0% MORE WATER

A GEOGRAPHIC COMPARISON OF THE CONSERVATION STRATEGIES OF SAN ANTONIO WATER SYSTEMS AND COLORADO SPRINGS UTILITIES

HONORS THESIS

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Abstract

Water is one of the most precious commodities in the world. While water as a resource is often taken for granted by those in developed countries, the availability of water as a basic necessity for human life is in doubt due to human misuse, overuse, and population growth. Conservation is by far the most effective means to reduce demand for new and threatened water resources. It offers hope to humanity in terms of the challenging problems surrounding water resources. The purpose of this study is to critically analyze what conservation practices were chosen by Colorado Springs Utilities and San Antonio Water Systems in order to improve water use efficiency in semi-arid municipalities in the United States. As two rapidly growing regions with limited new water sources and groundbreaking water conservation initiatives, these utilities provide a model for other regions to contend with rapid water demand increases without similar increases in water supply. Based upon this geographic comparison, a municipality looking to conservation measures should first use technology, like high efficiency toilets, to reduce demand. However, in the long run, this will not be enough. Changing the social acceptability of water waste and changing associated behaviors and constant conservation program reassessment, will have to be the long-term water conservation strategies in U.S. cities. The most effective way for utilities to change their customers water use habits is to educate them on making conscious and personal decisions to use less water and to use the water they do need more efficiently.

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Introduction

The struggle to maintain balance between population growth and water availability became increasingly difficult throughout the 20th century. From the Aral Sea to the Colorado River, freshwater supplies upon which humanity's future depends have been mismanaged both in terms of quality and quantity. A major challenge for the 21st century will be to better manage water resources more effectively than in the past.

In the case of the Aral Sea, the former Soviet Union decided that cotton would be an ideal crop for the desert of Kazakhstan and was needed as a strategic economic commodity. Therefore, almost the entire flow of two rivers, the Amu Darya and the Syr Darya, that supply water to the Sea, were diverted for irrigation. Sixty percent of the water disappeared from the Sea, and as a result, salinity doubled (Campbell, 2011). Today, local residents struggle to survive in this diminished environment. The Aral Sea fishing industry is extinct because of the high salinity levels, the local economy is unsustainable, and the region has become altogether unviable. Twice the amount of water must be now be applied to local farmlands in order to grow the same crop volume, due to both soil and water salinity. In addition, the community water supply must now be pumped from miles away.

Problems in water management are also experienced in the World's most developed countries. The case of the Colorado River is an ideal example for study. As the Colorado River winds its way through the American West, every drop has already been allocated. Its waters slowly diminish downstream, until the remnants trickle through a mudflat in Mexico that was once graced by the highly variable, but often prolific, flow of the mighty Colorado. Instead, much of the Basin's water is evaporated from canals on its way to major cities. This water has been applied to one of the driest deserts in the world in order to create golf courses and swimming pools, and has been dammed within reservoirs over many miles, in order to generate hydroelectricity and to create water supply storage. The current water supply phenomena in the basin can be best described by journalist Fred Pearce (2006), “Denver and Colorado Springs don’t quite see why they have to shut off their sprinklers so that Phoenix, Las Vegas, and Los Angeles can keep theirs on.” A recent study conducted by the scientists of Trout Unlimited found that many residents of cities with water supplied by the Colorado River do not know where their water comes from and that they share this resource with a vast network of Western cities which all cooperatively depend upon the Colorado’s water (Scholfield, 2011). Over the course of the 20th century the River’s water has become increasingly scarce and salty, and resultant legal battles, between basin states and stakeholders, have ensued.

Whatever the causes of regional water mismanagement, the future of the planet’s water supplies seems dismal. Countries, states, companies, and even municipalities are taking the steps toward sustainable water management. Einstein said “we cannot solve problems by using the same kind of thinking we used when we created them.” Instead of turning toward the traditional management practice of finding new water sources, no matter the cost, diverse groups are now looking into new ideas and innovation in order to solve water shortages. Cities are beginning to look inward in order to take advantage of the cheapest future water supply source: the water saved through conservation. Water conservation and reuse strategies combine technology, planning, and education to create a new face for water management. Not only is tightening the per capita use of water cheaper than the process of obtaining additional water rights, it also allows municipalities to support population growth, sustainably.

As a positive example of progressive water supply management in the United States, two innovative U.S. municipalities have been chosen to analyze their water management as they have struggled with issues concerning population growth, associated development, and ensuing water supply scarcity. The purpose of this study is to critically analyze the conservation practices of Colorado Springs Utilities and San Antonio Water Systems in order to aid in the application of future water conservation practices for semi-arid municipalities in the United States. As two rapidly growing regions with highly diversified water sources and groundbreaking water conservation initiatives, these two utilities provide a model for other regions to contend with a rapid increase in water demand due to population growth, without a corresponding increase in water supply.

Physical Geography and Water Availability of San Antonio

To truly analyze a region, the physical landscape must first be understood. Not only are the climate, geology, and vegetation of a region important, but it is also impossible to make effective decisions regarding water policy without first understanding the history of water management in a region.

San Antonio is located in south-central Texas, along the I-35 corridor. It is physically situated on the Balcones escarpment, a steeped face topographic feature that divides two regions by their elevation, vegetation, geologic features, and climatic characteristics. The escarpment formed due to differential erosion rates between several types of rock after a faulting event that uplifted the rock formation to the west during the Miocene Epoch approximately 27 to 12 million years ago (*see figure 1*) (Jordan, 1977). The elevation of San Antonio varies from 550 feet (ft) above sea level on one side of the fault to over 1000 ft above sea level on the other side of the fault.

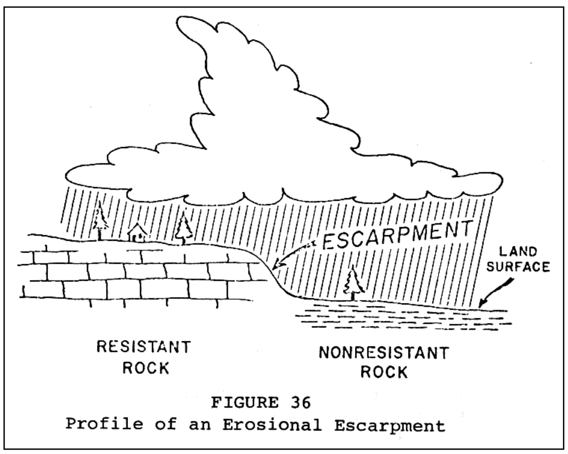

Figure 1: Differential erosion rates creating an escarpment (Jordan, 1977).

The escarpment dramatically impacts the climate of the region. To the east of the fault lies the Western Gulf Coast Plain. The Gulf Coast Plain's climatic conditions include no dry season and very hot summers, and it is classified as a humid subtropical climate. Dense vegetation exists on the Gulf Coast Plain due to the plain's relatively flat topography and fertile blackland clays and silty loams.

To the west of the fault is the Edwards Plateau, the southernmost extension of the Great Plains of North America (Fenneman, 1931). Nearly 31,000 square miles of south-central Texas comprise the Edwards Plateau region (Samson, 2008). The geology consists of flat layers of early Cretaceous limestone formed by coral and shells from ancient seas (Fowler, 2005). The Plateau's dry sub-tropical semi-arid climate relates to the decrease in moisture content of Gulf Coast air (Jordan, 1977). According to the National Oceanic and Atmospheric Association (NOAA), 78.7 cm (31 in) of rain falls on San Antonio in an average year, with a mean snow precipitation of 2.3 cm (0.9 in) (2011). Additionally, precipitation in the region is either feast or famine, not spread evenly over a season, and falls on steep topography and often dry vegetation which makes the San Antonio region one of the nation's top three flash flood areas (Samson, 2008). The temperature in San Antonio varies from a record high of 42^{0}C (108^{0} F) to a record low of -14^{0}C (6^{0} F) (NOAA, 2011). The decrease in precipitation and increase in evapotraspiration, the combination of evaporation and transpiration, rates significantly alter the vegetation. All "natural" vegetation in the Plateau region tolerates drought, and most of the species that inhabit this region can become dormant during extreme drought.

During the last Ice Age, glaciers never reached the San Antonio region, and therefore, no natural lakes exist in this region (Jordan, 1977). For that reason, only three water sources are available for beneficial water supply: groundwater, rivers and streams, and the Gulf of Mexico. The layers of permeable limestone that make up the Plateau create a region where surface water and precipitation disappear underground into

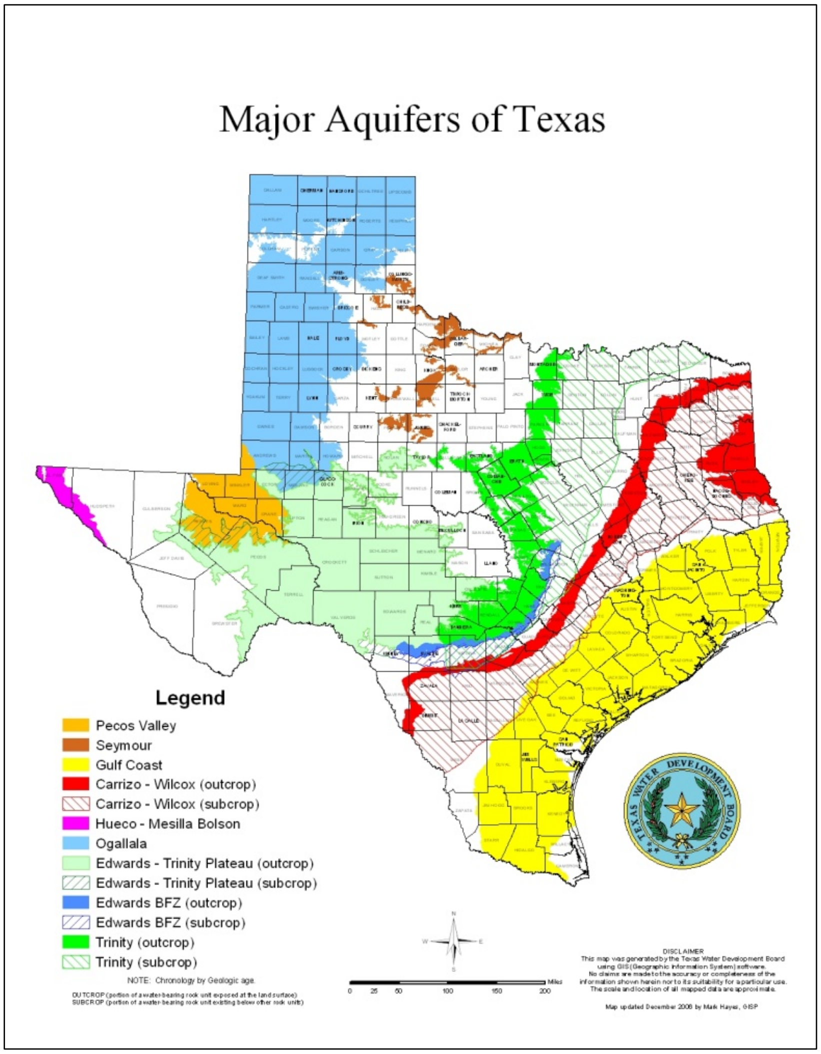

Figure 2- Major Aquifers of Texas. (TWDB, 2006)

highly productive karst aquifers (Fowler, 2005). Bexar County, the county encompassing San Antonio, contains three productive aquifers: the Edwards, the Carrizo-Wilcox, and the Trinity (*see figure 2*).

