorado River water was calculated

[479] 941. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[480] 941. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[481] 941. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[482] 941. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[483] 942. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[484] 943. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[485] 943. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[486] 943. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[487] 943. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

to have the largest difference between gross supply and permanent supply.[488] Additionally, when measuring for renewability, the Agua Fria River, Salt River and Verde River water supplies each declined.[489] The following renewable supply was calculated: "The minimum annual renewable supply for the study period, 800,000 acre-feet, is that amount that could, in theory, have been continuously withdrawn between 1983 and 2002 without supplement from groundwater resources." [490] However, this amount of renewable water was "barely available during the 2002 drought year." [491] The report notes that computer modeling of aquifer recharge was used to generate the annual renewable supply figure of 900,000 acre-feet per year between 1983 and 2002.[492] Renewable supplies expected to be available in 2035 were calculated, but Phoenix does not have physical access to import water from three of these basins, as importation would require "significant financial, environmental and social costs." [493] As a result, water from these basins were not analyzed in this research.[494] The biggest, most reliable source of new renewable supplies in 2035 is expected to come from effluent.[495] Other supplies from CAP and non-Indian agricultural priority water are also expected to be made accessible to the renewable water supply.[496] The following calculation was made: "If the mean renewable supply from existing

[488] 943. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[489] 943. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[490] 943. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[491] 943. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[492] 944. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[493] 944. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[494] 944. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[495] 944. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[496] 944. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

sources remains at the current level, then a future renewable supply of 3.2 million acre-feet in 2035 is a reasonable estimate... This includes 700,000 acre-feet of new, renewable supplies." [497]

This research also calculated the opportunity cost of restricting water supply to only renewable water resources. Opportunity cost was measured using economic tradeoffs that could be calculated in terms of acre-feet, housing growth or jobs that would be sacrificed so as to use only renewable water supplies.[498] The opportunity cost of using only renewable supplies was calculated to be 1.6 million acre-feet annually in the time period of 1983 to 2002.[499] This was accomplished by finding the difference between gross water supplies and renewable water supplies.[500] When examining the opportunity cost for housing units, the study found that the Phoenix region could support between 4.2 million and 7.6 million housing units.[501] This range is wide as a result of "the sensitivity of the analysis to assumptions about the amount of water delivered to each housing unit." [502] This study supports the data estimates that project there will be 2.6 million housing units by 2035.[503] Limiting the water supply to 3.2 million acre-feet of renewable water would result in an opportunity cost between 2 million and 3.7 million households based on two assumptions of water delivery, 0.76 acre-feet per household and 0.42

[497] 944. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[498] 944. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[499] 944. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[500] 944. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[501] 946. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[502] 946. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[503] 946. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

acre-feet per household.[504] However, the study notes an important caveat to its projections: the residential carrying capacity was measured assuming that all renewable water would go towards housing, which is not actually possible given that, "Much of the available, renewable supply is already allocated to economic activity and cannot be easily moved to new uses." [505] The study then advocates that people use the estimates for the renewable water supply "as an upper bound on the true volume of sustainable water supply available to metropolitan Phoenix…" [506] The research notes that renewable surface and groundwater supplies, and reclaimed water supplies are most likely lower than average estimates.[507]

The economics of water usage were also studied in this research. The report states that the Phoenix region is expected to double in population between 2000 and 2030, with a 2030 population of 6.3 million.[508] The region's supply of water "is expected to remain stable or even shrink."[509] A rough estimate of acre-feet of water used in relation to economic activity is then provided. The study calculated $121.7 billion in gross regional product in 2002 with fresh water withdrawal levels of 2.4 million acre-feet, resulting in an estimate of $51,000 produced per acre-foot of water.[510] Water entitlements and inefficient transfers of CAP water titles are also cited as

[504] 946-947. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[505] 947. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[506] 947. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[507] 947-948. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[508] 949. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[509] 949. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[510] 949. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

barriers to reducing water consumption levels.[511] The research asserts that entitlements have led to an over allocation of river water resources.[512] Markets are not used in the transfer of CAP water from one party to another, which does not incentivize water customers to use water efficiently, and the report notes that there are no incentives to trade water entitlements between economic sectors.[513]

Another important economic aspect to consider is Arizona state subsidies for water usage. This study claims that "the price of water in most of Arizona is too low to benefit the social welfare." [514] Additionally, it is stated that Arizona's water policies do not account for environmental costs, which create several results: agricultural production is subsidized with cheap water prices that provide farmers with competitive advantage, the cheap price contributes to the continuation of inefficient water usage technologies like flood irrigation, and lastly, the public is not fully compensated for this water usage, which forces water providers to manage water supplies with less funding.[515] CAP subsidizes agricultural water usage and provides 60% of its water deliveries through subsidized contracts, while the Central Arizona Water Conservation District, which runs CAP, also sells the excess water, valued at $250 per acre-foot, at a price of $21 per acre-foot.[516] Municipalities that agree to participate in this subsidy are

[511] 950-951. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[512] 950. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[513] 951. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[514] 955. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[515] 956-257. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[516] 954. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

assured of access to groundwater in the future.[517] SRP also helps to subsidize water usage: "The Salt River Project Agriculture Improvement and Power District (District) operates the Salt River Project (SRP), the Valley's original federal reclamation project, through contracts with the Salt River Valley Water Users Association (Association). The District assumes obligations for the federal water infrastructure and contracts with the Association to operate an irrigation system." [518] Revenues from electricity are used for water operations, and since these two service areas overlap, SRP water consumers pay a much cheaper price for water.[519] One final subsidy comes from the Arizona Revised Statute section 48-4463, which allows Central Arizona Groundwater Replenishment District members to access and use groundwater, but replace only a fraction of the amount withdrawn.[520] This report concludes by reiterating its ideas that new water policies must be created, regional cooperation for water infrastructure development must occur, and a tax and trade market system for groundwater permits should be created so as to maximize the utility of Phoenix's water supplies.[521] In conclusion, this source provided an estimate of the amount of water available to Phoenix, as well as policy solutions that could improve water usage within the context of sustainability.

