# Water Supply in the Southwest:

## A look at the water problem faced by the cities of Phoenix, AZ, Provo, UT, and Yuma, AZ

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By John Hehir and Mike Chachakis

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Advised by Professor Theodore C. Crusberg

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# Table of Contents

# Table of Figures & Tables

# Abstract

This project examined the effects of rapid population growth in the cities of Phoenix, AZ, Provo, UT, and Yuma, AZ on the water supply taken from the Colorado River as well as other sources. Each of these cities has a connection to the Colorado River in some way, whether the water is needed for plumbing, irrigation, or even to drink. The problems that are discussed deal with the effects that population growth has had on the river itself, the surrounding environment, and whether the river can sustain the growing populations, as well as other problems that could arise. Possible solutions for these problems are also discussed.

# Introduction

In the Southwest, there has always been a limited supply of water. The air is dry and there is very little rainfall throughout the year. Desert overruns this area of the United States. With the little rainfall, water evaporates quickly and there really is no trace of it. Rivers do run through the region bringing much needed water to the area, however.

The Colorado River is one of the major rivers that run through the region, supplying water to many towns and cities, as well as other animals, vegetation, and other aspects of the surrounding environment. Not only do the cities along the river use the water but cities as far as San Diego and Phoenix also bring in water from the Colorado River. This is done through different irrigation and pumping systems that give human populations the ability to sustain life where it was once thought to be nearly impossible. However, this causes many problems as the Colorado River can only supply a finite amount of water. This high demand causes changes to the river, the surrounding environment, and whether or not it is possible to further sustain the population.

The major area of concern for cities is what will be the new source of water as the population increases. The Southwest is one of the fastest growing region in the United States. According to the U.S. Census Bureau, "…the fastest-growing region was the West at 19.7 percent, which added 10.4 million people in the 1990s for a total of 63.2 million. The fastest-growing states in the nation were all located in the West: Nevada (66.3 percent), Arizona (40.0 percent), Colorado (30.6 percent), Utah (29.6 percent) and Idaho (28.5 percent). California recorded the largest numeric increase of any state, 4.1 million people."

People are relocating to this region because of the amount of land and the opportunities that are there. This creates a major problem for cities. For example, as the population increases, will the current water supply be able to supply the demand, or will new sources need to be discovered and utilized? Currently there are laws in effect that limit the cities and towns from taking an unlimited supply of water. All the water must be shared among its different users. This is to keep the river in tact and make sure that everyone gets their legal allocation of the river. The cities that are having the biggest problems with the water supply are trying to get the restrictions taken off so they are able to meet the demand created by their population. One other option is that they are trying to "purchase" the unused portion of a certain city's water supply.

Cities are trying to outsource from numerous rivers in order to meet demand. There is even talk about having a pipeline run from the Great Lakes in the north to the Southwest region. This might help solve the problem but would cost a lot of money and would take time to be completed. In the meantime the only thing that can help the water problem is how the populations work to conserve the water supply. During bad years when there are droughts, bans are placed on water usage. Such aspects controlled are when the population can water plants, wash cars, take showers, etc. There are even bans on the amount of water that can be used by a town or area within each city. These bans are placed on activities that are not essential to living.

With this increase in the demand for water, comes the possibility of it having an adverse effect on the environment and the rivers themselves. This problem could push certain vegetation out of the region while having new species sprout up. Also, the animals in the area could be affected. Animals that depend on the river as a source of water might disappear because of how the river has changed, and again this might bring

in new species. The change in water supply would also have an effect on the land and river itself. The land would become drier and thus affecting the animals and plants in the region. The river would become smaller and could change its course. The increase in human consumption can also lead to weather changes; less water in the river means less water is evaporated. This lack of evaporation means that there will be less rainfall. It becomes a never ending, vicious cycle that has the potential to wipe out or severely damage the survival of different species. Not only that, the increase in human need can also wipeout the human population itself. Not being able to sustain demand means that the human population would not be able to survive. Something would have to give, whether it is the population growth, or a new water source is discovered. This demand increase can affect the entire southwestern ecosystem and more than likely for the worse.

Everywhere water is in a limited supply, but in the southwest, it is magnified because of the type of environment and the amount that is there. The cities of Phoenix, Provo, and Yuma should give us a better understanding of the problem because they have the highest growth rates of any of the southwestern cities and are all connected to the same water network. They get their water from the Colorado River as well as other local rivers. The cities are working on trying to bring the water restrictions down in order to meet demand. From these three cities we will be able to determine if the water will be able to sustain the population growth and if the effects that arise due to the increased demand are manageable.

# The Colorado River

The Colorado River is third largest river in the United States, behind both the Columbia River and the Mississippi. However, it is equally important to the country as both of those mighty rivers. The Colorado begins in northern Colorado in the Rocky Mountains- hence the name- and ends in the southwest corner of the United States. The

**Figure 1: Overview of course of the Colorado River (http://en.wikipedia.org/wiki/Image:Colorado_watershed.png)**

total length of the river is around 1,450 miles. From beginning to end, the river will see a total elevation change of 8,900 feet and will see depths in some areas of over 100 feet (these depths are mostly in man-made lakes and reservoirs- the actual flowing river can reach depths of close to thirty feet). The river has an average discharge of 42,600 cubic feet per second. Originally, the River reached all the way south to the Gulf of California, where the borders of Arizona, California, and Mexico meet, however today this rarely occurs. This is due to the large amounts of river water used every year by the country's population. According to the Bureau of Reclamation, over one-half trillion gallons of water are extracted from the Colorado every year. This extracted water helps serve over

twenty-five million people. As of 1996, the entire river also generated 12.2 trillion kilowatt hours of power. Also, the Colorado River Basin and its reservoirs help irrigate over 1.4 million acres of land, which helps produce about fifteen percent of the nation's entire harvest and thirteen percent of its livestock. These examples show how the river has many useful ways of helping the populace of the United States expand and survive.