According to Maclay (1989), the Edwards Aquifer holds between 25 and 55 million acre feet of water. An acre foot is equal to the amount of water it takes to cover one acre with one foot of water, or 1233.5 cubic meters (m^3). However, the amount available for human consumption makes up only 5-10% of that amount (EAA, 2011). The contributing zone, the recharge zone, and the artesian zone comprise the functional units of the Edwards Aquifer (*see figure 3*). When precipitation falls on the contributing zone, the largest component region, it flows over the surface into the recharge zone. Most water infiltrates the aquifer through the recharge zone (the most environmentally sensitive zone) due to the extremely high permeability of fractures in, as well as the porous composition of, limestone. This permeability allows for quick recharge, but also contributes to water quality problems and low storage capacity.

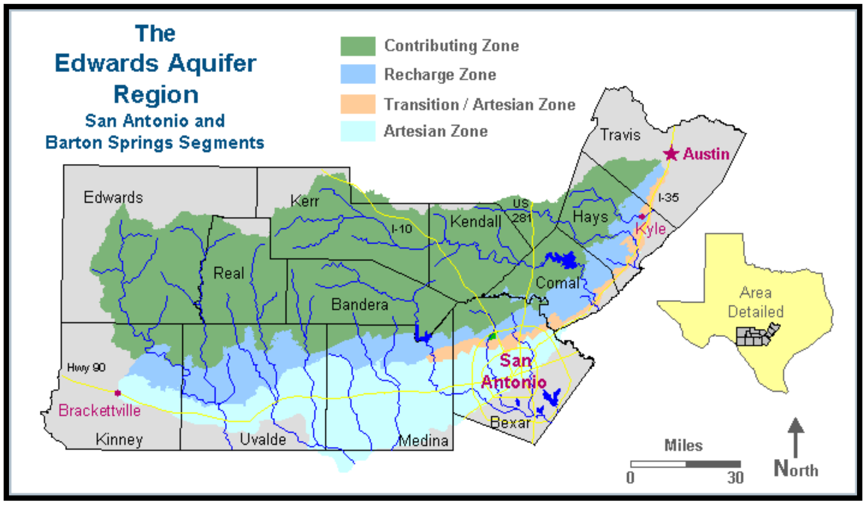

Figure3: Zones of the Edward's Aquifer (EAA, 2011)

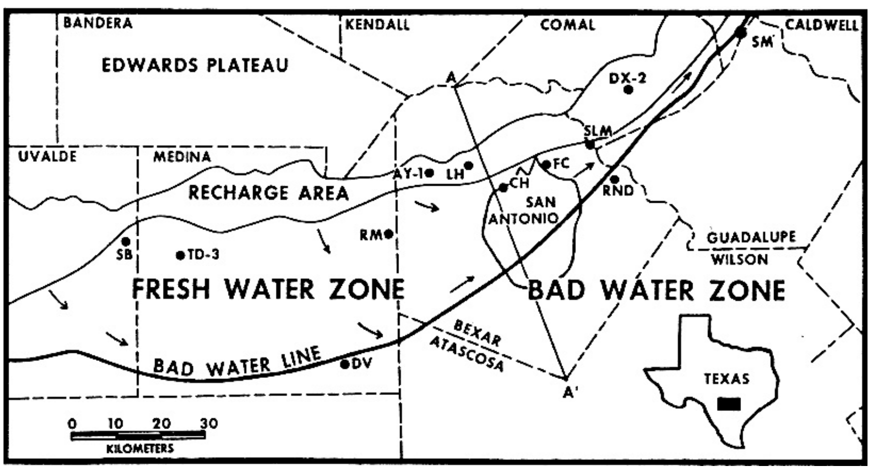

Figure 4: Brackish Water Line of the Edward's Aquifer (Ellis, 1986)

The residence time of water in this aquifer averages about two hundred years. Comparatively, the water of the Ogallala Aquifer, stretching from the Texas Panhandle through the Midwest, has an average residence time of several thousand years (Samson, 2008). Finally, water naturally escapes the aquifer into the artesian zone, because of gravitational pressure, and forms springs. The saline portion of the Edwards, to the east of the artesian zone, must be noted because desalinization of brackish aquifer water (more saline then fresh yet less saline than sea) may also become a treated water supply source for the city of San Antonio (*see figure 4*).

Unlike the Edwards Aquifer, the Trinity Aquifer runs throughout the state of Texas, but recharges only very slowly (Eckhart, 2011). Robert Mace (2000) predicts that the Trinity, however, provides up to 59,000 acre-feet of water annually to the Edwards Aquifer. Bexar County's final aquifer of note, the Carrizo-Wilcox Aquifer, currently remains unused by the city of San Antonio, but plans are on the table to acquire water rights to use the aquifer in the future as existing water supply sources become more scarce.

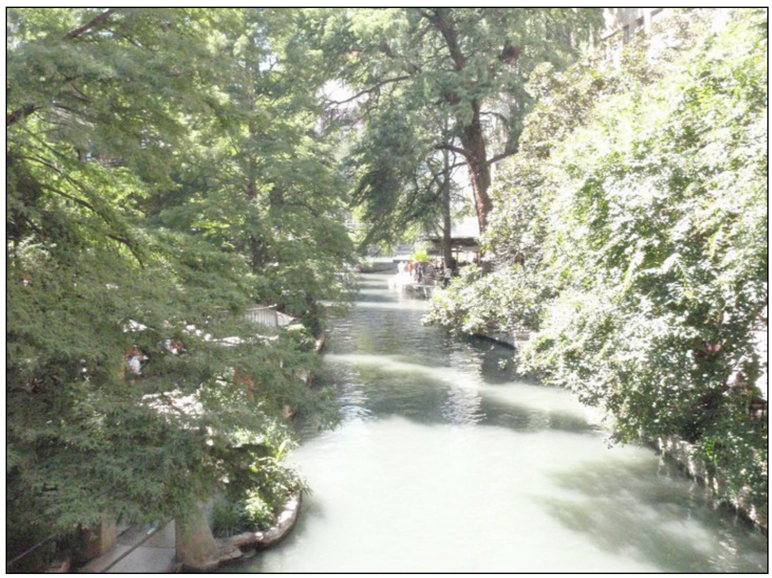

Figure 5- The San Antonio River

Surface water, naturally created by runoff and carried above ground, is limited in the San Antonio region. The spring-fed San Antonio River's headwaters originate in the northwest portion of the city. However, unless exceptionally high levels of rain fall in a given year on the Edwards Plateau recharge region, recycled water today provides the majority of the river's flow (*see figure 5*). This water is vitally important for those downstream and for the economic value to the tourist city of San Antonio. The nearby Comal and San Marcos Rivers are also fed by the Edwards Aquifer's springs, but do not supply water for the city. Canyon Lake, an Army Corps of Engineers' reservoir on the nearby Guadalupe

River, provides the only current source of surface water for the city of San Antonio, yet, while it is technically surface water, it still comes directly from the Edwards Aquifer. Finally, the Colorado River (of Texas), which originates in the Panhandle of Texas and flows six hundred miles south into Matagorda Bay, may be a potential future surface water source for San Antonio. Due to the arid nature of San Antonio, the Gulf of Mexico must also be considered as a potential water source. Located almost 150 miles south of San Antonio and consisting of water with high salinity levels, ocean water desalinization from the Gulf of Mexico remains a likely future water supply source.

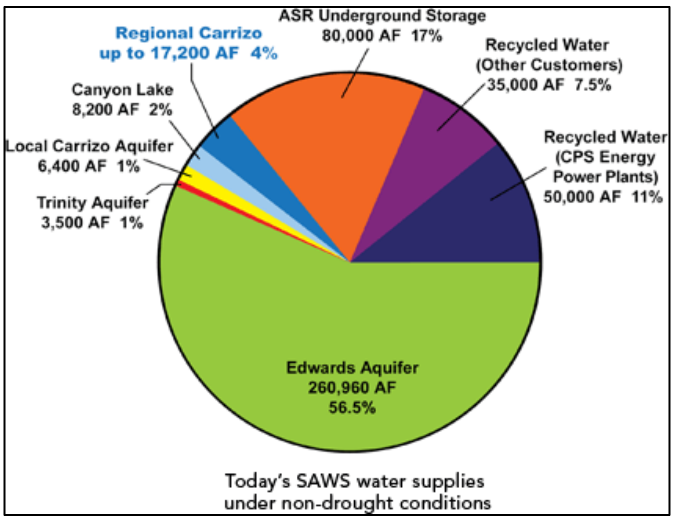

Figure 6 – SAWS's Water Sources (SAWS, 2009)

For most of its history, the sole source of San Antonio's water was the Edwards Aquifer. It was, until recently, the largest American city to rely solely upon groundwater for municipal supply. However, in recent years, San Antonio has diversified its sources to include available surface water, and in the future plans to even incorporate ocean water desalination (*see figure 6*). When water availability combines with historical context and population growth - water policy is adapted and novel water management strategies begin to coalesce.