[517] 955. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[518] 955. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[519] 955. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[520] 955. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

[521] 957-958. Jan C. Bush, et. al. "Examination of the Phoenix Regional Water Supply for Sustainable Yield and Carrying Capacity", *Natural Resources Journal*

Recent Water Demand Levels

Sectoral demand figures for the different AMAs were discussed in the previous chapter, but more recent water demand levels for the Phoenix AMA show some trends that are worth noting. The Phoenix AMA is the subject of Section 8.1 of the Arizona Water Atlas. This source provides a large quantity of information for the entire AMA. In one table, more recent statistics regarding sectoral water demand are published. [522] This table examines annual quantities of water, measured in acre-feet that are sourced from wells and non-groundwater sources.[523] Additionally, these annual figures are measured with population estimates and registered wells that pump less than 35 gallons per minute and more than 35 gallons per minute.[524] A more condensed version of this table can be seen below (**Table 5**), which highlights sectoral demand between 2000 and 2005 with figures for population, well pumpage and non-groundwater sources. There are important caveats to understand when reading this table. These statistics do not include losses from evaporation.[525] These figures include data for Indian demand.[526] The non-groundwater category includes water supplies from "surface water, CAP, effluent, spill water or tailings water.[527] Lastly, agricultural demand figures from small exempt irrigation rights.[528]

[522] 170. "Phoenix AMA", *Arizona Department of Water Resources*
[523] 170. "Phoenix AMA", *Arizona Department of Water Resources*
[524] 170. "Phoenix AMA", *Arizona Department of Water Resources*
[525] 170. "Phoenix AMA", *Arizona Department of Water Resources*
[526] 170. "Phoenix AMA", *Arizona Department of Water Resources*
[527] 170. "Phoenix AMA", *Arizona Department of Water Resources*
[528] 170. "Phoenix AMA", *Arizona Department of Water Resources*

Table 5: Cultural Water Demand in the Phoenix AMA

Year	Estimated and Projected Population	Well Pumpage			Non-Groundwater		
		Municipal	Industrial	Agricultural	Municipal	Industrial	Agricultural
2000	3,118,049	254,800	78,400	519,700	685,400	67,400	745,600
2001	3,213,086	295,600	88,800	429,900	742,900	73,600	622,700
2002	3,307,260	295,600	88,800	429,900	742,900	73,600	622,700
2003	3,405,497	295,600	88,800	429,900	742,900	73,600	622,700
2004	3,513,969	295,600	88,800	429,900	742,900	73,600	622,700
2005	3,650,464	295,600	88,800	429,900	742,900	73,600	622,700

Year	Total Water Used	Total Municipal Water	Total Industrial Water	Total Agricultural Water
2000	2,351,300	940,200	145,800	1,265,300
2001	2,253,500	162,400	162,400	1,052,600
2002	2,253,500	162,400	162,400	1,052,600
2003	2,253,000	162,400	162,400	1,052,600
2004	2,253,500	162,400	162,400	1,052,600
2005	2,253,500	162,400	162,400	1,052,600

[529]

[529] 170. "Phoenix AMA", *Arizona Department of Water Resources*

It is clear in looking at this table that agriculture uses the most water in the Phoenix AMA, even if there have been decreases in using well water and non-groundwater sources. Both the municipal and industrial sectors have increased their demand for water from both sources in acre-feet. The report specifies that from 2001 to 2005, agricultural demand was 47% of the total water demand, municipal was 46% of total water mand, and industrial was 7% of total water demand.[530] Water demand projections for the years following 2005 were not available, but this table did include figures for the expected population in the AMA for 2010, 2020, 2025 and 2030.[531] The AMA's expected population in 2010 was 4,341,229, which was expected to grow to 5,561,461 in 2020.[532] In 2025, the population was expected to grow to 6,151,663 and then to 6,763,848 in 2030.[533]

Future Water Demand Levels

Examining expected water demand levels is another important task to visualizing the future of Phoenix. A study report prepared by the United States Department of the Interior Bureau of Reclamation published a study report in December 2012 titled *Colorado River Basin Water Supply and Demand Study*. Arizona is one of the seven states that receives water from the Colorado River. [534]

This report states that other studies on climate change believe that the future of the southwest will be drier and prone to more severe droughts.[535] Some studies expect the Colorado River's yield could decrease 20% as a result of climate change.[536] Another stress to Arizona and

[530] 169. "Phoenix AMA", *Arizona Department of Water Resources*
[531] 170. "Phoenix AMA", *Arizona Department of Water Resources*
[532] 170. "Phoenix AMA", *Arizona Department of Water Resources*
[533] 170. "Phoenix AMA", *Arizona Department of Water Resources*
[534] SR-2. "Colorado River Basin Water Supply and Demand Study Study Report", *USBR.gov*
[535] SR-6. "Colorado River Basin Water Supply and Demand Study Study Report", *USBR.gov*
[536] SR-6."Colorado River Basin Water Supply and Demand Study Study Report", *USBR.gov*

Phoenix's water supply is the reduction of Lake Mead. This report states that Lake Mead's capacity was at 51% in December, 2012.[537] Water surface elevation was reported to be about 1,118 feet above sea-level mean sea level (msl).[538] The amount of water in Lake Mead is important to Arizona because if the water level falls below 1,075 feet above sea-level (msl) Arizona is forced to reduce its own water apportionment per guidelines for Lake Mead's management.[539] If the lake's water level fell below 1,025 feet above sea-level (msl) then CAP's apportionment of water would be reduced by about a third.[540] Based on a 1922 agreement, Arizona is forced to cut back more on its deliveries from the Colorado River than any of the other states in the basin.[541] Arizona's cutbacks account for 96% of the river's rationing.[542] Under rationing conditions, farmers would be the first to receive less water.[543]

Using several different demand projection models, this study also estimates that Arizona's water demand for the Colorado River to increase between 0.2 and 1.2 million acre-feet by 2060.[544] The demand models used accounted for the following scenarios: Current Projected Demand, Slow Growth Demand, two differing Enhanced Environment Demands, and two differing Rapid Growth demands.[545] This report specifically cites, "The broad demand range across scenarios in these states is due to substantial growth in M&I [municipal and industrial] demand, particularly in central Arizona and the Front Range of Colorado. Increase in tribal demand is also a significant contributor to the increases in Arizona." [546] The quote speaks to a

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[537] SR-6. "Colorado River Basin Water Supply and Demand Study Study Report", *USBR.gov*
[538] SR-6. "Colorado River Basin Water Supply and Demand Study Study Report", *USBR.gov*
[539] SR-6. "Colorado River Basin Water Supply and Demand Study Study Report", *USBR.gov*
[540] SR-6-SR-7. "Colorado River Basin Water Supply and Demand Study Study Report", *USBR.gov*
[541] 67. Andrew Ross. "Bird on Fire: Lessons from the World's Least Sustainable City", *Oxford Press*
[542] 67. Andrew Ross. "Bird on Fire: Lessons from the World's Least Sustainable City", *Oxford Press*
[543] 67. Andrew Ross. "Bird on Fire: Lessons from the World's Least Sustainable City", *Oxford Press*
[544] SR-31. "Colorado River Basin Water Supply and Demand Study Study Report", *USBR.gov*
[545] SR-30. "Colorado River Basin Water Supply and Demand Study Study Report", *USBR.gov*
[546] SR-34. "Colorado River Basin Water Supply and Demand Study Study Report", *USBR.gov*

high water consumption rate for the Phoenix area because this region is identified as one of the driving forces behind increases in future water demand.