The beginning of the Colorado River is formed some 9,000 feet above sea level by the Green River. The Green River begins in Wyoming, in the Wind River Mountains, and is unofficially considered the "true source" of the Colorado River. From here the River flows southwest into Utah and eventually enters Arizona. Eventually, the River becomes the natural border for the California-Arizona state line and for a portion of the Nevada-Arizona state border. Along the way, the river can go from a large, impassable waterway to nothing larger than a trickle that can be walked across. This is also due to the amount of water that is taken from the river every year. At its widest point the river is around 2,500 feet across. This is near the Imperial Dam in southwestern Arizona- near Yuma, Arizona. This dam, one of many, is used to help provide irrigation and drinking water for the area.

Along the way, there are also significant landmarks that have importance in the history of the country. Without this river, life in the west would never have become what it is today. The Hoover Dam, also known as the Boulder Dam, is one of the greatest and most important engineering accomplishments in the history of the United States. The dam itself is 1244 feet long, 726.4 feet high, 660 feet thick at the base, and 45 feet at the peak. This dam provides some form of electric power to almost the entire southwest- the turbines when at peak power can generate some 2,080 megawatts of electricity. The dam also serves as a bridge across the river for Route 93. This allows for further reach into

the west. The lake created by the dam, Lake Mead, is also useful. The water from this lake is dispersed across the area to provide irrigation, drinking, and plumbing for thousands of people.

**Figure 2: An aerial photograph of the Hoover Dam (http://en.wikipedia.org/wiki/Image:Hoover_dam_from_air_corrected.jpg)**

The Imperial Dam is also an important structure within the river system. This dam provides the Imperial Valley, which contains the city of Yuma, valuable water. The dam diverts River water to the All-American Canal, where it is dispersed throughout the Valley. The canal provides over five-hundred million acres of farmland with 2.9 million acre-feet of water. This water is used mostly for irrigation, where roughly seven-hundred farmers generate over one-billion dollars in yearly revenue. Without these dams, life in the southwest would be much more difficult. There are many other structures along the almost fifteen-hundred miles a river that provide energy and water to neighboring communities- these are but only a couple examples on how the Colorado River has

become the most human controlled river in the world. If deemed necessary, the flow of the river can be brought to a complete halt- this is the only river in the world that is burdened with this scenario.

**Figure 3: An aerial view of the Imperial Dam (http://en.wikipedia.org/wiki/Image:Imperial_Dam.jpg)**

The Colorado River Compact, originally developed in 1922, is what governs the distribution of the water. Without this agreement between states, the water would be a hotly contested and sought after commodity. The compact provides order and fairness to what would quickly become a free for all. This agreement between seven states, which is split up into two basins, sets an allocation total for each state, which is then to be distributed as each state sees fit. The Upper Basin consists of Colorado, Utah, Wyoming, and New Mexico. The Lower Basin contains Arizona, California, and Nevada. Arizona, however, does receive water as part of both the Upper and Lower Basins. The split is based partially on population and the amount of water necessary to sustain a standard of living. The allotment between basins is as follows:

| **Upper Basin, 7.5 million acre-ft/year (293 m³/s) total** | | |
|---|---|---|
| Colorado | 51.75% | 3.88 million acre·ft/year (152 m³/s) |
| Utah | 23.00% | 1.73 million acre·ft/year (68 m³/s) |
| Wyoming | 14.00% | 1.05 million acre·ft/year (41 m³/s) |
| New Mexico | 11.25% | 0.84 million acre·ft/year (33 m³/s) |
| Arizona | 0.70% | 0.05 million acre·ft/year (2.0 m³/s) |
| **Lower Basin, 7.5 million acre·ft/year (293 m³/s) total** | | |
| California | 58.70% | 4.40 million acre·ft/year (172 m³/s) |
| Arizona | 37.30% | 2.80 million acre·ft/year (109 m³/s) |
| Nevada | 4.00% | 0.30 million acre·ft/year (12 m³/s) |

**Table 1: Colorado River Water Allocation (http://en.wikipedia.org/wiki/Colorado_River_Compact)**

The Colorado River also provides homes to thousands of species of wildlife. These species could all be in danger if the river were to all of a sudden dry up. The over damming of water along the river has also proved dangerous to nature. The river gives a home to fourteen different species of fish- most are now endangered due to the damming of the river. Places that were once spawning grounds are now unreachable because of dams and river flow and size changes. Examples of such fishes are the razorback sucker, pikeminnow, bony tail, and humpback chub. In order to save such fish species, organizations and programs, such as the Upper Colorado River Endangered Fish Recovery Program, have been created to help solve some of these problems. There are also many endangered birds around the banks of the river, such as the bald eagle (the

**Figure 4: The Yuma Clapper Rail (http://www.fws.gov/Nevada/protected_species/birds/species/yucr.html)**

national bird), American peregrine falcon, and the Yuma clapper rail. Care must be taken to help prevent the extinction of these animals. Continued development and river damming could, in principal, lead to a premature extinction of thousands of creatures that live in the area. Many parks and sanctuaries have been created to help educate people about the problems and to give such animals a permanent home where they can live in peace without a threat.

The control of the river has also led to the drying up of the Colorado River Delta- where the river formerly met the Gulf of California. Although the delta is not entirely dry, it is not what it once was. Without the rivers deposit of silt and other nutrients, the land is starting to become less of a nutrient and animal rich marshland, but more of an extension of the desert. More care is needed to help keep what is left and restore what has been lost.

As a whole, the Colorado River has proved to be an important factor of the continued expansion west. However, it seems that with the increase of expansion, there are risks that are taken and problems that arise. These problems reach into many aspects of society- from the destruction of nature to overpopulation. The most important part of the equation, however, is what will the future bring and how the eco-system can remain in balance.

The three cities of Phoenix, Yuma, and Provo are perfect examples of what is happening throughout the southwestern United States. Each of these three cities either currently or eventually will rely heavily on the Colorado River for their water needs. The following pages are going to investigate what could cause the problems that might arise within each city, such as water shortages and overpopulation, and what can be done to solve possible future problems, or even stop them from occurring in the first place.