The Physical Geography and Water Availability of Colorado Springs

At first glance the city of Colorado Spring's similarities and differences from the physical geography of San Antonio are apparent. Colorado Springs' location situates it on the Eastern Front Range of the Rocky Mountains, in central Colorado, along the I-25 corridor. Colorado Springs, with an elevation of 6,140 ft asl stands nearly a mile higher than the highest elevation in the San Antonio region (NOAA, 2011).

Colorado Springs' climate differs from San Antonio, and even other places in Colorado, because of its elevation and proximal location to the mountains. This results in extreme shifts in temperature, precipitation, and weather conditions on a seasonal and even sometimes a daily basis. The highest recorded temperature in Colorado Springs' history reached 37^0C (99^0F), while the coldest temperature was recorded as -31^0C (-24^0F). While San Antonio has an extreme temperature range of 38^0C (100 degrees F), Colorado Springs has an extreme range of almost 52^0C (125^0F). Colorado Springs also has extremes in precipitation. Known for 300 days of sunshine a year, only 65 days are responsible for an average precipitation of 44.2 cm (17.4 in) and an annual snowfall average of 134.4 cm (52.9 inches) (NOAA, 2011). The differences in the predominant form of precipitation also dictates a difference in timing, not to mention amount, of precipitation when comparing San Antonio to Colorado Springs. Both Colorado Springs and San Antonio accumulate the majority of precipitation during the early summer months, before the highest temperatures occur. However, due to the orographic effect and the prevailing Westerlies, the Western slope of the Rocky Mountains receives much more rain than the Front Range, or Eastern slope.

The difference in precipitation occurs because warm air hits the Western side of the mountains, rises, and condenses causing frequent heavy rains. This orthographic trend can be seen in almost every mountain range in the Northern Hemisphere. Colorado Springs' climate, and the entire Front Range of the Rocky Mountains from Mexico to Canada, is typically classified as Mid-latitude steppe (McKnight, 2008). Like all of the Front Range, Colorado Springs represents a transition zone for vegetation and wildlife. The vegetation ranges from semi-alpine to semi-arid high plains (Hrebenar, 2005).

The Rocky Mountains dictate the geology and topography of the Colorado Springs region. During the Laramide Uplift, the granitic Rocky Mountain Range formed as the Pacific Plate subducted underneath the North Atlantic Plate, creating a mountain range nearly 1,000 miles from where the plates actually met (USGS, 2000). Pikes Peak, only a few minutes from downtown Colorado Springs, represents a dramatic elevation change, from 5000 ft on the western end of the American Great Plains, to over 14,000 ft. Many of the highest points of the Continental Divide are located close to the city of Colorado Springs.

The Denver Aquifer Basin makes groundwater available for the city. The Denver Basin, a deep bedrock aquifer, holds an enormous amount of water and numerous wells have been drilled to reach it. However, unlike the Edwards Aquifer, the Denver Basin's recharge rate is so small that it is unsustainable to depend upon it in the longer term, and all groundwater must be pumped out in order to be utilized (unlike the artesian zone of the Edwards). Therefore, unlike San Antonio, Colorado Springs gets most of its water from surface water sources.

Proximity to the Rockies means that instead of groundwater, the Springs' depends upon the annual snowmelt to provide seasonal flows of surface water. Local sources of surface water include: Fountain Creek, Ruxton Creek, Monument Creek, North and South Catamount Creek, North and South Cascade and Crystal creeks (from the north slope of Pikes Peak), and the seven lakes on the south slope of Pikes Peak (CSU, 2011). Colorado Springs depends upon a total of 17 reservoirs to capture these local surface water sources. Due to the seasonal nature of snow melt and the timing of precipitation, reservoirs are essential to ensuring that the spring and summer high precipitation and snow melt yields can provide water for the city long into the dry season. The largest local source of water is the Arkansas River, which begins near Leadville, Colorado, and then flows east into the Mississippi River.

However, since 80% of Colorado's rain falls on the Western slope of the Rockies, transmountain diversions transport West slope water to Colorado Springs (see figure 7). Transmountain pipelines divert water from the Blue River, the South Platte River, Eagle River, Roaring Fork River, Lake Creek, and the Fryingpan River (CSU, 2011). A new Southern Delivery System is currently being built, which will significantly contribute to the city meeting its fifty-year water supply projections. As shown, much of the water supplying the Front Range of the Rockies, and

Figure 7 – Transmountain Diversion across Continental Divide

therefore the Colorado Springs region, is diverted from the headwaters of the Colorado River Basin. The entire Front Range is part of one of the largest interbasin river transfers in the world. The nature of taking water from one region and providing it to another, simply because the population is located where the water is not, creates significant controversy. Transfers unquestionably alter the history of water use in Colorado as well as public perception and policy in terms of water use and associated development in the region.

Missionaries, Acequías, and Hybrid Water Law – The Historical and Legal Background of Water in San Antonio

Water rights, like other significant legal and political issues, are strongly tied to human culture and history. Both cities examined in this research have their regional water use practices unquestionably governed by the legal precedent and historical background of their respective states. Yet, not only have the historical foundations altered water law, but water law has made momentous impacts on each city's history and landscape.

Spanish explorers first laid eyes on the San Antonio region in 1691, though it is also speculated that Cabeza de Vaca stopped there in the 1500s. Spanish missionaries later founded San Antonio in 1718 and built Mission San Antonio de Valero (Ramsdell, 1959). Their purpose in settling San Antonio was to keep a strong presence in their territory so that the colony did not become occupied by nearby French settlers. Spanish expeditions from Mexico chose to travel to San Antonio, over other areas in the region, due to one primary reason: water.

In the San Antonio region, Native Americans flourished from abundant regional resources due to water availability and the regional bounty including pecans, wild grapes, and fish. They also used irrigation in the San Antonio River Valley for crops over their ten thousand year residence in the region (Ramsdell, 1959). When the Spanish missionaries came to settle the region, they brought with them a system of acequías, community water ditches for irrigation and consumption (*see figure 8*). Like many irrigation works in developing countries today, the acequías were also used for dumping garbage, sewer lines, and bathing until penalties were created to limit related pollution (SAWS, 2011).


Figure 8 - Acequia de Espada is Still a Functioning Acequias (EAA, 2011)

The Spaniards knew by 1731, with six missions and a military post, that irrigation was going to be necessary to support any further growth in this semi-arid climate (Nicholas, 2007). The acequías were by no means inexpensive; some took up to two decades to build and therefore had a relatively high associated cost. Several of the acequías were built so well they are still in use today (2007). The best-irrigated land lies mostly adjacent to the acequías - land usually owned by the local elite. Even as long as three centuries ago, water was directly equated to power and growth.

It is important to note that in addition to the acequías, the Spanish also brought with them a system of water allocation. Water in Europe had for the most part been allocated by a system of riparian rights. Riparian water rights dictated that surface water may be used beneficially by those who are located along the banks of the water body. Additionally, the water rights cannot be separated from land ownership, meaning that when a property is sold the water rights go along with it (James, 2003). Water not used directly on riparian land must be returned to the water body from which it came.

This made sense for Europe, a place where green grass can grow for miles without the addition of water, because of the abundance of precipitation. The riparian water allocation system also works well on the American East Coast, where water law was first established in the original thirteen colonies of the United States, and where most land gets adequate precipitation to grow crops without irrigation.

In the United States, a country with a strong religious foundation, the theory of natural flow developed. Natural flow meant that the water must not be "diminished in quantity or quality," an idea that sprang from the belief that water existed under a divine plan, and was by no means personal property (Pisani, 1996). This worked well in New England, at least until the Industrial Revolution. At that time, the theory of reasonable use became popular. Reasonable use instead promoted the idea of water providing "the greatest good for the greatest number of people" (James, 2003). Again, these theories worked well in New England, the East Coast, and Western Europe because of an abundance of precipitation. However, parts of Spain did require acequías because there was not enough rain for agriculture without irrigation. Spain, like San Antonio, is for the most part semi-arid.

Therefore, the riparian system made no sense for San Antonio, and most of Texas. Yet the Spanish were not the only ones to populate Texas. Germans, along with other Western European immigrants, and East Coast Americans also started arriving in this area in the mid 1850s (Geue, 1982). They brought with them the notion of riparian doctrine, and the plants and crops that did well in regions with dependable precipitation but which needed intense irrigation in San Antonio. In San Antonio water must be removed from the stream or river, like with acequías, in order to support agriculture on fields many miles away from water bodies – this is in direct violation of riparian doctrine.

Part of understanding San Antonio's water use today lies with the problem of riparian rights being used in a semi-arid region. The other important point to understand is underground water use. By 1877, the city of San Antonio had decided to enter a water supply contract with J.B. La Coste and Associates, who started generating a reliable water supply by building a gravity-fed pump-house near the headwaters of the San Antonio River (Nichols, 2007). The company switched hands in 1883 to George Brackenridge who built the first artesian well in 1889. One year later all of San Antonio's drinking water came from artesian wells instead of acequías (2007). Even later, the agricultural uses around San Antonio were also dependent on private wells extracting Edwards Aquifer water.

Here another problem began to arise. Most can easily make the connection that if water is pumped out of the ground, where springs emerge, the water on the surface will be diminished. Water law in Texas, however, treats ground and surface water as isolated systems – not affected by the other's depletion, pollution, or overabundance. Part of the problem of regulating groundwater, such as the Edwards Aquifer, is due to the complex nature of underground water resources. With new technology, water can be traced, yet when water rights were first developed, these systems were poorly understood, and therefore there was absolutely no way to regulate them sustainably.

Unfortunately, once a law is in place, making significant alterations is not easily done even considering the emergence of strong scientific evidence. For Texas, this is an even bigger problem since over 95% of Texas is privately owned. Those who bought property depend upon their perceived right to water and their livelihood may not survive economically without a continuation of that right. Many Texans additionally feel a sense of entitlement to use water however they want on their property. Likewise, while surface water tended to dictate how land was split under Riparian Doctrine (just look at the borders of any Eastern state), groundwater adheres to no such legal or political boundaries.

As San Antonio's population continued to grow into the 20th Century the need for water also continued to grow. The problems involving riparian allocation and lack of groundwater regulation became more acute. By 1905, the community waterworks' ownership switched hands again. George Kobusch bought the rights and renamed the water company San Antonio Water Supply Company (SAWS, 2011).