Climate change and rising temperatures play a role in this report's estimations for future supply and demand. The study reports that the temperatures throughout the entire basin are expected to increase 1.3 degrees Celsius between 2011 and 2040, and by 2.4 degrees Celsius between 2041 and 2070 based on comparisons to the period between 1971 and 2000.[547] The Lower Basin, where Arizona is located, is expected to experience decreases in fall and winter precipitation levels.[548] Snowpack levels are expected to decrease throughout the Basin, as a result of earlier melting and sublimation of snowpack, and because more precipitation is expected to fall as rain, as opposed to snow.[549] Levels for runoff are also predicted to decrease throughout the Basin.[550]

The study projects a 3.2 million acre-feet imbalance between water supply and water demand for the entire Colorado River Basin by 2060.[551] This projection is based on comparisons between median water supply and median water demand projections from the different demand scenarios.[552] The study mentions that using these median projections means that the imbalance could be greater than or less than the median projections in each scenario from year to year.[553]

Cape Town, South Africa Approaches Day Zero

[547] SR-19. "Colorado River Basin Water Supply and Demand Study Study Report", *USBR.gov*
[548] SR-19. "Colorado River Basin Water Supply and Demand Study Study Report", *USBR.gov*
[549] SR-19. "Colorado River Basin Water Supply and Demand Study Study Report", *USBR.gov*
[550] SR-19-SR-20. "Colorado River Basin Water Supply and Demand Study Study Report", *USBR.gov*
[551] SR-36. "Colorado River Basin Water Supply and Demand Study Study Report", *USBR.gov*
[552] SR-36. "Colorado River Basin Water Supply and Demand Study Study Report", *USBR.gov*
[553] SR-36. "Colorado River Basin Water Supply and Demand Study Study Report", *USBR.gov*

It is clear that Phoenix faces challenges in the future as it seeks to provide water to a growing population and economy that will have an increasing demand for water. There is a degree of uncertainty about its water supply as temperatures are expected to rise. As this thesis is being written in the spring of 2018, Cape Town, South Africa is currently in the midst of its own water crisis. [554] The population of Cape Town's metropolitan area is 4 million.[555] This is comparable to the population of the Phoenix metropolitan area. The water shortage in Cape Town has been the result of drought.[556] An article titled *Cape Town contends with worst drought in over a century* from CNN on June 1, 2017 outlines some of the causes of the drought.[557] At the time this article was written, Cape Town's had less than 10% of its useable water supply available for citizens.[558] Citizens were limited to consuming 100 liters, or 26 gallons, per person per day as a way to reduce demand and stretch water supply.[559] This article identified population growth, El Niño Southern Oscillation (ENSO) and climate change as threats to Cape Town's water supply.[560] Cape Town receives water from reservoirs which have been shrinking due to desertification.[561] The Western Cape is the region where Cape Town is located, its largest dam and largest water reservoir supply, Theewaterskloof Dam, was at 13.7% capacity at the time this article was written.[562] Patricia de Lille, Cape Town's Executive Mayor, explained in a quote how climate change influences the city's plans for water management: "Climate change is a reality and we cannot depend on rainwater alone to fill our dams, but must look at alternative sources

[554] Paul P Murphy. "In Less than 3 Months, a Major International City Will Likely Run out of Water", *CNN*
[555] Paul P Murphy. "In Less than 3 Months, a Major International City Will Likely Run out of Water", *CNN*
[556] Paul P Murphy. "In Less than 3 Months, a Major International City Will Likely Run out of Water", *CNN*
[557] Derek Van Dam. "Cape Town contends with worst drought in over a century", *CNN*
[558] Derek Van Dam. "Cape Town contends with worst drought in over a century", *CNN*
[559] Derek Van Dam. "Cape Town contends with worst drought in over a century", *CNN*
[560] Derek Van Dam. "Cape Town contends with worst drought in over a century", *CNN*
[561] Derek Van Dam. "Cape Town contends with worst drought in over a century", *CNN*
[562] Derek Van Dam. "Cape Town contends with worst drought in over a century", *CNN*

like desalination and underground aquifers." [563] Accepting climate change as a given is an important step that de Lille has taken as the leader of Cape Town's government. With an expectation that climate change will produce variability for measures of precipitation, temperature and water supply, this mindset puts Cape Town's government in a better position to manage its water. Climate change has reduced the frequency of winter cold fronts that produce rain in Cape Town.[564] A high pressure area in the Atlantic Ocean is preventing westerly winds from carrying precipitation to Cape Town.[565] An Intergovernmental Panel on Climate Change (IPCC) report expects this high pressure area to strengthen and contribute further to reduced rainfall levels.[566] The article states that climate change will influence the amount of rainfall produced and where it is distributed.[567] This article concludes by saying, "The reality is that the current water crisis in Cape Town shouldn't be treated as a short-term occurrence, but rather as a long-term problem. It requires strong governance to sustain the city's limited water resources into the future," and then, "Ultimately, though, water conservation begins at home." [568]

Cape Town is approaching "Day Zero", which is when taps will run dry.[569] To provide an understanding of how citizens are coping, people in Cape Town are forced to recycle bath water to flush toilets and take showers under 2 minutes.[570] A CNN article from January 31, 2018 titled *In Less than 3 Months, a Major International City Will Likely Run out of Water* reported that Cape Town was still using 86 million liters more than its target water usage amount.[571] At the

[563] Derek Van Dam. "Cape Town contends with worst drought in over a century", *CNN*
[564] Derek Van Dam. "Cape Town contends with worst drought in over a century", *CNN*
[565] Derek Van Dam. "Cape Town contends with worst drought in over a century", *CNN*
[566] Derek Van Dam. "Cape Town contends with worst drought in over a century", *CNN*
[567] Derek Van Dam. "Cape Town contends with worst drought in over a century", *CNN*
[568] Derek Van Dam. "Cape Town contends with worst drought in over a century", *CNN*
[569] Paul P Murphy. "In Less than 3 Months, a Major International City Will Likely Run out of Water", *CNN*
[570] Paul P Murphy. "In Less than 3 Months, a Major International City Will Likely Run out of Water", *CNN*
[571] Paul P Murphy. "In Less than 3 Months, a Major International City Will Likely Run out of Water", *CNN*

time this article was written, city officials had changed Day Zero from April 22, 2018 to April 12, 2018.[572] Day Zero has recently been moved back to mid-July.[573] The mayor of Cape Town's office issued a statement that said, "We can no longer ask people to stop wasting water. We must force them." [574] A scenario like this is ominous. In the absence of successful voluntary water conservation, the city government clearly believes it must impose mandatory restrictions because the situation is so dire. Another problem is that citizens are buying items that can store or hold water, and filling these items with water from the city's supply, taking even more away from the city for personal use.[575] An additional problem that citizens have mentioned is the fear of drinking tap water, which has driven them to go to centralized locations to obtain an allotment of water.[576] Cape Town's city government has been forced to take over management of centralized water sites by controlling crowds and limiting operating hours to certain times.[577]