# Phoenix, AZ

## *Geography*

Phoenix is the capital of the state of Arizona. It is located in the Salt River Valley in central Arizona and takes up roughly 475 square miles. This area is usually a dry area, but Phoenix does have the Salt River running through it. There are mountain ranges surrounding the city with the White Tank Mountains to the west, the McDowell Mountains to the northeast, the Superstition Mountains to the east and the Sierra Estrella Mountains to the southwest. This area of the United States has some of the hottest average temperatures with Phoenix reaching over 100 degrees Fahrenheit for most of the summer and the beginning of the fall. The low can vary depending on the time of year but there are not many days where the temperature will drop below freezing. Storms do come up from the Gulf of Mexico, but by the time they get to this region they are more or less dried out. Phoenix averages a measly 8.3 inches of rainfall per year.

| Month | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Avg high °F (°C) | 65 (18) | 69 (21) | 74 (23) | 83 (28) | 92 (33) | 102 (39) | 104 (40) | 102 (39) | 97 (36) | 86 (30) | 73 (23) | 65 (18) |
| Avg low temperature °F (°C) | 43 (6) | 47 (8) | 51 (11) | 58 (14) | 66 (19) | 75 (24) | 81 (27) | 80 (27) | 75 (24) | 63 (17) | 50 (10) | 44 (7) |

**Table 2: Average Monthly Temperature in Phoenix, AZ (http://en.wikipedia.org/wiki/Phoenix,_Arizona)**

## *Population*

As of 2005 the population of Phoenix was 1,461,575 with males making up 50.4% of the population and females making up 49.6%. The median age is 30.9 years with the majority (71.2%) being 18 and over. Whites make up for 73.7% of the population while Blacks (5.1%), American Indians (2.1%), and Asians (2.0%) make up the rest. Out of the population, 41.8% are part Hispanic or Latino. Phoenix ranks in the

top cities for population growth, with 3.14% from July 1st 2004 to July 1st 2005. With 44,456 people added over that year, Phoenix ranked 1st in terms of amount of people added

| | | |
|---|---|---|
| Total Population | 1,461,575 | |
| Males | 694,972 | 50.40% |
| Females | 683,008 | 49.60% |
| Median Age | 30.9 | |
| Under 5 Years | 121,471 | |
| 18 years and over | 981,509 | 71.20% |
| 65 years and over | 103,676 | 7.50% |

**Table 3: Population Breakdown for Phoenix, AZ (http://factfinder.census.gov/servlet/ACSSAFFFacts?_event=&geo_id=16000US0455000&_geoContext=01000US%7C04000US04%7C16000US0455000&_street=&_county=phoenix&_cityTown=phoenix&_state=04000US04&_zip=&_lang=en&_sse=on&ActiveGeoDiv=&_useEV=&pctxt=fph&pgsl=160&_submenuId=factsheet_1&ds_name=DEC_2000_SAFF&_ci_nbr=null&qr_name=null&reg=null%3Anull&_keyword=&_industry=)**

Phoenix is also part of the Phoenix-Mesa Metropolitan area which also ranks at the top in terms of population growth. A Census was taken in 1999 where the population of this area was 2,238,480. A year later another census was taken and the population was found to be 3,251,876. This was an increase of 1,013,396. That's a 45.3% average and again showed the most growth in terms of pure numbers to a metropolitan area.

## *Water Supply*

Phoenix is probably in the best shape out of the three cities in terms of it's ability to deal with its water problems. The city has watched the problem closely and made sure that it has not gotten out of hand. Currently there are no restrictions for the personal use of water. Phoenix plans to stay ahead of the increasing demand. However if the drought does continue, Phoenix will be forced to put restrictions on the water supply. If this

happens the city does have a drought plan, the "Drought Management Plan". This plan has four stages and has different levels of conservation methods. These could be voluntary or mandatory depends on the severity of the drought. Even in the middle of a 10 year drought, Phoenix is still able to obtain water from snow pack and through the Salt River Project (SRP) as well as the Central Arizona Project (CAP).

The SRP is a project that brings in water from the Salt and Verde Rivers. They use canals and pipes to bring the water to Phoenix. Just recently they added a new major water-banking facility. They will be able to store water from the Salt, Verde, and Colorado rivers here. This new facility is permitted to store up to 75,000 acre-feet of water per year- 325,851 gallons is equal to one acre-foot. This would meet the needs of the average residential households in the area.

| | Elevation Current (feet) | % Full |
|---|---|---|
| Roosevelt | 2,116.32 | 61 |
| Horse Mesa | 1,905.59 | 91 |
| Mormon Flat | 1,658.74 | 97 |
| Stewart Mtn. | 1,525.89 | 94 |
| Total Salt System | | 67 |
| | | |
| Horseshoe | 1,953.00 | 0 |
| Bartlett | 1,745.68 | 38 |
| Total Verde System | | 24 |
| | | |
| Total Reservoir System | | 61 |
| Total System Year Ago | | 77 |

**Table 4: Current Water Levels for the Salt River Project (http://www.srpwater.com/dwr/report.asp?dt=2/21/2007)**

The SRP has four reservoirs (Roosevelt, Horse Mesa, Mormon Flat, Stewart Mountain) for the Salt River and two reservoirs (Horseshoe and Bartlett) for the Verde River. As of February 21, 2007 the percentages that each is full are- Roosevelt 61%, Horse Mesa 91%, Mormon Flat 97%, and Stewart Mountain 94%. This is 67% of the total maximum capacity. For the Verde System, the Horseshoe is 0% full while the

Bartlett is 38%. This is a total of 24% of the maximum capacity. Out of the whole SRP system only 61% is full. This might seem like a good number, but it is a 16% drop off from a year ago (77%).

