5-2011

Consensus on the Colorado: Issues in the allocation of a limited resource

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CONSENSUS ON THE COLORADO:

ISSUES IN THE ALLOCATION OF

A LIMITED RESOURCE

by

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Bachelor of Arts
University of Notre Dame, Notre Dame, IN
1990

A thesis submitted in partial fulfillment of
the requirements for the

Master of Arts in Political Science
Department of Political Science
College of Liberal Arts

Graduate College
University of Nevada, Las Vegas
May 2011

THE GRADUATE COLLEGE

We recommend the thesis prepared under our supervision by

Jeffrey Dean Tilton

entitled

Consensus on the Colorado: Issues in the Allocation of a Limited Resource

be accepted in partial fulfillment of the requirements for the degree of

Master of Arts in Political Science

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May 2011

ABSTRACT

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The purpose of this study was to identify current issues in water allocation in the Lower Colorado River Basin and to locate existing areas of consensus among its stakeholders. Surveys, both paper and web-based provided the data required to measure overwhelming agreement on issues. The data analysis served to locate the areas of agreement within and between interest groups. While overwhelming agreement between all groups proved to be a relatively rare occurrence, the existence of issue specific agreement between two or more groups was more common than expected. Accord was demonstrated in all four major areas: allocation, augmentation, conservation, and environmental protection. The conclusion here is that while important differences of opinion remain in the basin, agreement is more prevalent than anticipated. The existence of these areas of consensus augurs the possibility of successful future negotiations on the reallocation of Colorado River water. If managed well, through practiced consensus building techniques, stakeholders exhibit the potential to navigate future shortages competently while protecting the interests of their respective constituencies.

ACKNOWLEDGEMENTS

I would like to acknowledge the role of all those without whose patience, support, and efforts this project would not have been possible. I begin with the most important, God. My family is next. Madeleine, my wife, Rose, my daughter, Patrick, my son, and Angele and Lamine, my grandchildren, sacrificed time and offered regular encouragement throughout the process. My parents, Jim and Judy, regularly reviewed my writing and offered suggestions and corrections where necessary. Dr. Parker, my advisor, recommended conferences, books, and the eventual methodology chosen to conduct the research. He also prevented the abandonment of the project at difficult moments. Drs. Fernandez and Smith were always available to discuss ideas and directions for the project. Jenifer Jefferies provided workspace, encouragement, and the occasional crack of the whip to prod this student. Fr. Bob and Fr. Joe added moral, spiritual, and intellectual support to the project and accompanied me to its fulfillment. My supervisors allowed me the time to write and the financial backing to complete the program. Colleagues patiently listened to my thoughts, supported me through difficult stages, and shared the victories in the process. I believe that nothing worthwhile is done single-handedly, and this effort is no exception. Those mentioned above, and those I have failed to mention deserve credit for the successes of this endeavor. The mistakes are all mine.

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CHAPTER 1

INTRODUCTION

To say that the Colorado River is over-allocated is the equivalent of saying that education is broken, healthcare is expensive, and our government is inefficient. Everyone sees the problem, but lacks the solution. The problem dates back to the original agreement dividing the waters of the Colorado River. The agreement presents a number of challenges. Stakeholders in the basin represent a variety of often-conflicting water uses. A changing environment projects diminished water resources. Scientific advances support these projections and question the original data used to allocate the resource. The population in the region grows faster than that of any other region in the country. This population growth increases municipal demand for water currently used for agriculture. These facts point to the need for change.

What is the mechanism for that change? In the past, change normally moved from the top down. The Colorado Compact, an attempt at consensus building, sought consensus only among a small group of representatives of the seven states. The result of that limited consensus turned out to be rejection at the level of state legislatures and ensuing court battles between states and federal government. Top down decision making proved ineffective.

Many argue consensus is the solution. Consensus here is defined as overwhelming agreement. In this case, all stakeholders would be represented at the negotiating table. Water managers, users, agriculturalists, urban residents, industrialists, and residents of the seven states, Arizona, California, Colorado, Nevada, New Mexico, Utah, and Wyoming would have an opportunity to present their perspective.

Incorporating all of these opinions signifies an attempt toward collaborative decision-making and implementation. Every perspective at the table and every attempt to address each of those perspectives would lead to a decision that, in the end, could be implemented by the various groups, and would avoid long legal delays.

Before initiating an attempt at consensus building, one needs to identify the issues, and among those, the areas of existing consensus. At the beginning of the process it is advisable to discuss the easier issues; those with existing consensus, first. This allows trust and relationship building and promotes the belief in the process and the ability of diverse interests to achieve consensus. The issues break down into four useful categories: allocation, augmentation, conservation, and environmental protection.

Allocation refers to the division of the estimated average annual flow between the stakeholders, and creates more controversy than the other three categories combined. Originally partitioned in the 1922 Colorado Compact, overestimation and a wet cycle promoted excessive use. Water managers scramble to match water supplies with exponential population growth in the region. If the current numbers were not enough, climate change threatens to reduce the entire pool of water resources. There simply is not enough water to go around at current usage rates.