Soon after, the water company was bought by Belgians who sold it to locals in the 1920s to recover financially from World War I (Nichols, 2007). Due to the instability of the company and rate increase arguments, the City issued seven million dollars in bonds to purchase the water system in 1925 and establish a City Water Board to govern the system. At that time the water system was serving 38,000 customers an average of 77 acre-feet a day (25 million gallons) (SAWS, 2011).

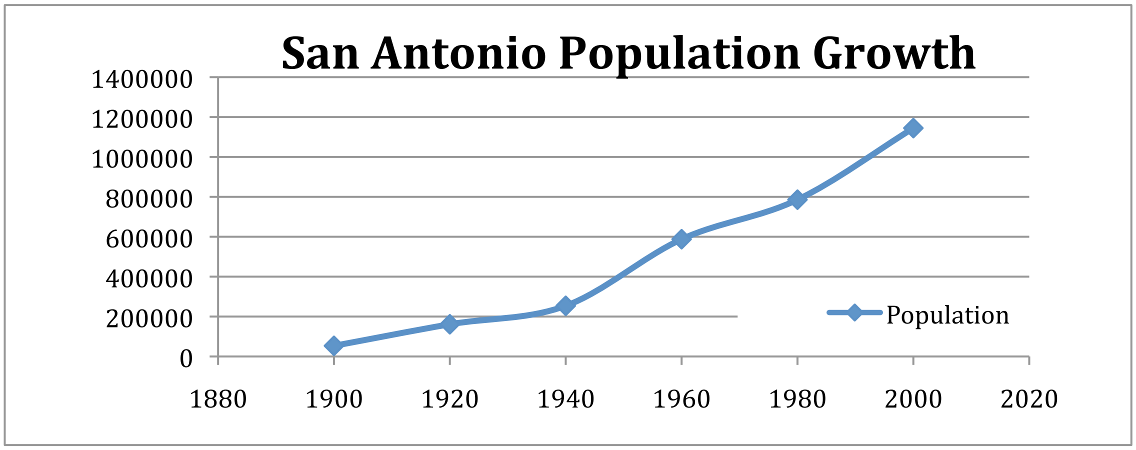

Figure 9: San Antonio Population Growth (U.S. Census, 2011)

After World War II, the building and population boom created a need for a unified water plan to meet ever-increasing demand. During the 50s and 60s, whether through springs or through pumps, San Antonio, with over 580,000 people, depended solely upon the Edwards Aquifer (*see figure 9*). The problem of groundwater regulation, or the lack there of, was becoming increasingly apparent to San Antonio's neighbors.

By this time Texas, and the majority of the United States, had developed groundwater policy due to increased reliance on groundwater and better pumping technology (James, 2003). Texas' groundwater policy before the 1990s could be summed up as strictly "law of the biggest pump", also known as absolute dominion. This type of water use means that if a landowner has a pump that can tap into the water table, the owner can pump as much water as possible, regardless of the harm done to others. Absolute dominion does not incentivize using water efficiently or ethically, and almost always ends up causing a *tragedy of the commons*.

Garret Hardin expressed a tragedy of the commons as what happens when there is a shared resource which everyone uses based on their own self-interest. Everyone acting in their own self-interest tries to get the most out of the system, thereby destroying the system. During this time, San Antonio was the largest user of Edwards Aquifer water in central Texas, and was acting according to its own self interest.

During the 1950s absolute dominion's effect was apparent in central Texas. The 1950s marked the drought of record for central Texas, as well as for most of the United States. More water had to be used, because of lack of precipitation, yet less water was available for pumping for the same reason.

Following the 1950s, the 1960s marked the beginning of a wave of environmental legislation spurred by John F. Kennedy's Secretary of the Interior, Steve Udall, and the monumental novel, *Silent Spring*, by Rachel Carson on the hazards of DDT. Soon after, the National Environmental Policy Act (NEPA) was created. Around the same time that this act was signed into law by Richard Nixon in 1974, another law was created with the intension to protect threatened species and species in danger of extinction. The Endangered Species Act (ESA), provided certain listed species and their habitats protection under federal law. In Texas, the first controversial species on the list was a tiny clear salamander whose habitat lies fifty miles north of San Antonio and depends on the flow of the San Marcos springs, provided, of course, by the waters of the Edwards Aquifer.

Under the Endangered Species Act, the Texas Blind Salamander (*Typhlomolge rathbuni*), and several other endangered species located in the San Marcos and Comal Springs supposedly guaranteed the flow of the springs. To guarantee flow to the springs meant to regulate the pumping and permitting of the Edwards Aquifer. Yet, significant regulation did not occur until the Sierra Club brought suit in 1991 against the United States Fish and Wildlife Service (USFWS) and the Secretary of the Interior for allowing the “taking”, or the lack of protection through enforcement by the USFWS, of endangered species (Votteler, 1998). The court decided that it was legal to regulate pumping of the Edwards, and the Edwards Aquifer Authority (EAA) was created in 1993.

Meanwhile, amidst the controversy in 1991, a vote passed through the San Antonio City Council that established one utility that would be solely responsible for water supply, wastewater, stormwater, and reuse (SAWS, 2011). In 1992, it took $635 million in water and wastewater bonds to merge together all the disparate water entities in order to form San Antonio Water System (SAWS) (SAWS, 2011). SAWS needed to ensure that there was water for the future, and needed to plan for additional sources of water supply due to the newly imposed pumping regulations. Otherwise, the city’s growth would cease.

Due to its physical location, the city could not just obtain new water rights from a nearby water source without incurring astronomical costs. Therefore, SAWS decided to take a stance, and instead of getting new water, they would go to almost any length to use the water they had more efficiently. The slogan *0% more water, 50% more people* is a message conveyed by SAWS at almost every level of their organization. It took many conservation strategies to get there, but due to the regulation of the Edwards Aquifer, conservation became the way forward for San Antonio.

Today, San Antonio is still a rapidly growing city. For the 10-year period from 2000 to 2009 the city had an average growth rate of 21%, one of the highest in the nation during this period (Census, 2009). The expense of conservation is to be compared with the marginal cost of the next available large water source, the ocean. Though, like

Colorado Springs, the notion that growth could be limited by water availability was evident at least as long ago as the 1800s.

The heart of San Antonio is located at 29.2 ^{0} North Latitude and 98.3^{0} West Longitude. John Wesley Powell, the first director of the United States Geological Survey, marked the 100th meridian as the start of the West in *A Report on the Lands of the Arid Regions of the United States,* in 1876 (Reisner, 1986). Powell stated anywhere west of the 100th meridian would need to be irrigated to grow crops, and only *one to three percent* of two-fifths (the Western portion) of the United States could be reclaimed even with irrigation (Powell, 1878). Even so, today, San Antonio is continuing to grow despite these natural limitations on its water supply. This is made possible through the city's decision to utilize water conservation as the means by which they could grow in population with the addition of 0% more water.

Gold and Water Law – The History and Legal Framework of Colorado Springs

> Virtually every people who know it associate gold with purity. As a help to physical labor, gold is virtually useless. It is a heavy soft metal…. Its appeal comes from four qualities: it is rare, it is remarkably inert, and will combine with almost nothing around it… and its shiny. Its force lay in its commanding cultural appeal, an allure that comes close to enchantment.
>
> Elliott West in *The Contested Plains: Indians, Goldseekers, and the Rush to Colorado* (pp 97)

Like San Antonio, Colorado Springs is located West of Powell's hundred degree demarcation. As with San Antonio, Colorado Springs ignored Powell's warning and has quickly grown to over 300,000 residents (Census, 2010). The similarity stops here. One hundred and fifty years ago the state of Colorado was inhabited by no more than a couple of native nomadic tribes, a few frontiersmen, and a handful of explorers. The barriers of the Rocky Mountains and violent natives were enough to keep all but the most daring of settlers away.

Gold was discovered in Cherry Creek, a tributary to the South Platte River, in 1858 by William Russell and company. They were exploring the Denver area when they found the precious mineral that would spur a mass wave of Europeans and Americans settlers to settle Colorado (West, 1998). For more than fifty years, rumors had spread, some based on truth others not, about gold in the Front Range of Colorado. Explorers had come and gone with little, if any, gold in their pocket. During the 1850s, a depression, the slowing down of mining in California, and decent reports of findings were enough to motivate many "restless men down on their luck and looking for a turn of fortune" to form expeditions to the Front Range (West 1998, pp 101).

Pikes Peak, which for many was the only familiar landmark, became symbolic of the gold rush, even though the majority of the precious mineral lodes were discovered eighty-five miles north of the peak. This reality aside, the slogan "Pikes Peak or Bust" was the rallying cry of thousands of miners as they came to the Front Range looking for gold. Like California's, whose population went from 10,000 non-native inhabitants to over 200,000 in a two-year span, Colorado's population exploded into the all too familiar boom and bust towns tied to mining (Wyckoff and Dilsaver, 1995). Indeed, mining vastly altered the settlement of the region, as it did for most of the Mountainous West, turning what might have been a twenty-year settlement process into a process that took a period of only a few months. Many miners who came to make millions ended up settling as farmers or other suppliers, to feed and support the steady inflow of newcomers.

Miners from far and wide came to Colorado, with the majority from California. Many of these had travelled to California for the initial American gold rush, but had found little there. So they moved on to Colorado with new hopes that their fortune would be found in Cherry Creek, South Park, or elsewhere along the Front Range of the Rockies. What is particularly important about their origins in California was that this state had established an unofficial water rights system now known as *prior appropriation*. To present-day, this system of allocation has been perfected, reworked and litigated through numerous court battles, but its fundamental characteristics remain the same: 1) First in time, first in right, 2) Intentional diversion for beneficial use, and 3) Use it or lose it.

Gold is extracted from rocks through a process using water; therefore, miners had to get water to their mining claims. It cost a great deal to build the infrastructure to divert water from creeks and rivers and to apply it to their claim. So, if an individual established a claim upstream of another individual who had been mining for a period of time, and had already spent money on developing the claim, there had to be a means devised to protect that prior developed claim. Therefore, prior appropriation was established in order to protect, maintain, and incentivize developers; *first in time* became *first in right*.