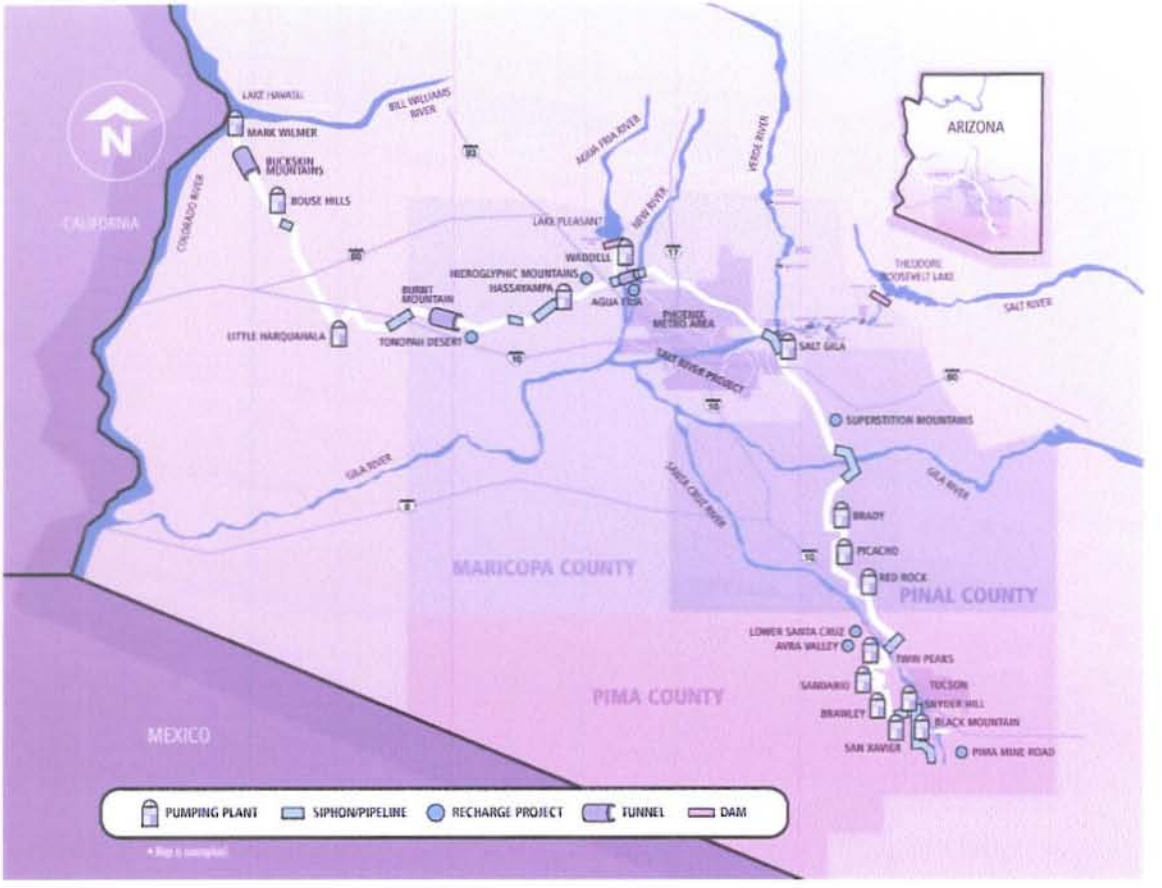


**Figure 5: The Central Arizona Project**
**(http://www.cap-az.com/Images/operations/main_map.gif)**

The CAP is a project that brings in the water from the Colorado River through out Southwestern Arizona. It cost $3.6 billion to construct and the full bill still has not been repaid to the federal government. The CAP brings an average of 1.5 million acre-feet of Colorado River water each year. If there is a demand for more water, the CAP can run the pumps and canals all year long, brining in roughly 2.2 million acre-feet. Phoenix is not the only city to get water from the CAP. Cities such as Mesa and Scottsdale also

receive water from the CAP. The CAP does have measures in place to make sure that if there is a major drought, or if the amount of water in the Colorado River is below normal levels, there should not be a problem with providing water. They do this by storing water behind the dams. They have stated that they have enough water behind the dams that if a major drought were to happen, they would have enough water to maintain the supply for three to five years depending on the city's demand for the water.

In 2005, Phoenix received 122,100 acre-feet out of the allotted 162,537 acre-feet. Last year Phoenix was allotted 168,709 acre-feet of water but only needed 101,766 acre-feet through October. The three most demanding months for 2006 were May, August and September, when Phoenix received 12,738, 16,935, and 12,089 acre-feet respectively. The two other major users of the CAP are Mesa (10,506 acre-feet), Scottsdale (57,253 acre-feet), and Tucson (62,320 acre-feet). This shows that the CAP is utilized by many cities, but Phoenix takes a majority of the water brought in from the Colorado River.

### *Future Problems and Possible Solutions*

As shown, Phoenix is going to have a problem with their population in a few years. Since it's one of the fastest growing areas in the United States, it'll grow to be one of the highest populated areas. Here lies the problem with the water demand. As of right now, Phoenix is working and preventing any possible ways of having the demand be higher than the supply. They are doing this by storing massive amounts of water through the CAP and SRP. As stated, the CAP has enough water to last three to five years if there was massive amount of supply lost. Measures like this help ensure that the water will be enough to meet the demand. Also, both projects continue to expand as the demand gets greater. The SRP recently added a new facility which will increase the amount that is

being stored. While both these measures from the CAP and SRP are good for preventing the problems that could occur, the main problem is there is only a certain amount of water in the region. If these two projects stored enough water as time goes on it might provide enough water for the demand for a period of time but the demand would eventually catch up. There is talk about outsourcing the water from other parts of the country such as the Great Lakes. The Great Lakes hold roughly 20% of the fresh water on earth. If this were to happen, it would cost lots of money to put a pipe-line from this area to the Great Lakes. This would help solve the demand for water greatly, and would probably end all fear of not having enough water for the demand.