Economic inequality plays into this crisis as well. Those who have the money have left Cape Town temporarily as a way to alleviate water demand.[578] However, some groups, like disabled peoples, the elderly and those in poverty do not have the same luxury to pack up and leave.[579] Some cannot afford to purchase bottled water, or stores run out of their bottled water stock before they can receive a new shipment.[580] A citizen who was interviewed for this CNN article gave a particularly ominous statement at the article's conclusion, "It's been a hard transition because a lot of Capetonians aren't understanding how we got to this point when the

[572] Paul P Murphy. "In Less than 3 Months, a Major International City Will Likely Run out of Water", *CNN*
[573] Craig Welch. "Why Cape Town Is Running Out of Water, and Who's Next", *National Geographic*
[574] Paul P Murphy. "In Less than 3 Months, a Major International City Will Likely Run out of Water", *CNN*
[575] Paul P Murphy. "In Less than 3 Months, a Major International City Will Likely Run out of Water", *CNN*
[576] Paul P Murphy. "In Less than 3 Months, a Major International City Will Likely Run out of Water", *CNN*
[577] Paul P Murphy. "In Less than 3 Months, a Major International City Will Likely Run out of Water", *CNN*
[578] Paul P Murphy. "In Less than 3 Months, a Major International City Will Likely Run out of Water", *CNN*
[579] Paul P Murphy. "In Less than 3 Months, a Major International City Will Likely Run out of Water", *CNN*
[580] Paul P Murphy. "In Less than 3 Months, a Major International City Will Likely Run out of Water", *CNN*

municipality was well-informed that we would experience a drought…There are a lot of angry people and not enough answers on how this is going to be resolved." [581] This quote is relevant because the citizen interviewed states that Cape Town's citizens had an expectation that their city government could be relied upon to successfully prepare the city for drought. It seems that the people trusted their city government to create a comprehensive plan to guide the city's water management. Nonetheless the city has reached this crisis point where water is scarce and in high demand, and Day Zero approaches.

As a way to prepare for Day Zero, Cape Town is creating 200 emergency water stations that are intended to serve about 20,000 residents each.[582] The use of tap water for car washes, pools or water gardens has been declared illegal.[583] A National Geographic article titled *Why Cape Town is Running Out of Water, and Who's Next* states that in January 2018, Cape Town requested that citizens reduce water usage to 50 liters per day, or about 13 gallons.[584] A quote from David Olivier, a Global Change Institute research fellow at University of the Witwatersrand in South Africa is also telling: "The fundamental problem is the kind of lifestyle we're living. There's almost a sense of entitlement that we have a right to consume as much as we want. The attitude and reaction of most posts on social media is indignation. It's 'we pay our taxes' and therefore we should be as comfortable as possible." [585] Based on this quote, there seems to be a cultural mindset that promotes overdraft of water resources even in Cape Town. This quote also portrays a degree of selfishness as it relates to water conservation. Olivier's quote suggests that people are focused on securing their own level of comfort, rather than coming together to find

[581] Paul P Murphy. "In Less than 3 Months, a Major International City Will Likely Run out of Water", *CNN*
[582] Craig Welch. "Why Cape Town Is Running Out of Water, and Who's Next", *National Geographic*
[583] Craig Welch. "Why Cape Town Is Running Out of Water, and Who's Next", *National Geographic*
[584] Craig Welch. "Why Cape Town Is Running Out of Water, and Who's Next", *National Geographic*
[585] Craig Welch. "Why Cape Town Is Running Out of Water, and Who's Next", *National Geographic*

ways to reduce water consumption. The quote also portrays disconnect between individual attitudes and actions, and their collective impacts on a greater community level. It seems that the view in Cape Town is to think of one's water usage in isolation, rather than as an aggregate to city-wide water usage. In this case, an attitude that minimizes individual impacts on a greater system is an invitation to personal inaction for the purpose of changing behavior or finding a solution to a common problem.

It is fascinating that Cape Town is experiencing this crisis when it has previously been lauded for its water management policies by winning international water management awards.[586] The National Geographic article states that Cape Town made a concerted effort to protect itself against water shortages over the past 20 years by reducing water usage from large reservoirs, reducing per capita water consumption, reducing leaks, raising water consumption prices and promoting water efficiency.[587] The largest water users have even had their names published publicly as a way to shame them.[588] However, this article notes that city officials believed past precipitation levels would continue, which was a critical mistake.[589] According to the article, Cape Town officials knew that population growth and climate change necessitated the discovery of new water sources 10 years ago.[590] Although Cape Town's dams were full in 2014, the subsequent three years of drought have put the city in this dire situation.[591] Data shows that reservoirs are currently at 26% capacity, which is critical because the city plans to shut off tap water when reservoirs reach 13.5%.[592]

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[586] Craig Welch. "Why Cape Town Is Running Out of Water, and Who's Next", *National Geographic*
[587] Craig Welch. "Why Cape Town Is Running Out of Water, and Who's Next", *National Geographic*
[588] Craig Welch. "Why Cape Town Is Running Out of Water, and Who's Next", *National Geographic*
[589] Craig Welch. "Why Cape Town Is Running Out of Water, and Who's Next", *National Geographic*
[590] Craig Welch. "Why Cape Town Is Running Out of Water, and Who's Next", *National Geographic*
[591] Craig Welch. "Why Cape Town Is Running Out of Water, and Who's Next", *National Geographic*
[592] Craig Welch. "Why Cape Town Is Running Out of Water, and Who's Next", *National Geographic*

Timely reactions and responses from institutions are identified as critical going forward to keep pace with changes in water supply.[593] Two institutions that control Cape Town's water, the ruling party in Cape Town and the African National Congress, expected Cape Town's drought to be a short-term problem that would work itself out on its own.[594] The National Geographic article includes a quote indicating that these organizations have now realized the impact of climate change, as well as the fact that water demand is going to increase.[595] In current efforts to find new sources of water for Cape Town, more wells are being drilled, four desalination plants are being constructed and an effluent treatment plant is also being constructed.[596]

Cape Town's water struggles can be used to understand worst-case scenarios for Phoenix. Cape Town has a similar population to Phoenix. Even though Cape Town is located near the ocean and has a Mediterranean climate, the city is still arid and surrounded by desert.[597] Drought poses a threat to both cities' supplies of water. There also seem to be some cultural attitudes at play which inform individuals to disregard water conservation efforts. Additionally, both cities have worked to shape policies that encourage water conservation, yet both remain vulnerable to experiencing higher demand for water than is available for consumption. A major takeaway from Cape Town that could help Phoenix would be to assume that climate change will continue. Using this assumption, Phoenix could better create policies that assure water supplies in dire times, such as multiple year droughts. Population growth was identified as a catalyst for increasing water demand. It would be prudent for Phoenix to examine how many more people and how

[593] Craig Welch. "Why Cape Town Is Running Out of Water, and Who's Next" *National Geographic*
[594] Craig Welch. "Why Cape Town Is Running Out of Water, and Who's Next", *National Geographic*
[595] Craig Welch. "Why Cape Town Is Running Out of Water, and Who's Next", *National Geographic*
[596] Craig Welch. "Why Cape Town Is Running Out of Water, and Who's Next", *National Geographic*
[597] Craig Welch. "Why Cape Town Is Running Out of Water, and Who's Next", *National Geographic*

much more industrial and agricultural production can be sustained by current and future water supplies during severe droughts.