The system of prior appropriation was strictly enforced by miners and ideally, regulated itself. Initially, anyone taking surface water out of its banks for anything other than *beneficial use*, using the water for its purpose without waste, was immediately chastised because others were so dependent on the same water. It would then seem that prior appropriation is well-suited for conservation. However, the principle of *use it or lose it*, meaning that the user cannot claim more water than they use, means that in years of plenty a rancher, for instance, must apply the same amount of water to a field as during a dry season, even though their fields may not need it.

Today, almost all Western states have some form of prior appropriation because of scarce precipitation. Colorado, though, has the strictest form of appropriation, known as the Colorado Doctrine. The Colorado Doctrine was legally established in 1922 in *Wyoming v. Colorado*. Although at the time the legal precedent in the United States followed the riparian doctrine, the Supreme Court ruled that "the early adaption and continual practices" of prior appropriation in Colorado gave the state the right to decide on what water allocation practice it could implement within its own boundaries

(WYOMING v COLORADO 1922). This case made it possible for each state to create its own form of water rights based on its' physical needs and historical uses.

While the Colorado Doctrine has its roots in mining, the evolution of the doctrine has taken place in how it applies to urban centers, such as Colorado Springs. The first city established in the Pikes Peak region was Colorado City. Situated on the Eastern slope of Pikes Peak, at the present day site of Colorado Springs, the city was established in 1859 to provide the "Pikes Peak or Bust" miners with supplies for the mining operations of South Park, to the west of Pikes Peak. In 1862, it was even in the running to become the capital of the newly formed Colorado Territory, but because of bad location and timing it became a ghost town by 1869. Meanwhile, Denver City's growth took off because of its prominent location to large mining operations (Sprauge, 1988).

Like most western mining towns, Colorado City contained brothels, gambling, and drinking. General William Jackson Palmer, a railroad tycoon, looked at Pikes Peak and saw the potential for much more. Palmer was transfixed by the scenery and wanted to transform the landscape into an internationally known resort (Wyckoff, 1999). He wanted to create a city entirely different from the crude, saloon ridden, untamed cities of the West (Sprauge, 1988). As a railroad tycoon he wanted to extend the Kansas Pacific Railroad by building a North-South line from the exploding gold town of Denver down through Mexico, with a gleaming resort town along the way. Palmer was successful in building the line formerly known as the Denver-Rio Grande or the DRG, until it became part of the Union Pacific. He was also successful in the establishment of the city of Colorado Springs in 1871.

Palmer's utopian resort town was elite to the extreme. Unlike other Western towns, it banned alcohol and saloons, while hotels, tourist attractions, spas and sanitariums, libraries, lecture halls, and parks abounded. The main thoroughfare was designed so that Pike's Peak could be clearly seen (*see figure 10*).

Figure 10: Pikes Peak Ave in Colorado Springs in 1898

Thousands of trees were planted along this main boulevard, necessitating the city's first major irrigation project (Wyckoff, 1999). In the 1870s the city had only a few hundred residents, but by the 1880s, it had over 4,000. By the early 1900s, the city had reached a population of 30,000 (Sprague, 1988).

Palmer had a love for greenery, which can be seen at both his estate and also in the over two thousand acres he donated to become city parks. Like Palmer, many of those who traveled to the Springs became infatuated with the pristine environment, a far cry from the industrial-era cities of Europe and the Northeast, and much of the economy developed around the preservation of the environment, a far cry from San Antonio. The environmentally conscious development started with protecting the clean air that was such a great asset to the city, followed by protection of the "healing" springs in Manitou, and the Peak that drew visitors from far and wide. "People flocked to Pikes Peak on the new western railroads to find health and adventure and romance in the Rockies," says Western author Marshall Sprague in *Newport in the Rockies* (1980, pp Forward). The success of Colorado Springs has always been tied to its idealized environment.

Climatologists during the 1870s, probably heavily influenced by the idea of Manifest Destiny, thought that as settlers moved West as was God's plan, the water would follow. Climatology Professor Cyrus Thomas even said during this time period:

> Since the territory [of Colorado] has begun to be settled, towns and cities built up, farms cultivated, mines opened, and roads made and travelled, there has been a gradual increase in moisture… I therefore give it as my firm conviction that this increase is of a permanent nature, and not periodical, and that it has commenced within eight years past, and that it is in some way connected to the settlement of the country, and that as population increases the moisture will increase. (Reisner, 1986, pp 36)

John Wesley Powell stated, as mentioned previously, that this was not the case, the time period simply represented a wet spell. Powell held fast to his beliefs that the Western climate could not support people the way the East coast climate had. Yet, many held onto the philosophy that the *Rain Follows the Plow*. This mistaken belief inadvertently helped accelerate the Dust Bowl in the 1930s via removal of the vast grasslands anchoring the soil.

Water supply maintenance has always been one of the Springs' greatest challenges for maintaining growth and local quality of life. Even the initial planning of the city called for irrigation canals, in addition to drinking water canals, which were being built at the same time as the Denver rail line. Because the only surface water in the city was two trickling creeks, Monument and Fountain, Palmer had to cite the distant mineral springs at Manitou to justify the city's name (Sprague, 1988).

The first improvement to the canal system of the 1870s came during a grasshopper plague in 1891. Disgusted by insect carcasses, residents demanded a new water delivery system. The resulting South Slope system consisted of tunnels and reservoirs supplied by snowmelt on the Southern Slope of Pikes Peak. This provided the growing city with water into the 1930s. During that decade the water utility acquired labor intensive, New-Deal supplied pipelines to transport water from the North slope to the city.

The end of World War II brought enormous growth to the region with a new Army post, an Air force base, NORAD (North American Aerospace Defense Command), and the Air Force Academy. Colorado Springs Utilities, along with the nearby city of Pueblo, decided to join Denver in obtaining water from the other side of the Continental Divide. The resulting Blue River Project was completed during the early 1950s. While this project satisfied, for a while at least, the thirst of the Springs and the dream of visionaries, it also greatly upset those on the Western slope, who saw this water as theirs. Transmountain diversions continued to transport water across the divide with larger projects like the Homestake and Fry-Ark (a federally mandated project for flood control as well as water supply purposes) projects taking place in the 1960s and 1970s. Work is currently being completed on the Southern Delivery System, a pipeline that allows the city to full utilize its water rights, so that Colorado Springs can meet its fifty-year water projection needs. These diversions have created conflict between the East and West Slopes. Eighty percent of the precipitation falls on the West Slope where only 20% of the population lives. While those on the West Slope are well aware of this issue, those on the East Slope, with the population to push legislation through, are not as concerned with where their water comes from as they are with providing water for the needs of citizens, job growth, and tourism. Yet, according to Jenny Grey Bishop at Colorado Springs Utilities (CSU), these diversions in fact promote conservation. She stated that when:

> water is allocated in Colorado, anyone who has an interest in that water can oppose [ones'] case. And, in order to get people to leave you alone essentially, you have to abide by their stipulations. They can get certain clauses into your final decree for that water. And so, in order to make Pueblo happy, say, we would have to say that, you know, we agree to reuse this amount, and conserve this amount, or promote programs that promote conservation, or things like that. It isn't necessarily hard and fast rules per se. There isn't anything in Colorado water law that says you must do these things, but there is an encouragement among the community and stakeholders…that in order to move forward with your case, you make these concessions (Grey Bishop, interview [2011]).

In short, Colorado Springs, like San Antonio, has recently discovered the need for water conservation measures in order to grow despite limits in water supply growth.

0% more water – Why a City Chooses to Use Less

The goal of every water agency is to have enough water to meet the needs of its customers. Through enforcing statutes that protect against the wasteful use of water and incentivizing the efficient use of water, a city can significantly reduce demand. In fact, SAWS can boast the nation's largest water recycling program. They are also touted world-wide for the startling statistic that even as the city's population doubled over the last twenty years, the city has used and distributed the same volume of water. SAWS, therefore, dramatically reduced their gallons per capita per day (gpcd) use of water at the same time as the city grew rapidly.

This feat would be significant if the city contained only a couple thousand inhabitants, but San Antonio is America's 7th largest city. With a current population of just over two million, San Antonio proves it is possible for water conservation practices to significantly reduce the water demand of a city of any size (DSHS, 2011). Additionally, the quality of life has not been lowered by using less water. According to Karen Guz, the Director of Conservation for SAWS:

> This community has dropped its per capita tremendously over the years, and yet all of the economic indicators are fantastic for San Antonio in comparison with the rest of the country. We've grown, we've thrived, we've added more industry and diversified our economy – all while our per capita [water] consumption was dropping. So if someone thinks that even quality of life goes down – all evidence seems contrary because people are moving here in droves (Guz, interview [2011]).

Colorado Springs, like other arid municipalities pressed with population growth and costly new supplies, is attempting to become like San Antonio, a leader in conservation.

However, CSU has to face both similar and different challenges because of its different historical, legal, and physical background. There are significant battles of economics, politics, and geography that combine to propel or inhibit conservation. A utility must be able to overcome obstacles like these in order to achieve significant savings of water. By comparing these two municipalities, best practices for other arid and semi arid cities can be developed.

The specific plans that each municipality employs are extremely important in conserving water, but why they chose those plans is even more critical if a growing municipality is to learn from their successes. It may seem like an easy choice to decide what programs to use, but when pioneering the way forward, the easiest choice may not always be the best, as discussed in the next section. Furthermore, telling customers that they need to change the way that they have always done things makes decision making a much harder task.

Unquestionably, social barriers make conservation more difficult than all the physical and legal barriers combined. Guz agrees, "It is one of the hardest things we do. Everyone who has been on a diet knows changing behavior is the hardest part" (Guz, interview [2011]). For all these reasons and more, why a particular conservation program is chosen by a given municipality is crucial to understanding the conservation method, its applicability, and level of success.

Each city has its own logic and reasoning behind conservation. CSU's decision to conserve water comes from several sources. First, some of the water right agreements, based upon prior appropriation, now have clauses requiring conservation. Many water rights transfers included clauses that say, "ok we'll let you reassign this water, but we want this percentage of conservation and this percentage of reuse," says Grey Bishop (Grey Bishop, interview [2011]). Scott Winter, the Director of Conservation at CSU, agreed, stating that "There has to be an assurance that the water that you are using or trying to acquire you use efficiently before you require more resources" (Winter, interview [2011]).