**Figure 6: The New Facility for the Salt River Project**
**(http://www.srpnet.com/water/graphics/nausp.jpg)**

# Provo, UT

## *Geography*

Provo is a city located roughly fifty miles south of Salt Lake City and is the third largest city in Utah.. It is located in the Utah Valley at an elevation of 4,549 feet. To the east is the Wasatch Range which contains the Y Mountain that looks over the city. To the west is the Utah Lake. Provo has a total area of 41.8$mi^2$, 39.6$mi^2$ of it being land and 2.2$mi^2$ being water. According to the census, Provo doesn't get as hot as Phoenix usually does, but still has a high average temperature during the summer months. July on average is the hottest month at 93.7 degrees while August (91.9 degrees) and June (85.8 degrees) follow. Provo does get more precipitation with its annual average of rain being 20.15 inches. Having a higher elevation and lower temperature during the winter months, Provo does account for 60.4 inches of snow per year.

Provo, Utah is constantly talked about as one of the best places to live in the United States. It offers many opportunities for people that come in terms of jobs and the quality of living. The area is ideal for living with the landscape, and the right environment, which is why the wildlife here also flourishes. The temperatures in Provo provide for an ideal setting for wildlife to raise their young. During the spring, deer are a common sight around the mountains. Birds such as the osprey and bald eagle are also present in this area. The ospreys are usually found by the lakes as they are known as the "fish-eating hawk". The bald eagles migrate south to this area during the winter months.

### *Population*

As of 2005, Provo, Utah had a population of 115,135 with males making up 48.1% of the population and females making up 51.9% of the population. Provo has a high percentage of its race being white (86.6%) while Asian (2.2%) and Native Hawaiian and Other Pacific Islander (1.3%) follow. Roughly seven percent of the population reported that they were some other race. Out of the population, 12.8% reported being part Hispanic or Latino. The median age for the population is 24.5 with 78.7% being 18 years and over, 10.4% is under five years, while 5.4% is 65 years and over. From July 1st 2004 to July 1st 2005, Provo increased its population by 1.56%. This isn't as much as Phoenix, but Provo is part of one of the fastest growing metropolitan areas in the United States. The area of Provo-Orem, Utah had a huge increase from 1990-2000 with a change from 263,590 to 368,536. That's a change of 104,946 (39.8%). This area continues to grow as the area provides opportunities and is ideal for families to grow.

### *Water Supply*

The Colorado River serves more than two-thirds of Utah with its water, but actually only gives 15% of the total amount of water needed by Utah. Utah shares the Colorado River with other states but is allotted to take 23% of the Upper Basin which is an average of 1.4 million acre-feet per year. Since the birth rate is high in Utah (30.1 per thousand people compared to 16.2 for the nation average), Utah looks to have a higher share through the Central Utah Project (CUP). The CUP has most of its development on the Green River which is a tributary of the Colorado River. The CUP contains three main units and three sub units. The three main units are the Bonneville, Vernal, and Jensen.

The sub units are the Upalco, Uintah, and Ute Indian Unit. Provo is part of the Provo River Project. The construction of the project started in May 1938 and the water was available in 1941 when the Deer Creek Dam was completed. This project irrigates 48,156 acres of farmlands in the surrounding counties. The main part of the project is the Deer Creek Reservoir. This reservoir stores water from the Provo River, the Weber River, and the Duchesne River. The dam is located roughly sixteen miles to the north and east of Provo, Utah. The Deer Creep Reservoir has a maximum capacity of 152,570 acre-feet. There is also a spillway to catch the extra water from the overflow. In order to get water from the other rivers, canals and diversion dams are used. The longest canal is the Provo Reservoir Canal, which is twenty-three miles long and runs from the Provo River. This project is very valuable to the economy of the area. In 1992 the area that was irrigated by the project was 35,702 acres which produced a crop value of $14,781,995.

**Figure 7: Deer Creek Dam and Reservoir (http://www.usbr.gov/dataweb/assets/images/auto_generated_images/a_Deercrk.gif)**

### *Future Problems and Possible Solutions*

As with Phoenix, Provo is going to have a problem with the demand for water due to its increase in population. Provo doesn't have the growth that Phoenix does in numbers, but it also does not have the supply of water that Phoenix has either. Provo does have the Deer Creek Dam and Reservoir to supply it with water but that will not be able to supply Provo and the surrounding farmlands as the area continues to expand. What seems like the best solution for the demand of water is that Provo is going to have to have a greater share of water from the CUP. Currently the CUP is getting water from the Colorado River and its tributaries such as the Green River and piping it to parts of Utah. If Provo gets more water from the CUP, it should be able to meet demand. The CUP is also going to have to expand in order to meet the demands of Provo and other parts of Utah. The CUP is the main provider of water in the state of Utah so staying ahead of the demand is crucial to avoiding the disaster of supply not meeting the demand. The area that Provo is in does not have the limited supply that the areas further south have. Provo is surrounded by water systems that should meet the demand. Provo just needs to make sure to take measures of storing water and staying ahead of the water demand.

# Yuma, AZ

## *Geography*

The city of Yuma is located in the western portion of Arizona. More specifically, the city is in the very southwest corner of the state, with Mexico to the south and west and California to the north. According to the United States Census Bureau, the city itself fills an area of 106.7 square miles, with the entire county having a water area of a measly 0.1 square miles (0.07% of the city's area). The city sits only 138 feet above sea level. The city is also close to where the Colorado and Gila Rivers meet- known as the Gila and Colorado River confluence, which is off to the west of the city. The Colorado is used as a natural state line that separates California from Arizona.