Other Cities Struggling with Water Management

Water scarcity is a problem throughout the world, not just in Cape Town and Phoenix. Mexico City residents receive running water at certain times throughout the day, and some only receive a few hours of running water for an entire week.[598] Reports in Melbourne, Australia estimate that the city's water supply could be depleted in a decade.[599] In Jakarta, Indonesia, people are using water at such a rate that the city is sinking faster than the rate of rising sea levels.[600] In 2015, water shortages in Sao Paulo, Brazil's reservoirs caused pipes to draw in mud.[601] Residential water flows were reduced to a few hours twice a week.[602] The National Geographic article states that Sao Paulo reached a point where its water supply would only last for 20 days.[603] Fortunately, rains came and the city did not have shut off its taps.[604] The article cites that the following causes are leading to increased competition for water, "Competition for water is increasing, as population growth drives demand for drinking water and agriculture and as countries become more affluent. In fact, cities aren't always aware that the water they think they can count has been claimed or polluted or is being consumed by other users." [605] This quote echoes some of the challenges that Phoenix faces, as well as a degree of uncertainty in assuring an adequate supply of water. Identifying affluence as a driver of increased water demand is important because it relates to a

[598] Craig Welch. "Why Cape Town Is Running Out of Water, and Who's Next", *National Geographic*
[599] Craig Welch. "Why Cape Town Is Running Out of Water, and Who's Next", *National Geographic*
[600] Craig Welch. "Why Cape Town Is Running Out of Water, and Who's Next", *National Geographic*
[601] Craig Welch. "Why Cape Town Is Running Out of Water, and Who's Next", *National Geographic*
[602] Craig Welch. "Why Cape Town Is Running Out of Water, and Who's Next", *National Geographic*
[603] Craig Welch. "Why Cape Town Is Running Out of Water, and Who's Next", *National Geographic*
[604] Craig Welch. "Why Cape Town Is Running Out of Water, and Who's Next", *National Geographic*
[605] Craig Welch. "Why Cape Town Is Running Out of Water, and Who's Next", *National Geographic*

cultural mindset that both Cape Town and Phoenix share in common. People in these cities seem to want a comfortable lifestyle where they can consume water as they please. This quote also reinforces the idea that cities may be under the impression that they have more water than is actually available.

Alternative Futures

Phoenix's history has been discussed and analyzed throughout this thesis. It is worth wondering what Phoenix would be like in 2018 if different decisions had been made in the past, or if water consumption levels were different. What if a policy like Proposition 202 had been successfully enacted in Arizona? What would Phoenix's population be today? How much water could have been saved if Phoenix was able to reduce daily per capita water consumption between 1980 and 2018? These questions, and many others, are important to ask when thinking about future water management policies. Perhaps another country, region or community can view what has happened in Phoenix throughout its history, and avoid making the same choices that have placed Phoenix in its current position, as a city that expects to nearly double in population by 2030, while water demand increases and water supply dwindles as a result of climate change and agricultural, industrial and municipal consumption. Using some of the data and statistics from sources, tables and figures discussed earlier, this section will aim to show some of the outcomes that could have been produced if Phoenix had consumed water differently or had fewer people. Specifically, this section will compare different scenarios for the Phoenix AMA's municipal, industrial and agricultural water demand.

First, different levels of municipal sector per capita water consumption will be calculated using data from *Evolution and Evaluation of the Active Management Area Management Plans*.

The purpose of this section is to imagine hypothetical changes to water consumption. As a result, this section will combine different figures from different time periods as a means to demonstrating the potential to reduce water usage.

It is helpful to look at the municipal water demand figures from Table 3. The Phoenix AMA's 1980 population was 1,470,000.[606] This figure includes the entire AMA, not just Phoenix. The 1980 population was chosen to create comparisons because it is about half of the Phoenix AMA's current population in 2018, 3,100,000.[607] Additionally, this population number was used because more data for water usage became available in the 1980s, and water conservation became a bigger public issue. When looking at Table 5, the Prescott AMA's population consumed 131 gallons per capita per day in 1985 in comparison to the Phoenix AMA, which consumed 308 gallons per capita per day in 1985. The Prescott AMA's water consumption in 1985 is far and away the lowest of any in this table, while the Phoenix AMA is much higher than the rest. The idea behind this calculation is that if people in another part of Arizona could use much less water, then people in Phoenix could use less as well. The calculation that follows can be found in Appendix A (**Calculation 1**).

If the Phoenix AMA had consumed 131 gallons per capita per day with a population of 1,470,000, then 192,570,000 gallons of water would have been consumed on a daily basis. If the Phoenix AMA consumed the reported level for 1985, 308 gallons per capita per day, then Phoenix would have consumed 452,760,000 gallons of water. The difference between 452,760,000 gallons and 192,570,000 gallons is 260,190,000 gallons. This is a massive

[606] 169. "Phoenix AMA", *Arizona Department of Water Resources*
[607] 169. "Phoenix AMA", *Arizona Department of Water Resources*

difference in the amount of water that could have been available each day if the AMA had reduced its gallons per capita per day consumption to the Prescott AMA's level.

Another comparison to look at involves changes in the Phoenix AMA's industrial water demand. The Phoenix AMA's water demand should not be compared to water demands in the other AMAs because Phoenix's is so much larger. This is different from the previous comparison, where it is possible for people change their lifestyle and water consumption habits via a personal choice. It is much more difficult and unrealistic to expect a sizably larger industrial sector in one place to reduce its water consumption to a smaller sector's levels.

The Phoenix AMA's 1985 annual industrial water demand was 73,485 acre-feet, and increased in the subsequent periods when it was measured again.[608] Based on data from the Phoenix AMA management plan in Table 2, water pumped from wells and from non-groundwater sources for industrial use totaled 162,400 acre-feet in 2005.[609] Data from this source does not include demand figures past 2005. The purpose of this comparison is to show how much water would have been consumed for industrial use in acre-feet between 2005 and 2018, using the 1985 and 2005 demand levels as constants. This calculation can be found in Appendix A (**Calculation 2**). Had the Phoenix AMA's industrial water use remained at its 1985 levels between 2005 and 2018, 955,305 acre-feet of water would have been consumed. Using 2005 industrial water use levels, the Phoenix AMA would have used 2,111,200 acre-feet during this same period. The difference between these figures over this time period is 1,155,895 acre-feet of water.