Secondly, when water is allocated in Colorado, anyone who has an interest in that water can oppose the allocation. So that water stipulations are met, negotiations take place in order to make all stakeholders happy and to avoid litigation, which could lead to a decision that is not sought by any of the parties. Even though it is not legally mandated, like in San Antonio, there is encouragement among the community and stakeholders to make compromises regarding this precious commodity. This is especially important in Colorado Springs and Denver where there is a geopolitical strain due to 80% of the water falling on the west side of the Continental Divide where only 20% of the people live. Therefore, it is much easier to convince those on the West slope to agree to inter-basin transfers to the East slope if they know the water is being used as efficiently as possible.

Finally, there is the motivation of wanting to do the right thing. A significant part of conservation in Colorado is due to simply wanting to be a good steward of the resource, especially since the community is socially tied to the environment. Winter indicates that, "everyone wants to steward the resource. We are constrained in ways that some of the stakeholders don't understand, so we're limited to what we can do to some extent, but I think we all want to try to do the right thing" (Winter, interview [2011]).

Therefore, Winter devised four criteria for CSU to decide how to best conserve water. First and foremost, the water savings of a potential program must be considered.

Even if a program is cost effective and socially acceptable, if the water savings are not there, there is little reason for a utility to invest in the program. For instance, if a program is designed to make dishwashers more efficient, yet dishwashers make up less than one percent of residential water use, the program would not be highly effective (CSU, 2008). All of CSU's water conservation programs are measured in cost per acre-foot (cost/af), just like at SAWS, so that the rate can be compared with the supply side to justify programs. As Guz said, one the largest barriers to conservation is economics. It takes a utility and a City Council that has "drunk the Kool Aid of conservation," for a conservation program to be effective (Guz, interview [2011]).

The second criterion CSU devised to measure conservation programs is their social acceptability. How well the public and the stakeholders will accept a particular program's rules matters immensely. Part of social acceptability lies with cost. Grey Bishop explained that:

> Rates are totally a relative thing. People moving here from outside of the area, think "oh, utilities are so ridiculously cheap." Even among the Front Range utilities, [our rates] are at the middle or lower part of utility pricing. People who have lived here though, and are use to five cent cups of coffee or whatever, got really upset over the 12% rate increase.... I mean you thought you were taking their first child for slave labor (Grey Bishop, interview [2011]).

Even though the rate change did not affect most residents, the average customer didn't understand this. That is why the marketing of a plan is vitally important. CSU tries to maintain a consistent message, so that customers know when change is coming and hear the message of conservation over and over again. Additionally, gradual steps are usually met with less residence than a total overhaul of a familiar process. Therefore, new technology, like the switch to high efficiency toilets, is much more acceptable than telling people to change their habits, to, for instance, only flushing a toilet once a day or only watering their yard once a week.

Third on the criteria for the creation of a program is the likelihood of a program's success. For example, in Colorado Springs during the first three years of the high efficiency toilet (HET) rebates, very few people purchased them because the toilets could not be found at any of the city's home improvement stores. Now that the technology is available, the use of HETs is exploding and may even be the most popular rebate this year. Simple things, like HETs, can equate to enormous conservation savings.

Finally, the fourth criteria when considering a conservation program for Colorado Springs Utilities was whether or not the program required a significant increase in staff. If a program requires hiring twenty more employees, the likelihood of the program being adopted is small. The most noticeable difference between the two cities' different water conservation programs is in how many people are assigned to the water conservation department. The difference in employee numbers, between CSU and SAWS, is an easy indicator of the size of the entire conservation operation. When asked how many employees worked solely with conservation, Winter responded that CSU had basically two people dedicated 100% of their time, about 1/3 of a manager, about 1/3 of an education coordinator, and two temporary workers that worked part time, adding up to one person. "So that's pretty much it, it's the equivalent about four, when you add the little partial pieces together" says Winter (Winter, interview [2011]).

SAWS, on the other hand, has the same amount of personnel assigned to water and wastewater as CSU has assigned to water, wastewater, natural gas, and electricity combined. That is, SAWS has 1,690 employees to maintain its operations while CSU has 1,850 employees to handle a much broader range of utilities. The number of employees reflect the budget of each organization, as well as the organization's political and economic clout.

Instead of four people working in or with the conservation department, SAWS has twenty full time and five part time employees working specifically with conservation. A large staff allows them to have more specialized positions. One employee's position involves contending with the top "1%ers", the residential customers that use the most water in the city; one employee holds education classes; and the five part time employees enforce water waste regulation. Furthermore, each employee has a specific stakeholder group with which they work on these issues. Specializations allow for more face to face time with stakeholders and more data to be derived for specific programs. This positively reinforces conservation and provides for more funding. The more people working in conservation, the more overhead cost. But this also indicates more employees working to engage the public in water conservation.

SAWS, with one of the largest conservation departments in the country, did not jump on the conservation bandwagon until 1993, right after the organization was established to carry out the function of managing the water resources of an ever growing arid municipality. The Sierra Club lawsuit and the establishment of the Edwards Aquifer Authority (EAA) were agents in propelling San Antonio into a position where conservation is an imperative part of water management. Elliott Fry, Resource Analyst for SAWS Conservation Department, said:

> I think to be quite honest and fair here, one of the big things hanging over San Antonio's head is the fear of having a federal judge come back in and try to manage our water again. I think that, lying not so deep below the surface, is that fear. It doesn't come up as much anymore, but back in the 90s it was there…. A lot of people still remember that. You just don't want a federal judge to come in and say – look this is how you're going to do it. You couldn't get your affairs in order so we are going to set them for you. Let us be fair, it is still around. It comes up in news stories periodically (Fry, interview [2011]).

Conservation was clearly needed. Today, SAWS objective when developing conservation programs is the bottom line of lowering their gpcd. Their current program, which is extremely dynamic, is designed to meet an ambitious gpcd goal of *116 by 2016* (Guz, interview [2011]). In comparison the two other major Texas' cities Dallas and Houston have gpcd's of 180 and 140 respectively. To meet this ambitious goal, SAWS must reduce their water consumption by about one billion gallons per year. This is the equivalent of lowering of the average gpcd by two gallons a year, based upon San Antonio's projected growth.

To procure "proactive relatively permanent savings", SAWS turns to their data to find out where water is being consumed (Guz, interview [2011]). For San Antonio, that means addressing the 50/50 split between commercial and residential use, even though they have 90% residential meters and 10% commercial and industrial meters. Guz explains that it is logical to evaluate programs for anyone who is using any significant chunk of water. SAWS objective isn't to be "mean," but to create an opportunity for their customers to thrive, and possibly improve, while using less water (Guz, interview [2011]).

Next, SAWS looks at the metrics of savings a program can provide. The current funding cap for conservation programs for SAWS is $400/af. Since conservation is classified as a water supply, just as it is at CSU, the program has to be competitive with the supply side. Most of SAWS programs cost between 200 and 400 dollars per acre foot. SAWS evaluates opportunities by making sure each program is something a customer would accept, that would be cost effective for the customer, and that it will also yield a substantial water savings at $400 an acre foot or less (Guz, interview [2011]).

Finally, SAWS prides itself on being extremely dynamic. "So it's a constant analysis, every program has to compete with the others," says Guz (Guz, interview [2011]). Questions are continually being asked: if customers are actually using it, if it is truly obtaining the savings it was designed for, and if it is being run as efficiently as possible? Those questions are answered by the intensely detailed and ever improving data gathered by the conservation staff. This data justifies SAWS ending a program that is no longer acquiring water at $400/af or less cost, and then these monies are allocated to a new innovative approach. A prime example of this is the washing machine rebate SAWS reimbursed for nearly a decade. However, a thorough analysis of the data showed this program was a *free rider,* since most of the washers were being bought in affluent neighborhoods, where as Guz expressed, "There is no way they are buying a top loading washing machine; they all buy the more efficient machines" with or without a rebate (Guz, interview [2011]). Therefore, this program had become a gift rather than an incentive. SAWS, after notifying customers of the end of the program, switched its resources over to the coin operated washing machine market where this rebate program has saved many more gpcd.

The dynamics utilized in SAWS' conservation department allows flexibility in program management. Guz said:

> There are some communities where I feel terrible for the conservation manager because they have to go to three committees and City Council in order to change a program. I think – how awful. We don't change a program abruptly – we did like three months of announcements before we ended the washing machine rebate. But, I didn't have to go to three committees and City Council in order to do that. It wasn't a line item in City Council. It is more of there is this much money and the general plan is this, and I certainly report to people and I'm very accountable, but I'm not stuck (Guz, interview [2011]).

The general consensus at SAWS is that micro-management of conservation will just not obtain the same results and be as effective as departmental flexibility. Conservation goals need to be set as a range, not a target line, since forecasting the weather for this application, the biggest predictor of consumption, is not possible. Therefore, the "why" each municipality chooses, directly effects the "what" programs, employed to conserve water.

How to Conserve – The Methods of each City

After noting why conservation practices were chosen for both CSU and SAWS, the next step in this study is to examine how a municipality concerned with creating a conservation program can draw from these two examples in order to better understand conservation program's effect on the consumption of water. For the sake of organization, the easiest way to break up programs is by strategy. The three common strategies both SAWS and CSU use for conservation are rebates and incentives, education and outreach, and regulation (Guz, 2008).

The first item that comes to mind when thinking of water conservation is the purchase of more efficient products. In almost every city involved in water conservation, rebates or incentives are used to promote the purchase of high efficiency toilets, showerheads, irrigation systems, and washing machines. San Antonio and Colorado Springs participate in these actions as well. In fact, San Antonio gave away nearly 10,000 free residential toilets in their *Kick the Can* program in 2010 alone (Per. Comm.). *Kick the Can* gives customers up to two completely free toilets per household when they exchange their pre-1992 toilets for an HET, and it is estimated that the program saved 114 million gallons citywide in a single year (Per. Comm.). Colorado Springs also has a toilet rebate program that refunds up to $125 of the purchase of a HET for commercial users. For residential users, however, CSU is looking to let market incentives take over.

Every municipality is concerned with *free rider* programs, such as HE washing machines for SAWS or HETs for CSU. For CSU, their HET rebate had become indicative of a product customers were going to purchase in any case, even without the rebate, because they are so efficient. Saving 60-80% every flush, HETs pay for themselves in a few short years (EPA, 2011). Just like washing machines in San Antonio, CSU wants to make sure they are allocating their money in the best way possible, and not giving their customers rebates for products that they would already buy.