The city is located in the Yuma Desert, which is a part of the larger Sonora Desert. The Sonora Desert is one of the smaller deserts of the southwestern United States, but is also one of the hottest. This city is considered to be the warmest city in the state of Arizona and also the sunniest city in the United States. The city averages almost 4,200 hours of sunshine each year. The following table shows the monthly average rainfall and the monthly average high and low temperatures for the city of Yuma.

| Yuma, Arizona - Monthly Climate Normals | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Year | Jan. | Feb. | Mar | Apr. | May | Jun. | Jul. | Aug. | Sep | Oct. | Nov. | Dec. |
| High °F | 87.9 | 68.7 | 74.4 | 78.9 | 86.3 | 94.2 | 103.3 | 106.6 | 105.3 | 100.5 | 90.3 | 77.4 | 68.5 |
| Low °F | 60.5 | 44.2 | 46.9 | 50.8 | 56.5 | 63.8 | 72.0 | 80.7 | 80.1 | 73.2 | 62.2 | 50.9 | 44.3 |
| | | | | | | | | | | | | | |
| Avg °F | 74.2 | 56.5 | 60.7 | 64.9 | 71.4 | 79.0 | 87.6 | 93.7 | 92.7 | 86.8 | 76.2 | 64.2 | 56.4 |
| Rain " | 3.17 | 0.35 | 0.22 | 0.21 | 0.14 | 0.04 | 0.02 | 0.26 | 0.64 | 0.31 | 0.29 | 0.24 | 0.45 |

**Table 5: Average Climate for Yuma, AZ ( http://www.desertusa.com/Cities/az/az_yuma.html)**

As can be seen, the city of Yuma has the stereotypical climate for a desert- high heat, low humidity, and little to no rainfall (only 3.17 inches falls on average each year)- making the necessity for water all the more important.

This desert has a wide range of animal and plant life and is also a favorite place to stay for tourists and "snow birds". Yuma sees an average of around 95,000 visitors every winter- more than doubling the population. All are hoping to get away from the cold of winter and find someplace a little warmer to stay. This influx of people every season takes a toll on the city's water supply.

## *Population*

Yuma is the tenth largest populated city in the state of Arizona, while Phoenix is the largest with almost sixteen times the population of Yuma. However, the more important statistic is that the Yuma metropolitan area has the third fastest growth rate throughout all areas within the United States.

As of 2005, Yuma had a total population of 88,775 people. From 1990 to 2000, the Yuma metropolitan area experienced a population increase of 53,131 people, a 49.7%

jump during that time span. Also from 1990 to 2000, the city of Yuma itself saw a population boom of 36.1%. From 2000 to 2005, the city of Yuma experienced an increase of 11,260 people, or a 14.5% increase. The population count continues to grow for the city. This rapid rate of growth puts a strain on many aspects of city development.

According to the U.S Census last taken in 2000, Yuma had a population density of 726.8 people per square mile. The population of Yuma can be broken up in different ways. As of 2000, the city consisted of a predominately white population- the highest portion being males under the age of eighteen. Caucasians accounted for 68.33% (52,968 persons), 45.67% of the population has some Hispanic or Latino heritage, while African Americans only made up a mere 3.21% (2491 people) of the population. Those are the three highest populations for the city.

| Race | Yuma City, Arizona |
|---|---|
| Total | 77,515 |
| White Alone | 52,968 |
| Black or African American alone | 2,491 |
| American Indian and Alaska Native alone | 1,168 |
| Asian alone | 1,164 |
| Native Hawaiian and Other Pacific Islander alone | 145 |
| Other race alone | 16,557 |
| Two or more raced | 3,002 |

**Table 6: Total Population by Race (www.census.gov)**

Almost 30% of the population consists of those under the age of eighteen (22,930 people), with the second highest age demographic being in the twenty-five to forty-four year age group, accounting for 27.1% (20,998 persons). Thirty-one is the median age of the population of Yuma. The ratio of men to women within the city is almost a perfect 50/50 split- there are 38,589 males and 38,926 females living within the city limits.

There were also 19,618 families living within the city, with an average family size of 3.27 and an average household size of 2.79 people per household.

| Age Group (years) | Number of Persons |
|---|---|
| 0-18 | 22,930 |
| 18-24 | 9,250 |
| 25-44 | 20,998 |
| 45-64 | 13,588 |
| 65+ | 5,921 |

**Table 7: Total Population by Age (www.census.gov)**

These statistics are important because it shows the youth within the city. This city does not consist of people who are ready to pass on, but is of those who are becoming ready to start their own lives and begin to have children of their own. This could lead to another boom in the population, putting a heavy tax on the surrounding area in more ways than one, the most important of that being the necessary water supply.

### *Water Supply*

Most of Yuma's drinking water comes from the Colorado River. The city uses a system of pipes and canals to pump water to the city's treatment facilities. Yuma also uses treatment facilities that attain water through wells that pump water from underground; however, most water comes from the river itself. Even though Yuma is located in the state of Arizona, the city is not a member of the Central Arizona Project, or CAP. However, the CAP system does help provide 1.5 million acre-feet of Colorado water each year, although indirectly. Instead, it is a member of its own Yuma Project.

The Yuma Project, Gila Project, and Wellton-Mohawk Project all work together to get Yuma its necessary water. A lot of the water is not only used for drinking and other needs, but also for irrigation. The Yuma Project provides 68,091 acres of land with

useable water for irrigation. Excess water is also drained out of the land and is returned to the Colorado River, to possibly be used in other areas, through an extensive drainage system.

The Gila Project provides the Yuma Mesa Division with 42,131 acres of river water. The Imperial Dam is used to divert water into the All-American Canal System. This water is then fed into the Yuma Mesa pumping plant, where it is pumped into the Yuma Auxiliary Project for use throughout the city. The Yuma Mesa Pumping Plant provides the Yuma Project only with about 3,400 acres of water.

The Wellton-Mohawk Project is also important to the Yuma water supply. This project uses limited 278,000 acre-feet of Colorado River water each year in order to help irrigate some 75,000 acres. The district uses 378 miles of canal, three pumping plants, ninety drainage wells, and four pump stations to provide this water. The Wellton project also provides water to surrounding towns and communities.

However, even though all this water is being used for irrigation, more is needed. Problems are arising with the rapid population growth. Demand is being to become greater than the supply. As a result, there are movements to try and begin to use more water for municipalities and industries and less for agriculture.

### *Future Problems and Possible Solutions*

If the population growth rate in Yuma remains constant, it is projected that by the year 2010, there will be over 100,000 people living within Yuma City. By the year 2020 there could be close to 140,000 people living in the area. This is a large population that is growing rapidly. This is an issue that needs to be addressed quickly and efficiently. If not taken care of now the future will hold only more problems. If the population rises

before more water sources can be found and utilized, drought will continue to plague the region, not to mention the Colorado River can start to become over utilized. More drainage of the river can help the river dry up in some places and can even allow it to change course; effectively altering the environment that relies on the river for everyday necessities.