Augmentation describes attempts to import water from sources other than the Colorado River. It presents an expensive, yet potentially viable part of the solution. The ocean is right there and desalination technology continues to improve in efficiency. A city taps into regional groundwater aquifers and pipes the water to where it is needed. Outdated canals and water delivery structures are updated to reduce waste. It has often been argued that the water problem is not one of quantity; it is one of distribution.

Conservation represents all attempts to reduce the consumption of Colorado River water. Current programs exist in many agricultural and municipal water districts. Farmers attempt to transition from wasteful flood irrigation to improved drip irrigation. Water managers encourage reuse, not only on crops and lawns, but also in toilets, sinks and showers. Economists promote the transfer of water from lower to higher valued uses. Any number of measures similar to these would leave more water in the system.

Environmental protection encompasses water quality concerns, control of invasive species, and protection of endangered species. Lacking an official allocation, environmentalists struggle to acquire water rights and use them effectively. Salinity control programs work to limit damages to agricultural production and municipal and industrial infrastructure. Invasive species compete for water and threaten native species. Endangered species struggle to survive in conditions far different than nature provided. Additional water resources left in the system go far in alleviating some of these dilemmas.

A set of 24 issue statements, 6 in each category were presented to respondents in a survey. The respondents were asked to rate their level of agreement, or disagreement, on a Likert scale, from strongly agree to strongly disagree. The analysis of this data will be discussed in Chapter 3.

Respondents emerged from a list of Lower Colorado River Basin members of the Colorado River Water Users Association (CRWUA). The home page of the CRWUA (2011) website describes the group as follows: "CRWUA is a non-profit, non-partisan organization, formed to plan, study, formulate, and advise on ways to protect and safeguard the interests of all who use the Colorado River." Consensus building appeared to be a natural exercise for such an organization.

The purpose of this thesis is to identify the issues and locate consensus among Lower Colorado River Basin stakeholders. This data could then be put to use by future collaborators as they struggle to change the current system.

CHAPTER 2

COLORADO RIVER HISTORY

The Colorado River

The pre-development Colorado River dropped 14,000 feet from its headwaters in Rocky Mountain National Park to its mouth in the Gulf of California (Sea of Cortez). A raging torrent in the spring, it reduced to a trickle in the late summer, fall, and winter. The river possessed a high percentage of endemic fish species as well as lush wetlands, vegetation, and wildlife. It carved the picturesque canyons associated with the American Southwest (Adler, 2007). A product of frigid snowmelt, the river combined with the flows of the Gunnison, Green, San Juan, Gila, Yampa, White, Little Colorado, Muddy, Virgin, Salt, and the Verde(Reisner, 1993). It drained 244,000 square miles, yet its flows only equaled those of the Delaware River(Fradkin, 1981).

"Not the Rocky Mountains nor the Pacific Ocean, but the Colorado River which flows from one toward the other, is the single most unifying geographic and political factor in the West" (Fradkin, 1981).

The Anasazi Indians of Chaco Canyon were among the first to divert the Colorado River for agricultural use as early as 600 A.D. The group developed complex water distribution systems, including diversion dams, adobe-lined ditches, and reservoirs. Chaco Canyon was abandoned somewhere around the mid-1100's. The Hohokam underwent similar difficulties. They constructed from 200 to 250 miles of canals. These canals contributed to high salinity in the water. The salt stunted the crops and required additional water to lower salinity levels. This society collapsed around 1450 A.D.

(Fradkin, 1981).

The Spanish ventured numerous times into the basin, yet for the most part, made little impact in agriculture. In 1539, Don Francisco Vasquez de Coronado sought the Seven Cities of Cibola, to no avail. The Mormons, under Brigham Young, established agriculture in Utah in 1846. Irrigation was the key to their success and by 1902 they had 6 million acres irrigated (Reisner, 1993).

The United States government envisioned the potential of the region and initiated a number of explorations similar to Lewis and Clark's voyage. Lieutenant Joseph C. Ives set out in 1858 to determine the navigability of the Colorado River. He left Yuma and traveled up river to Las Vegas Wash before turning back (Stevens, 1988). He described "graceful clusters of stately cottonwoods in full and brilliant leaf" (Adler, 2007).

John Wesley Powell addressed the river from the other end. He began at the headwaters of the Green River in May of 1869 and traveled through the Grand Canyon (Reisner, 1993). In his writings, he proposed using watersheds as the basis for land and water allocation in the West, rather than the traditional gridlines employed in the East. He also emphasized that distribution should be planned and implemented by a higher-level entity, most likely the federal government. The failure of those in power to heed his recommendations led Powell to say later,

"Gentleman, it may be unpleasant for me to give you these facts. I hesitated a good deal, but finally concluded to do so. I tell you, gentleman, you are piling up a heritage of conflict and litigation of water rights, for there is not sufficient water to supply the land" (Fradkin, 1981).