This brings up the question of why a program is effective in San Antonio, with one of the lowest gpcd's in the country, and not for another. Guz stated that utilities tend to leap into toilet programs. She questions:

> Do you have a peak problem? Do you have a sewer problem? Do you have an infrastructure problem? Do you have a lot of older homes? Why are you wanting to jump into a toilet program? They often think –well that's what people do when they do water conservation (Guz, interview [2011]).

Clearly, what works in one place will not necessarily be what works in another place. Each municipality needs to find out what works best for their community, not just jump into a program because a leader in conservation has implemented it.

The key to selecting the right program is data. If a program, for instance rain water harvesting, is not economically efficient and climatically realistic for a particular region, there is no reason to invest capital that could be better spent in other places and yield more results. Rainwater harvesting, for both CSU and SAWS, is an impractical program to support. In Colorado, rain barrels are illegal due to prior appropriation. Yet, Winter says that there is a common misconception of the benefits rain barrels can provide. "There is this perception that rain barrels are going to create a huge benefit in terms of water savings," when in reality, unless you have giant cisterns and are extremely frugal with that water, they are not cost effective (Winter, interview [2011]). Guz, in the state of Texas, not limited by strict prior appropriation, agrees. Even though from a regulatory standpoint customers can use rain barrels if they would like, it just does not make sense for SAWS to incentivize this program since the cost/af is much higher than 400 dollars (Guz, interview [2011]).

Part of the problem is that, like the Springs, precipitation is highly variable in San Antonio. Both areas have climatic conditions where most of their rain falls at the same time, and then doesn't occur again for a long period of time. Customer's calculations for rainwater harvesting just do not add up to significant conservation savings under a complex model. Using a simple mathematical model, some rainwater advocates calculate that because San Antonio receives thirty-two inches of rain a year, and because they have a 1,000 sq ft roof, they can capture an estimated 32,000 gallons of a rain a year. However, while it is raining, customers don't water their grass, and therefore don't empty their barrel. So instead of 4,000 gallons being captured in four inches of rain, they were not even capable of capturing 50% of the rain that fell on their roof before the barrel filled. Now their barrel is full and they don't need it, because it is still raining. The joke common at SAWS is "We get thirty-two inches of rain a year, and you should be here the week it all comes" (Guz, interview [2011]). When it doesn't rain customers need far more than fifty-five gallon cisterns in order to water as often as they would like. Yet Guz explains with the exception of a few people watering really efficiently and infrequently, that:

> What they want is not realistic. They [the customer] say I'm going to put in this tank and it's going to magically be filled with water even though there has been no rain, and I'm magically going to be able to water more than I did before, even though no rain filled that tank. It's a bizarre psychology. It hasn't been raining for

> a while so we have people calling wanting rain barrels. There is nothing cost effective about giving out a fifty-five gallon rain barrel. That will not be a blip on their water bill. People use 2,000 gallons to water when they have an in-ground irrigation system. A fifty-five gallon barrel isn't touching it (Guz, interview [2011]).

Monitoring is obviously vital to developing the best program. So instead of wasting money on inefficiency, it is vital to focus on funding only the best programs.

For San Antonio, that means programs like large scale retrofitting. Instead of companies depending on the unpredictability of rain, they can depend on the predictability of air conditioning in Texas. Large-scale retrofits include things like harvesting cooling tower blow down. If there is a source of cooling tower blow down, that doesn't have biocides within it, SAWS will work with building managers to use that water efficiently. After being diluted with condensate, this water can become a reliable yield for irrigating the landscape around large buildings. SAWS uses retrofit water for all of its headquarter building irrigation. An onlooker wouldn't be able to discern a difference, except during a drought, when SAWS has one of the only green lawns.

Data driven programs avoid what Guz calls *green bling*. Guz relates this back to rainwater harvesting saying:

> When a little tiny tank is put in, with potable water backup, that's called *green bling*, which is worse than not doing it at all. You just wasted resources to make yourself feel good. It is like eating diet food that's labeled diet, but its high calorie, and you eat ten times as much or something. It's absolutely pointless (Guz, interview [2011]).

If not careful, other programs that are successful on paper can become green bling, a cover-up for some customers' overwhelmingly large use of water for irrigation.

On paper, the best programs for San Antonio are Kick the Can and large scale retrofitting. Yet, while Kick the Can and rebates for showerheads may look good and may even obtain significant water savings, like 2,000 gallons per month for a household, those savings must be taken in perspective. If a household uses 20,000 gallons a month from May to August on their lawn, those indoor technological savings are completely wiped out (Guz, interview [2011]). So while utilities definitely care about indoor savings, it does not mean that those savings can make up for the largest use, irrigation. Guz explains that people want to oversimplify the process and say:

> Ok good, that's all I have to do. I do large scale retrofit and I do toilets and I'm done. I don't have to mess around with behavior. Well, really if that's all you do, your per capita will go up every year, because you have not addressed how they're running their irrigation systems (Guz, interview [2011]).

This is where education comes in.

Education in the broadest sense is to make someone aware of what they were not aware of before. The concept is that by conducting education and outreach, water users will become aware of their impact and will choose to use less whether for economic, ethical, environmental, or other reasons. Before the drought of 2000, the main focus of CSU was in fact education. Education is critical because it addresses the social behavior that is so hard to change, yet makes such an enormous impact. There are several issues regarding education that all relate back to measuring successes with detailed utility data.

The largest downside to education is that it cannot be measured as easily as the rebates and incentives. A high efficiency toilet (HET), for instance, has a direct and measurable result. The toilet does not need to be reinvented to determine how effective it is because data on the savings can be found very easily (Guz, interview [2011]). Education on the other hand, is very hard to measure.

SAWS is attempting to create a system of measuring the effect of education in several ways. The first is the traditional method of recording how many people say they come into contact with conservation programs and to gauge the extent of that contact. Three levels exist, including attending an event where people are gathered and may learn about conservation (like the Rodeo), attending an event where customers are there for something similar (like Earth day), or finally, where SAWS' conservation department organizes one-on-one face time with people attending an event to specifically learn about how they can conserve water (like a home audit).

The most valuable time is the direct one-on-one contact. It usually results from block rate price increases designed to charge the most expensive water, discretionary irrigation use, accordingly. That occurs in a variety of ways at SAWS and CSU. Most of this education time is spent on outdoor conservation, not only because of its large impact, but because changes to outdoor water use is about behavioral change. Winter stated that classes and xerioscape demonstration gardens are most effective at getting people to take action and to be efficient and effective lawn irrigators (Winter, interview [2011]). Both SAWS and CSU must continually educate about irrigation for lawns, especially since many people are moving to both areas are from around the country, where copious irrigation of water guzzling St. Augustine grass may be the norm.

Guz, with a much larger conservation department, is able to accommodate much more face-to-face time with customers, including home and business water audits, which any customer can request. A plumber, or SAWS employee, will come to a home or business and identify ways for that customer to save water.

Additionally, because a significant portion of residential water use is by the top 1% users, they receive personalized letters and phone calls saying as politely as possible that that they use more water than 99% of city customers. Guz said "We are trying to convince them to stop overwatering obsessively. You're talking about people who routinely use 50,000 gallons – 100,000 gallons, a month. It is highly personal to them" (Guz, interview [2011]). The correct combination of education and incentives can significantly change outdoor use for any customer and hammer home the message that a xerioscape lawn can be just as appealing, and much less costly, in both terms of water and dollars.

One of the greatest challenges with education is that it is personal, and therefore face-to-face time is non-expendable. Due to the personal nature of these programs, SAWS' plan is to be as direct and as likeable as possible. If homeowners like the employee they are speaking with, then they will be much more likely to believe their message and to begin conserving water.

There is also the regulatory or enforcement side, which is a form of education, to reduce water usage. If water is running down the street, a customer is obviously wasting that water. If they get a ticket, and the waste stops, a discernable change in their consumption can be seen, just like with other forms of education. However, also like education, weather greatly effects the consumption. So even if a household cuts back their use in May, when it is much hotter in June, their consumption still increases, and their water use will increase in any case. So this is a tricky metric to measure.

Although one-on-one contact is expensive and requires high overhead costs, it is essential, to Guz, because:

> Getting someone to change how they are setting their irrigation is entirely about changing their mindset. It's their behavior, where with a toilet we just need you to put a toilet in and then thank you, you're done. You use the toilet the same way, you're going to not change any of your biological needs regarding that toilet, but for the landscape we need to talk to you all the time (Guz, interview [2011]).

To justify the costly one-on-one sessions, SAWS is attempting to accurately measure the customer's pre- and post-session water use. Guz mentions that SAWS is thinking of applying a new concept by Bill Christianson of the Alliance for Water Efficiency called *savings decay* to that metric (Guz, interview [2011]). Since savings decay is a new concept, neither CSU or SAWS currently measure education savings in this way. . Currently, both programs assume "out of sight, out of mind" with regards to measuring the effects of their education programs. The common belief is that 100% of the information customers were told is completely lost after a year. However, the principle of savings decay states the effects of education do not just end after a year, but fade away, or decay, at approximately 20% a year. If this study is correct, it could alter both cities' conservation program objectives, significantly.

Fry is working to reconfigure software to try to better manage pre- and post-water usage, automatically (Fry, interview [2011]). SAWS would not have to start from scratch with education if their belief that everything the customer was told a year ago wasn't totally forgotten; it would change their entire data analysis and educational outreach theory. CSU would be able to diversify their message instead of staying consistent. The savings decay strategy may change the way both utilities conduct analysis of their programs.

Drop by Drop – Steps Municipalities can take to Reduce GPCD

Analysis. Upon inquiry, interviewees at both CSU and SAWS indicated that any steps municipalities take towards conservation were easily defined in one word: analysis. This makes a great deal of sense. Any successful business, including utilities which are really publicly owned businesses, knows that efficiency is king. Setting ambitious goals and collecting data to both monitor those goals and to identify problematic areas are popular business models. So, taking these models and applying them to conservation only makes sense, or as the Environmental Protection Agency says *WaterSense* (2011).