If 1.5 million acre-feet is necessary to sustain the city of Yuma and surrounding areas, a two fold increase in population would mean even greater water needs. According to the 2000 Census, from 1990 to 2000 Arizona's population grew by over forty percent, with neighboring Nevada surpassing that with a growth of over sixty percent. Even though Arizona does not use all of its allocation of river water, with these areas as well as others in the southwest experiencing these same population trends, the Colorado is beginning to become strained. Not only does more people mean that plumbing and drinking water are needed, but more farmers need more water fortheir crops that feed the growing population. Water is a necessity, and using the river as a sole source of water is not the answer.

There are many ways, however, to avoid such problems. The Department of Reclamation has several projects underway that are being developed to help with the continued water shortage in the southwest. The Water 2025 Initiative is one of those aids. Instead of finding new sources of water, this project is determining better ways to conserve water. Through better technology, current facilities are being updated and made more efficient. One example is with the Yuma County Water Users Association. Water 2025 gives monetary grants to those who qualify for helping with the water situation. With that money, the association is reducing seepage within its canals. The upgrade of the canals (only 5.8 miles worth) will save over 7,500 acre-feet every year. Its efforts

like these that will have the largest impact on the water supply- saving water that is lost during the process of transporting it from the river to where it needs to be. The Water 2025 initiative is the leader in figuring ways to prevent future crises. Water 2025 has invested over 5.6 million dollars in fighting water shortages from Colorado all the way to Arizona- and every state in between. With water being scarce as it is, not many new sources are viable. The only answer is conservation.

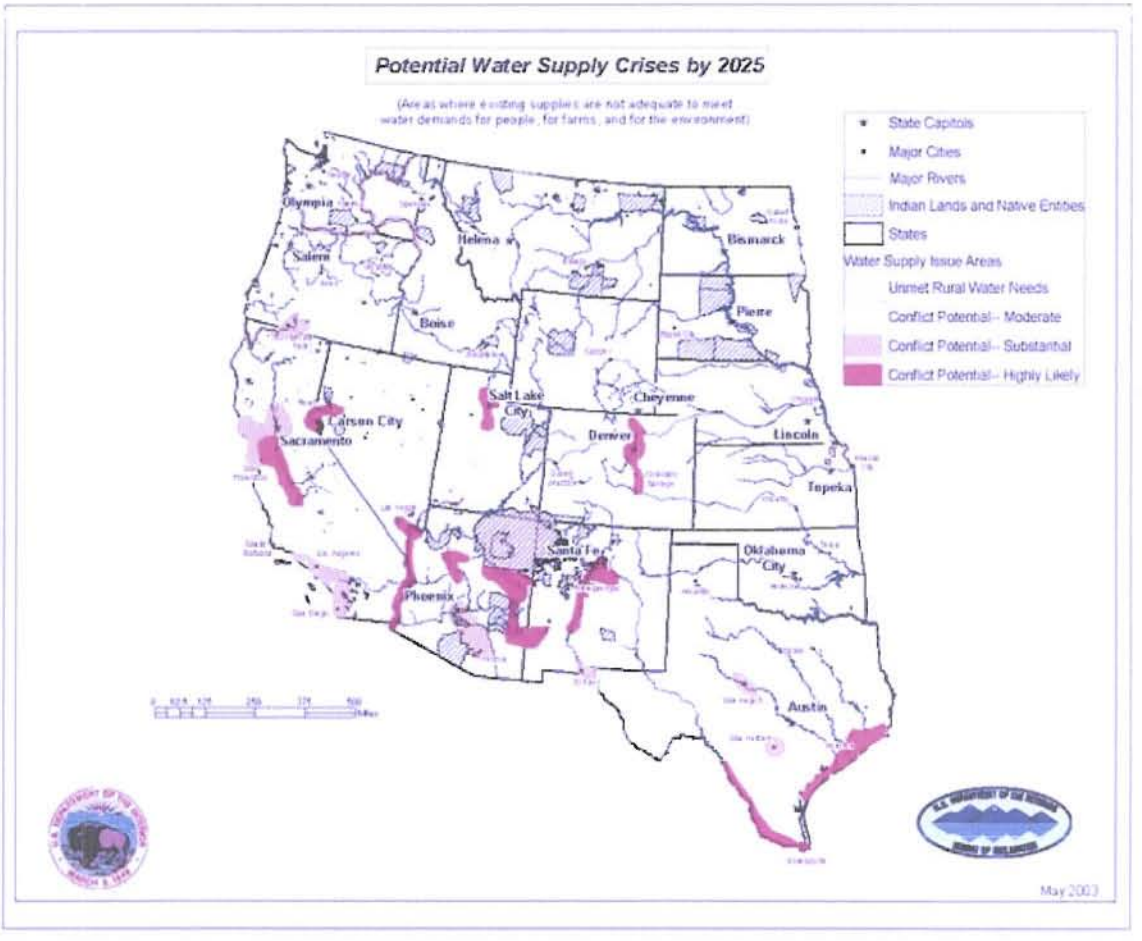


**Figure 8: Potential Water Supply Crises by 2025**
**(http://ceres.ca.gov/biodiversity/Meetings/archive/water03/water2025.pdf)**

# Conclusion

The southwest has some of the highest population growth rates in the country. With this growth rate, there are problems rising such as the demand for water. There is only a certain amount of water in the southwest and as the time goes by, that water will be in high demand. Right now there are steps in place to make sure that the supply is keeping up with the demand but eventually there just will not be enough. The systems in place right now are created to hold water and provide for the demand. Eventually the store water will be used and there will be a need to outsource. There is talk about brining in the water from other rivers in the area or maybe even put a pipe to the Great Lakes. This would be a good solution and would probably get ride of the concern for future water, but would cost a lot of money. The problem is real and needs to be dealt with now while there is still time before it is preventable.