[608] 18 Sharon B. Megdal, et. al. "Evolution and Evaluation of the Active Management Area Management Plans", azwater.gov

[609] 170. "Phoenix AMA", *Arizona Department of Water Resources*

Finally, the Phoenix AMA used its lowest amount of agricultural water in 1998, when it consumed 1,021,155 acre-feet annually.[610] These figures can be seen in Table 4. However, in 1985, the Phoenix AMA annually consumed 1,363,530 acre-feet of water.[611] Agricultural water demand has fluctuated over time for this AMA.[612] This comparison will examine how the Phoenix AMA would have consumed water over time if its lowest consumption rate remained constant with the 1998 rate. These calculations can be found in Appendix B (**Calculation 3**).

If the Phoenix AMA could have used 1,021,155 acre-feet annually between 1985 and 1990, then 5,110,775 acre-feet would have been consumed. Using 1985's consumption rate of 1,363,530 acre-feet annually, the Phoenix AMA actually consumed 6,817,650 acre-feet over this time period. The difference between these rates is 1,711,895 acre-feet.

Between 1985 and 1998, the Phoenix AMA would have used 13,275,015 acre-feet with 1998-level consumption rates. The Phoenix AMA could have also saved water had its agricultural water demand been lower between 1985 and 1990. Agricultural demand decreased after 1985, then increased, and decreased again between 1990 and 1998. The sum of acre-feet demanded by the Phoenix AMA between 1985 and 1998 was 15,264,815 acre-feet when adding the water demand rates for 1985 to 1990, 1990 to 1995 and 1995 to 1998. Phoenix would have used 1,989,800 less acre-feet if its demand had remained constant with the 1998 rate over this time period. Calculations can be found in Appendix B (**Calculation 4**).

Using different measures, this section has shown optimal situations where the Phoenix AMA could have saved water over varying periods of time in its past. While this section's

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[610] 30 Sharon B. Megdal, et. al. "Evolution and Evaluation of the Active Management Area Management Plans", azwater.gov

[611] 30 Sharon B. Megdal, et. al. "Evolution and Evaluation of the Active Management Area Management Plans", azwater.gov

[612] 30 Sharon B. Megdal, et. al. "Evolution and Evaluation of the Active Management Area Management Plans", azwater.gov

calculations have been hypothetical, they are important because the potential to conserve large quantities of water is so critical to have for the future. Had Phoenix saved more water in the past, it could have placed itself in a better position moving forward if an event like Cape Town's drought was to occur in Phoenix.

Barriers to Change: Municipal Cooperation and Politics

One of the difficulties in inspiring forward-thinking, long-term planning for climate change is articulated in Andrew Ross' book, *Bird on Fire: Lessons from the World's Least Sustainable City*. In one passage, Ross writes about the popularity of apocalyptic films and environmental disasters. [613] There is an expectation that people will experience climate change through massive, momentous events.[614] Climate change deniers use the absence of these kinds of events as further proof for their belief that climate change does not exist.[615] However, Ross notes that climate change can be seen all around when looking at "the die-off of oceans, forests, reefs and habitats, desertification or salinization of soil, species extinction, and bioaccumulation of carcinogenic toxins." [616] Ross discusses the difficulty in portraying these phenomena to the public and the difficulty in recognizing changes like global warming because they happen slowly.[617]

When writing about the Hohokam, Ross states that the outcome of a civilization in danger would be determined more by how residents work together to avoid the least desirable outcomes.[618] This exemplifies the importance of cooperation as it regards Phoenix's water

[613] 43-44. Andrew Ross. "Bird on Fire: Lessons from the World's Least Sustainable City", *Oxford Press*
[614] 43-44. Andrew Ross. "Bird on Fire: Lessons from the World's Least Sustainable City", *Oxford Press*
[615] 43-44. Andrew Ross. "Bird on Fire: Lessons from the World's Least Sustainable City", *Oxford Press*
[616] 44. Andrew Ross. "Bird on Fire: Lessons from the World's Least Sustainable City", *Oxford Press*
[617] 44. Andrew Ross. "Bird on Fire: Lessons from the World's Least Sustainable City", *Oxford Press*
[618] 50. Andrew Ross. "Bird on Fire: Lessons from the World's Least Sustainable City", *Oxford Press*

management practices because rights to water in Arizona are dictated by prior appropriation, which means that the first beneficial users obtain the rights to that particular water source.[619] Communities at the outer edge of urban areas have a less stable water supply than those in the center.[620] This creates the potential for a future scenario where some communities in the Salt River Valley run out of water before others, which would produce a scenario where some communities have the power to divert their own water to others, or to keep it for themselves.[621] Additionally, Phoenix's water management has been difficult to regulate because there are 120 water providers in the Salt River Valley that vary in size.[622]

Ross writes that making use of better technology or tightening regulations are poor choices to fix problems related to unsustainable growth levels.[623] The costs to implement these changes rise, which leads people to fight against higher taxes that would fund these solutions.[624] Many come to view taxes for environmental regulation as a restriction of personal freedom, and support for lower taxes strengthens while people enjoy subsidized costs for water and nonrenewable energy that do not reflect their impact on the environment.[625] This type of anti-regulation, small government preference aligns with the political scene in Arizona. However, in Ross' view, there is a serious need for people to come together in solidarity for the purpose of water conservation, rather than to fight stricter regulations or refuse to allocate water to other communities. Ross asserts that communities with little precipitation thrive when they come

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[619] 73-74. Andrew Ross. "Bird on Fire: Lessons from the World's Least Sustainable City", *Oxford Press*
[620] 70. Andrew Ross. "Bird on Fire: Lessons from the World's Least Sustainable City", *Oxford Press*
[621] 71. Andrew Ross. "Bird on Fire: Lessons from the World's Least Sustainable City", *Oxford Press*
[622] 70. Andrew Ross. "Bird on Fire: Lessons from the World's Least Sustainable City", *Oxford Press*
[623] 50. Andrew Ross. "Bird on Fire: Lessons from the World's Least Sustainable City", *Oxford Press*
[624] 50. Andrew Ross. "Bird on Fire: Lessons from the World's Least Sustainable City", *Oxford Press*
[625] 50-51. Andrew Ross. "Bird on Fire: Lessons from the World's Least Sustainable City", *Oxford Press*

together to create collaborative water management plans, citing Mormons in Utah's Great Basin as an example.[626]

Harvey Molotch's urban growth machine concept demonstrates how a community's institutions can change and become focused on the idea that growth is good. [627] Those in charge of leading a community see growth as a positive because everyone seems to benefit from it.[628] However, in reality many forms of urban growth are actually not beneficial, and costs higher than the benefit the public receives are incurred in order to provide infrastructure and services.[629] According to Ross, environmental costs "would surely break apart every municipal budget" if they were accounted for. [630]