Fry suggests before taking any steps, one should conduct a water audit of the system. That way, the utility knows where the water goes. A good audit will clearly point out weaknesses and "low hanging fruits" that are usually the most cost effective conservation programs to implement (Fry, interview [2011]). For instance, in San Antonio during the late 1980s and early 1990s there was a clear decrease in gpcd solely due to fixing leaking infrastructure, not conservation measures. However, many utilities don't dig deep enough to really be able to address problematic areas (Fry, interview [2011]).

One-time audits are not enough either. Even considering how large SAWS has become, every ten years they redo their water audit procedure. This allows them to be efficient, and efficiency equals water savings. In addition to the auditing process, a water utility must be flexible and allow for the unpredictability of the weather in terms of the effectiveness of water conservation procedures.

SAWS' final suggestion is to have a solid water management plan. Fry states that a good framework for water use is essential; but this is much harder for smaller utilities to implement (Fry, interview [2011]). Even though CSU is a much smaller entity than SAWS, a solid fifty-year plan allows them to be effective at conservation. Grey Bishop says that CSU is confident of their fifty-year plan and knows exactly where the water is going to be coming from (Grey Bishop, interview [2011]). Though a billion gallons sounds like a lot, for a big city like San Antonio it is only a sliver of the total water supply. Therefore, Fry's suggestion is that bottom-up water management, conservation, and analysis - all at the same time - is really the best strategy (Fry, interview [2011]). "You don't want to do any one component without the other two. And, that's probably the best answer for anyone starting out – here is your toolset" says Fry (Fry, interview [2011]).

Conclusion

The current state of water around the world is nothing short of desperate. With an ever-increasing human population and considering ever-increasing technology, the solution to water depletion seems to point toward greater water conservation. However, conservation cannot just be implemented without careful consideration of the customer's mindset and the legal, historical, and physical nature of a region.

For any municipality wanting to implement conservation practices, they should start conservation with implementing incentives and replacement programs for new highly efficient technological appliances. This is a cost effective means for every arid and semi-arid city to reduce its water usage quickly, efficiently, and economically. As seen with both SAWS and CSU, if the cost/benefit is equal to or less than the cost of acquiring more water, it makes little sense not to implement a conservation strategy. One caveat is that even technological programs should be monitored and constantly reviewed to ensure that incentives are not expended on technology that does not make an impact in the home or business or on a product that would be purchased by the customer in any case.

The primary challenge to water conservation comes when there is water available to use, even if it is not sustainable. However, utilities making the intelligent and ethical decisions to not deplete future sources, and instead spend the extra dollar on implementing conservation, will become ever more prevalent as the public demands environmental friendly practices and the utility industry demands better standard practices. In order to successfully implement conservation strategies when the cost is higher than new water sources requires careful knowledge, navigation, and negotiation considering the geography of a region.

Historical water uses and local expectations must also be addressed in order for a program to be successful. The physical availability of water must be considered, and conservation programs need to be tailored to both effective, available technology and marketed towards fitting the specific physical need(s). The legal bounds of an encompassing region must, of course, be followed. If any one of these steps is ignored, conservation programs are likely to fail and create a city culture with negative connotations toward conservation practices.

That being said, the ultimate objective must not be to solely depend on technological advances tailored toward municipalities' backgrounds. Technology is the starting point, but the true battle for a sustainable and reliable water future is a battle of hearts and minds. Education must create a social environment where water users know the true price of their water - otherwise it will continue to be wastefully applied to lawns and flushed down toilets and the sink until a true crisis in water supply occurs.

The other option when water runs out: to halt and reduce growth. The human race cannot afford to wait until all else fails to change consumptive patterns. The United States cannot sit back and watch as half of the country runs out of water, because that half of the country also supplies most of the food and textile products. Therefore, hard decisions must be made, political objectives must turn toward long term instead of immediate gratification, and all of this begins with a change in the public's mindset. Every municipality must have education and outreach as its top priority in order to be successful, because no technological changes will matter unless people are invested in that change. Just as a broker considers financial security among the top qualities of a business, water security needs to become one of the top investments for a city.

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Appendix – IRB Approval

Melissa Rowell

Application for IRB Exemption Data Sheet

IRB Exemption Application Number: EXP2010E7092

Section I

1. This project is: Thesis/Dissertation
2. If you are a student, please provide your supervising faculty member's full name:

Dr. Laura Stroup, Assistant Pr

Section II

1. If this is an academic or classroom project, does the scope extend beyond Texas State University?

Yes

2. Would you describe this project as "a systematic investigation, designed to develop or contribute to generalizable knowledge?

Yes

3. Will the results of your project be put on the internet, shared at a conference, published, or otherwise disseminated?

Yes

4. Will identifiable private information from individuals be collected from contact with research participants ?

Yes

5. Will identifiable private information from individuals be collected from other sources (e.g. medical records)?

No

6. Does the project involve fetuses, pregnant women or human in vitro fertilization?

No

7. Does the project involve prisoners?

No

8. Does the project involve any persons who are mentally impaired or homeless or who have limited autonomy?

No

9. Does the project involve the review of medical records if the information is recorded in such a way that subjects can be indentified, directly or through identifiers linked to the subjects?

No

10. Does the project involve survey or interview techniques which include minors as subjects in which the researcher(s) participate in the activities being observed?

No

11. Will a drug, biological product, medical device, or other product regulated by the FDA be used in this project?

No

12. Will the participants be asked to ingest substances of any kind?

No

13. Will the participants be asked to perform any physical tasks?

No

14. Does the research attempt to influence or change participants' behavior, perception, or cognition?

No

15. Does the project involve questions or discussions of sensitive or deeply personal aspects of the subject's behavior, life experiences or attitudes? Examples include substance abuse, sexual activity, sexual orientation, sexual abuse, criminal behavior, sensitive demographic data, detailed health history, etc.

No

16. Does the project involve techniques which expose the subject to discomfort, harassment, embarrassment, stigma, alarm or fear beyond levels encountered in the daily life of a healthy individual?

No

17. Does the project involve the deception of subjects?

No

18. Does the project involve videotaping or audiotaping of subjects?

No

Section III

1. If you are choosing one of the six federal categories of exemption, which **one** are you choosing?
**If your project falls under more than one exemption, choose the one that is most applicable. You may cite the others in #3 below.

Category 2

Please note for questions 1, 3, and 4 :

The text areas are limited to 2000 characters/approximately 300 words. Even though you are allowed to type more than the specified limit, those additional words/characters will be cropped/cut off when you move to the next question.

2. What is the purpose of the project? (300 words or less)

I will begin my research with a general knowledge of water laws and water resources in the United States. Water has been called the oil of the next century, and for good reason since it is the essential of human life. However, many places across the U.S. country are running into water shortages due to lack of water resources in the first place, mismanagement, or tremendous population growth amongst other things. Since many states have different laws, types of available water, and population statistics, I wanted to compare two regions that have done an exceptional job in water management, but approached challenges dealing with shortages in different ways: Texas and Colorado. The two water utility districts that I have chosen for my thesis are San Antonio Water Systems (SAWS) and Colorado Springs Utilities (CSU) due to their water management practices and how they are planning to meet future water needs with new technology and conservation techniques to execute new ways of water supply management.

3. Explain how this exemption category pertains to your project: (300 words or less)

Research Exemption Category 2, involves disclosing personal information, but that information having little to no risk for study particants. In Geography, we conduct research on human subjects which generally has little risk for involved participants. Participants recruited for this study will decide whether they would like to take part in the study, and can opt out at any time. This information will then not be used in the thesis. Additionally, the use of a consent form notifying participants not to disclose any information that they would not contribute in a public forum, represents full disclosure of the minimal risks inherent in such a study. Those not signing the consent form will not be able to participate in the study.

4. If you believe your project poses no risk to human participants or should be exempt from IRB review for other reasons, please explain: (300 words or less)

Through email, I will set up phone and in-person interviews with CSU and SAWS employees at a set time in their offices (or over the phone). The interviews will last for no more than one hour each. I will the interviewee sign a consent form so that I can quote them in research write-ups. A consent will be sent beforehand/provided to each interviewee at least two days before the interview so that they had ample time to clear it through their employer. Along with the consent form, I will send a basic outline of interview questions so that the interviewee would have time to prepare for the issues being discussed, get any additional information they wanted to share with me such as a pamphlet, and obtain their employers permission, if needed. Before the interview begins, I will make sure that the interviewee would be allowed to see what I quoted them on before my thesis was published by sending them a copy of their quotes along with the context I mentioned them. After all formal interviews, I will send thanks yous to the interviewees to let them know I appreciated their help and the donation of their time toward my thesis. In addition to interviewing employees of the utility districts, I also plan on talking informally, with no names/positions etc, to people whose water is affected by CSU or SAWS. Such informal talks would be used to get a sense of whether citizens know where their water comes from, whether they are informed on conservation programs, and whether they have complaints about their water rates and why, etc.

Categories of Exemption: (Return to Section III, Question 2)
Exempt Categories of Research listed at 45 CFR, Part 46, Sec. 101(b)

(1) Research conducted in established or commonly accepted educational settings, involving normal educational practices, such as
(i) research on regular and special education instructional strategies, or
(ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.

(2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless:

(i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and

(ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, or reputation.

(Please note: Surveys on sensitive or personal topics which may cause stress to study participants may not be exempt from IRB review.)

(Note: The section of this category pertaining to standardized educational tests may be applied to research involving children. This category may also apply to research with children when the investigator observes public behavior but does NOT participate in that behavior or activity. However this section is NOT applicable to survey or interview research involving children.)

(3) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (2) of this section, if:

(i) the human subjects are elected or appointed public officials or candidates for public office; or

(ii) federal statute(s) require(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.

(4) Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available or if the information is recorded by the investigator in such a manner that subjects cannot be identified, directly or through identifiers linked to the subjects.

(Example: existing data, records review, pathological specimens)

(Note: This data must be in existence before the project begins)

(5) Research and demonstration projects which are conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine:

(i) public benefit or service programs;

(ii) procedures for obtaining benefits or services under those programs;

(iii) possible changes in or alternatives to those programs or procedures; or

(iv) possible changes in methods or levels of payment for benefits or services under those programs.

(Note: Exemption category refers to federal government research)

(6) Taste and food quality evaluation and consumer acceptance studies,

(i) if wholesome foods without additives are consumed or

(ii) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the Food and Drug Administration or approved by the Environmental Protection Agency or the Food Safety and Inspection Service of the U.S. Department of Agriculture