# References

Keys III, John. *Cooperation Key to Reclamation's Future Water Works.* http://www.swhydro.arizona.edu/archive/V5_N2/feature5.pdf

United States Census Bureau. www.census.gov

City of Yuma, Arizona. 2007. City of Yuma: Strategic Communications Office 2007. http://www.ci.yuma.az.us/

Yuma, Arizona. http://www.hometownlocator.com/PlaceDetail.cfm?SCFIPS=04027&City=Yuma

The Sonoran Desert- Desert U.S.A. Desert-USA.com and Digital West 2007 Media, Inc. http://www.desertusa.com/du_sonoran.html

Yuma, Arizona- Desert U.S.A. Desert-USA.com and Digital West Media 2007, Inc. http://www.desertusa.com/Cities/az/az_yuma.html

Yuma, Arizona. Wikipedia: The Free Encyclopedia. http://en.wikipedia.org/wiki/Yuma,_Arizona

City of Yuma Arizona: Yuma Population Numbers. City of Yuma - Strategic Communications Office 2007. http://www.ci.yuma.az.us/census_info.htm

Yuma: Community Profile. http://www.ci.yuma.az.us/az_dept_commerce.pdf

Colorado River. Wikipedia: The Free Encyclopedia. http://en.wikipedia.org/wiki/Colorado_River

Gila Project: Arizona. U.S. Department of the Interior: Bureau of Reclamation. http://www.usbr.gov/dataweb/html/gila.html

The Green River. Sublette County Joint Tourism Promotion Board 2007. http://www.mountainmancountry.com/attractions/destinations/green-river.html

Hoover Dam. Wikipedia: The Free Encyclpedia.
http://en.wikipedia.org/wiki/Hoover_Dam

*Advanced Water Education Workshop for Valley Educators Water Facts and Reflections*. http://dcdc.asu.edu/K-12Education/workshop/notes.pdf

*Workshop on Water and Growth: Future Water Supplies for Central Arizona.*
http://sustainability.asu.edu/docs/water_institute/Workshop_Issues.pdf

Irrigation: Wellton-Mohawk Irrigation and Drainage District. MGM Internet Solutions 2004. http://www.wellton-mohawk.org/irrigation.html

Lake Mead. Wikipedia: The Free Encyclopedia. http://en.wikipedia.org/wiki/Lake_Mead

Yuma Project: Arizona and California. U.S. Department of the Interior: Bureau of Reclamation. http://www.usbr.gov/dataweb/html/yuma.html

Colorado River Compact. Wikipedia: The Free Encyclopedia.
http://en.wikipedia.org/wiki/Colorado_River_Compact

Colorado River Delta. http://ag.arizona.edu/colorado_river_delta/data/basemap.html

Upper Colorado River Endangered Fish Recovery Program.
http://www.fws.gov/coloradoriverrecovery/

Arizona Game and Fish Department. AZGFD 2006.
http://www.azgfd.gov/outdoor_recreation/wildlife_area_co_river_nature.shtml

Colorado River Water Users Association: Overview.
http://www.crwua.org/colorado_river/overview.htm

Image: Imperial Dam.jpg. Wikipedia: The Free Encyclopedia.
http://en.wikipedia.org/wiki/Image:Imperial_Dam.jpg

U.S. Fish and Wildlife Service: Nevada Fish and Wildlife Office: Yuma Clapper Rail.

http://www.fws.gov/Nevada/protected_species/birds/species/yucr.html

Water 2025: Preventing Crises and Conflict in the West.

http://ceres.ca.gov/biodiversity/Meetings/archive/water03/water2025.pdf

U.S. Cities and Metro Areas: Census 2000

http://www.infoplease.com/ipa/A0884086.html

Fastest Growing Cities

http://money.cnn.com/2006/06/20/real_estate/fastest_growing_cities/index.htm

State & County Quick Facts: Phoenix, Arizona

http://quickfacts.census.gov/qfd/states/04/0455000.html

Factfinder: Phoenix, Arizona

http://factfinder.census.gov/servlet/ACSSAFFFacts?_event=&geo_id=16000US0455000&_geoContext=01000US%7C04000US04%7C16000US0455000&_street=&_county=phoenix&_cityTown=phoenix&_state=04000US04&_zip=&_lang=en&_sse=on&ActiveGeoDiv=&_useEV=&pctxt=fph&pgsl=160&_submenuId=factsheet_1&ds_name=DEC_2000_SAFF&_ci_nbr=null&qr_name=null&reg=null%3Anull&_keyword=&_industry=

Daily Water Repots for the SRP

http://www.srpwater.com/dwr/

Central Arizona Project

http://www.cap-az.com/

Period of Record Monthly Climate Summary for Provo, UT

http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?utpbyu

City of Provo Demographic Profile

http://www.provo.org/econdev.Provo_Profile_main.html

City of Phoenix, Arizona

http://www.phoenix.gov/

Utah Valley – Where the Wild Things Are

http://deseretnews.com/dn/view/0,1249,595052278,00.html

Best Places to Live: Provo, UT

http://money.cnn.com/magazines/moneymag/bplive/2006/snapshots/PL4962470.html

Factfinder: Provo, UT

http://factfinder.census.gov/servlet/ACSSAFFFacts?_event=Search&geo_id=&_geoContext=&_street=&_county=provo&_cityTown=provo&_state=04000US49&_zip=&_lang=en&_sse=on&pctxt=fph&pgsl=010

Provo River Project Utah

http://www.usbr.gov/dataweb/html/provoriver.html

Colorado River Water Useres Association – Urban Uses

http://www.crwua.org/colorado_river/urbanuses.htm

Central Utah Project

http://www.usbr.gov/dataweb/html/cupoverview.html

Growth Loads Strain on Arizona Water Supply

http://www.doi.gov/news/opeds/arizona.htm

Great Lakes Mailer

http://www.audubon.org/states/oh/oh/documents/GLMailerFinal.pdf

The future of the Great Lakes: Who will control the water?

http://toledoblade.com/apps/pbcs.dll/article?AID=/20010610/SRGREATLAKES/106100022