Ross writes that land development has always been a major part of Phoenix's identity because the land is viewed as something to be used for economic gain.[631] Phoenix's culture of growth is so dominating that academic researchers have to be careful when discussing environmental problems, or their research will not be seriously considered by the majority Republican leadership in the state, which disregards the validity of scientific evidence pointing towards climate change.[632]

In Phoenix, growth has been encouraged because, "Growth A does not pay for itself, so it begets Growth B to cover the costs of A, and so on." [633] In the end, paying for growth does not occur until an economic crash occurs.[634] In the case of the Great Recession, "debts simply got

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[626] 72. Andrew Ross. "Bird on Fire: Lessons from the World's Least Sustainable City", *Oxford Press*
[627] 81. Andrew Ross. "Bird on Fire: Lessons from the World's Least Sustainable City", *Oxford Press*
[628] 81. Andrew Ross. "Bird on Fire: Lessons from the World's Least Sustainable City", *Oxford Press*
[629] 81. Andrew Ross. "Bird on Fire: Lessons from the World's Least Sustainable City", *Oxford Press*
[630] 81. Andrew Ross. "Bird on Fire: Lessons from the World's Least Sustainable City", *Oxford Press*
[631] 56. Andrew Ross. "Bird on Fire: Lessons from the World's Least Sustainable City", *Oxford Press*
[632] 63-64. Andrew Ross. "Bird on Fire: Lessons from the World's Least Sustainable City", *Oxford Press*
[633] 82. Andrew Ross. "Bird on Fire: Lessons from the World's Least Sustainable City", *Oxford Press*
[634] 82. Andrew Ross. "Bird on Fire: Lessons from the World's Least Sustainable City", *Oxford Press*

restructured, repackaged, and sold as derivatives." [635] Here, Ross demonstrates the short-term attitude and approach to managing a city that Phoenix had during its period of massive growth. In fact, Ross writes that proposing growth limit to the amount of people that could be supported by the city's water resources "had not been a politically feasible option during the region's sixty-year growth spurt." [636] The growth mindset is so embedded in Phoenix that the very prospect of limiting growth because of limits to the water supply is considered unconscionable by the very people elected to govern, legislate and plan for the city.

Under the original Groundwater Management Act of 1980, new homes were supposed to receive building permits only if they had an assured water supply that would last for 100 years.[637] However, development lobbyists influenced the drafting of the bill, and a clause was placed in the act allowing developers who did not have this assured water supply to pay a Groundwater Replenishment District (GRD) agency for aquifer recharge in other areas with the same amount of water from CAP.[638] However, the GRD did not have to have the assured water supply of 100 years.[639] This provision essentially allowed developers to exploit state water management policy for their own gain.

Proposition 202, a proposal to limit urban growth, was successfully placed on the state's ballot in 2000 after a Morrison Institute study found that urban growth does not pay for itself.[640] This bill proposed urban growth boundaries for every city, county and town in Arizona with more than 2,500 people.[641] This bill was the first to propose state-wide growth control.[642] The

[635] 82. Andrew Ross. "Bird on Fire: Lessons from the World's Least Sustainable City", *Oxford Press*
[636] 82. Andrew Ross. "Bird on Fire: Lessons from the World's Least Sustainable City", *Oxford Press*
[637] 69. Andrew Ross. "Bird on Fire: Lessons from the World's Least Sustainable City", *Oxford Press*
[638] 69. Andrew Ross. "Bird on Fire: Lessons from the World's Least Sustainable City", *Oxford Press*
[639] 69. Andrew Ross. "Bird on Fire: Lessons from the World's Least Sustainable City", *Oxford Press*
[640] 83. Andrew Ross. "Bird on Fire: Lessons from the World's Least Sustainable City", *Oxford Press*
[641] 83. Andrew Ross. "Bird on Fire: Lessons from the World's Least Sustainable City", *Oxford Press*
[642] 83. Andrew Ross. "Bird on Fire: Lessons from the World's Least Sustainable City", *Oxford Press*

proposal initially polled at 70% in favor, but ultimately lost with 70% voting against after pro-growth interests lobbied against it.[643]

Political entanglements in Phoenix and throughout Arizona create a political climate where even proposing growth-reducing policies cannot be considered or passed. One Arizona political figure, Grady Gammage, Jr., was one of the more vocal detractors to Proposition 202.[644] Gammage is a land-use attorney who also worked at the Morrison Institute as a public policy advocate.[645] Gammage's father was president of Arizona State University for 30 years, and had also invested in local land development projects.[646] Proponents for Proposition 202 tried to gain Gammage's support, but were ultimately rebuffed, with Gammage claiming that he could not support the bill because he represented prominent land developers.[647] Gammage did not think it was a well-thought proposal, and he believed that it would be a better plan for cities that were on the verge of running out of land.[648] Gammage defends Phoenix's growth patterns as "heritage", claiming that Phoenix's ranch homes are symbolic of Phoenix itself and the city's lifestyle.[649]

The impact of the land development industry cannot be understated. After a housing crash, a 1988, an article estimated "that 20% of the region's jobs and one third of economy's dollars were tied to land development." [650] Arizona Strategic Planning for Economic Development (ASPED) was formed to diversify the region's economy, but the housing market's recovery led to its reemergence as a dominant economic force and employer.[651] During the Great

[643] 83. Andrew Ross. "Bird on Fire: Lessons from the World's Least Sustainable City", *Oxford Press*
[644] 83. Andrew Ross. "Bird on Fire: Lessons from the World's Least Sustainable City", *Oxford Press*
[645] 83. Andrew Ross. "Bird on Fire: Lessons from the World's Least Sustainable City", *Oxford Press*
[646] 83. Andrew Ross. "Bird on Fire: Lessons from the World's Least Sustainable City", *Oxford Press*
[647] 84. Andrew Ross. "Bird on Fire: Lessons from the World's Least Sustainable City", *Oxford Press*
[648] 84. Andrew Ross. "Bird on Fire: Lessons from the World's Least Sustainable City", *Oxford Press*
[649] 85. Andrew Ross. "Bird on Fire: Lessons from the World's Least Sustainable City", *Oxford Press*
[650] 87. Andrew Ross. "Bird on Fire: Lessons from the World's Least Sustainable City", *Oxford Press*
[651] 87. Andrew Ross. "Bird on Fire: Lessons from the World's Least Sustainable City", *Oxford Press*

Recession, Phoenix's regional economy collapsed because of the housing market.[652] In 2009, Arizona had the highest number of job losses in the United States, with unemployment measured at over 10%. [653] Housing values dropped by 50% and 70,000 homes had been foreclosed.[654] In 2010, about 66,000 Arizona homeowners lost their homes to mortgage holders.[655] Given the influence that the development industry has on Arizona's economy and Phoenix's economy, it makes sense that the city overdeveloped its housing supply. Overreliance on the development industry to produce economic growth is indicative of poor governance. The growth mindset, the Republican control of Arizona politics and the development industry's ability to influence policymakers have conspired to create a system of economics and politics that promotes growth above all else.

Robert Jerome Glennon's book *Water Follies: Groundwater Pumping and the Fate of America's Fresh Waters* narrates similar political difficulties to changing water management in Arizona. [656] In one chapter, Glennon covers the excessive groundwater pumping of the San Pedro River, near Sierra Vista, Arizona.[657] Glennon writes that the river received attention in 1999 because the river was listed as endangered, which had greater environmental implications, as the river is an important location for the Western Hemisphere's migrating bird populations.[658] Glennon writes that at the time politicians and land development interests were concerned that the increased attention directed towards the river "may retard growth", and a political battle

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[652] 86. Andrew Ross. "Bird on Fire: Lessons from the World's Least Sustainable City", *Oxford Press*
[653] 86. Andrew Ross. "Bird on Fire: Lessons from the World's Least Sustainable City", *Oxford Press*
[654] 86. Andrew Ross. "Bird on Fire: Lessons from the World's Least Sustainable City", *Oxford Press*
[655] 86. Andrew Ross. "Bird on Fire: Lessons from the World's Least Sustainable City", *Oxford Press*
[656] Robert Jerome Glennon. "Water Follies: Groundwater Pumping and the Fate of America's Fresh Waters", *Island Press*
[657] 54. Robert Jerome Glennon. "Water Follies: Groundwater Pumping and the Fate of America's Fresh Waters", *Island Press*
[658] 54. Robert Jerome Glennon. "Water Follies: Groundwater Pumping and the Fate of America's Fresh Waters", *Island Press*

ensued between conservationists and pro-growth interests. [659] Ultimately, Glennon concludes that population growth is a catalyst for increases in groundwater demand, and that Arizona politicians and land developers do not acknowledge that river and stream survival may require population limits.[660] Glennon also writes that those who advocate against growth should expect "a hostile audience", and that groundwater issues can become muddled and confusing by claims that scientific results are not certain. [661] This stems from the long-term nature of accurately recording groundwater pumping and surface flows.[662] The passage of time is a detriment to the long-term survival of a resource like groundwater because the impacts of increased pumping may not be clear until years in the future.[663]

[659] 54-55. Robert Jerome Glennon. "Water Follies: Groundwater Pumping and the Fate of America's Fresh Waters", *Island Press*

[660] 69. Robert Jerome Glennon. "Water Follies: Groundwater Pumping and the Fate of America's Fresh Waters", *Island Press*

[661] 69. Robert Jerome Glennon. "Water Follies: Groundwater Pumping and the Fate of America's Fresh Waters", *Island Press*

[662] 69. Robert Jerome Glennon. "Water Follies: Groundwater Pumping and the Fate of America's Fresh Waters", *Island Press*

[663] 69. Robert Jerome Glennon. "Water Follies: Groundwater Pumping and the Fate of America's Fresh Waters", *Island Press*

Chapter 6

Conclusions

If Phoenix is to experience a serious water shortage catastrophe in the future, then it is clear that such an event has been over a century in the making. Time and again, Phoenix has looked for ways to continue growth at all costs. A study could be done for the purpose of finding out the optimal range of people that should reside in the city. Based on the Hohokam's demise in prehistoric times and the uncertainty of the city's water supply, one might guess that such a range includes fewer people. Over the course of a century, pro-growth interests in Phoenix have created their own economic, political and social conscience that now dominates both the city and the state at large. This system acts as a barrier to proposing new legislation that could better manage the city's water supply and protect citizens. However, this system ultimately protects itself and the interests of those who benefit from it. A massive shortage of water like Cape Town's is a public health crisis. With Phoenix's population expected to rise, the outcomes of such a shortage could be even worse. Rather than propose new types of policies or chart a new course for the city, it seems that Phoenix's leadership is more comfortable operating within the pro-growth mindset. Opposition to this way of thinking is dismissed, including the results from scientific studies. Phoenix's past, present and future are both puzzling and troubling. The city will press onward in its quest for growth, no matter the cost. It seems that few people have ever questioned why growth was the quest to begin with, and not balance or harmony. Phoenix has the appearance of a city that is out balance and out of harmony with nature: a large quantity of people overusing water resources in an area that has little water as it is. A disastrous water shortage may not occur in the immediate future, but signs point to the fact that it is possible, and that should be enough cause for concern and motivation for change. Until such an event occurs,

it seems that the culture of growth in Phoenix will dismiss research like this thesis as speculative in nature. However, it is the goal of this thesis to portray Phoenix as an example of poor water management as a result of overconsumption stemming from population growth, economic growth and an irresponsible political system.

Appendix A

Calculation 1

1980 Phoenix AMA population: 1,470,000

1985 Prescott AMA 131 GPCD

1985 Phoenix AMA 308 GPCD

1,470,000 x 131 GPCD = 192,570,000 Gallons of Water

1,470,000 x 308 GPCD = 452,760,000 Gallons of Water

452,760,000 Gallons of Water – 192,570,000 Gallons of Water = 260,190,000 Gallons of Water

Calculation 2

1985 Phoenix AMA Industrial Water Demand: 73,485 acre-feet x 13= 955,305

2005 Phoenix AMA Industrial Water Demand: 88,800 acre-feet (Well Pumpage) + 73,600 acre-feet (Non-Groundwater) = 162,400 acre-feet

73,485 acre-feet x 13 years = 955,305 acre-feet

162,400 acre-feet x 13 years = 2,111,200

2,111,200 acre-feet – 1,155,895 acre-feet = 955,305 acre-feet

Appendix B

Calculation 3

1985 Phoenix AMA Agricultural Water Demand = 1,363,530 acre-feet

1998 Phoenix AMA Agricultural Water Demand = 1,021,155 acre-feet

1,363,530 acre-feet per year x 5 years = 6,817,650 total acre-feet 1985-1990

1,021,155 acre-feet per year x 5 years = 5,105,755 total acre-feet 1985-1990

6,817,650 total acre-feet – 5,105,755 total acre-feet = 1,711,895 total acre-feet 1985-1990

Calculation 4

1,363,530 acre-feet per year x 5 years = 6,817,650 total acre-feet 1985-1990

1,023,970 acre-feet per year x 5 years = 5,119,850 total acre-feet 1990-1995

1,109,105 acre-feet per year x 3 years = 3,327,315 total acre-feet 1995-1998

1,021,155 acre-feet per year x 13 years = 13,275,015 acre feet 1985-1998

6,817,650 total acre-feet + 5,119,850 total acre-feet + 3,327,315 total acre-feet

= 15,264,815 total acre-feet 1985-1998

15,264,815 total acre-feet - 13,275,015 acre feet = 1,989,800 total acre-feet

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