Private investors soon visited the area, specifically the Imperial Valley. John Beatty, a Denver land promoter, hired Charles Robinson Rockwood to explore the Colorado Delta in 1892. He immediately realized the potential of irrigating the valley with Colorado River water. He was joined by Anthony Heber, a Chicago investor who already had holdings in California, Don Guillermo Andrade, a Mexican businessman with extensive land and water rights in the Delta, and Harry Chandler, owner of the Los Angeles Times and Mirror. Together they formed the Colorado Development Company in 1896. The group hired George Chaffey, a Canadian engineer, to achieve their dream (Round, 2008). Chaffey oversaw the construction of 400 miles of canals in 22 months and by May of 1901 water was flowing from the river into the valley.

Less than 8 months after water had begun to flow into the Imperial Valley, two towns had been built, 2,000 settlers had arrived, and 100,000 acres stood ready for harvest. Silt, however was beginning to be a problem. As chance would have it, spring floods came two months early that year. The flood created the Alamo River and filled the Salton Trough, now known as the Salton Sea (Reisner, 1993). Beginning in February of 1905, the flood lasted 16 months. Overall, 30,000 arable acres were flooded, damaging millions of dollars of property, and requiring two years for workers to stem the flow (Adler, 2007).

President Theodore Roosevelt pledged to support future development in the Imperial Valley in 1907. He also branded developers in the area as men who, “in conscienceless fashion [deify] property at the expense of human rights” (Round, 2008). In 1910, the Department of the Interior constructed levees to protect the Imperial Valley.

That same year, railroads were completed to connect Los Angeles, Mexicali, El Paso, and New Orleans. 1911 saw the creation of the Imperial Irrigation District by farmers frustrated by the schemes of the developers (Round, 2008). The Imperial Irrigation District then sent their lawyer, Phil Swing, to Congress in 1917 to push for the construction of the All-American canal. Arthur Powell Davis, nephew of John Wesley Powell, blocked the initiative in favor of a more coordinated, regional solution to Colorado River water use. The Fall-Davis report of 1922 recommended the construction of a dam as a means to control the river (Stevens, 1988). Before any dam would see the light of day, the states needed a water-sharing agreement.

The Colorado Compact

The Colorado Compact required 11 months to draft. It was signed at The Bishop's Lodge, in Santa Fe, New Mexico, in November of 1922. Based on estimated average annual flows of 17.5 million acre-feet, the decision was made to divide the Colorado River Basin in two, each receiving one-half or 7.5 million acre-feet. The rest was allocated to possible future agreements with Mexico and surplus availability for the lower basin. California refused to sign without a conjugal authorization of a dam (Reisner, 1993).

The Boulder Canyon Project Act of 1928 addressed this question. Based upon the Swing-Johnson Bill, written by Phil Swing and Hiram Johnson, California congressmen, it authorized the construction of a dam, at or near Boulder Canyon (Stevens, 1988). Hoover Dam was the high point for the industrial era in Colorado River water allocations. Controlling the Colorado River allowed the United States

Government, through the efforts of the Bureau of Reclamation, to achieve its policy of manifest destiny. In 1900, the population of the Colorado Basin was 260,000. By the 1930's that number had reached one million. California's change was even more drastic. From the same 260,000 in 1900, the state hit 3.5 million in 1940 (Fradkin, 1981).

By 1944 a treaty had been signed allocating 1.5 million acre-feet per year (1.7 million acre-feet in flood years) to Mexico. The Upper Basin agreed to allocations on a percentage basis in the Upper Colorado River Basin Compact of 1948. Colorado received 51.75%, Utah 23%, Wyoming 14%, and New Mexico 11.25%. This compact recognized the fact that the Upper Basin was required to send a fixed amount, 7.5 million acre-feet, to the Lower Basin (Arizona, Nevada, California) each year and that might lead to future shortages on their part.

Recent Agreements

For nearly 50 years the "plumbing system" installed on the Colorado River had functioned to prevent flood and drought, as well as managing the other water needs of its stakeholders. In 1983, its limits were surpassed and for 62 days at Hoover Dam water flowed over the spillways, causing millions of dollars worth of damage downstream. In the late '90's the water levels again rose beyond the levels of comfort. The Long-term Operating Criteria lacked guidelines for water management when flows exceeded the normal range (ROD, 2001).

Before instituting guidelines, an environmental impact statement had to be prepared. The purposes of the guidelines were listed in the Executive Summary of the

Final Environmental Impact Statement (ROD, 2001). They included: minimization of flood damages from river flows, water releases in accordance with the 1964 Decree in *Arizona v. California*, the protection and enhancement of environmental resources, reliable water deliveries, minimized curtailments in the Upper Basin, and consideration of power generation needs.

With these goals in mind, the federal government proposed to create Interim Surplus Criteria to be used annually. These criteria would determine conditions under which the Secretary of the Interior may declare availability of surplus through the year 2016. Under Article II(B)2 of the 1964 Decree, flows greater than 7.5 million acre-feet per year at Lee's Ferry signify a surplus in the Lower Basin. This determination coordinated with the Colorado River Basin Projects Act of 1968 and Long-Range Operating Criteria. Using these criteria, the Annual Operating Plan would seek to equalize Lake Powell and Lake Mead each water year (October 1 to September 30).

Surpluses, according to the Boulder Canyon Project Act, were allocated 50% to California, 46% to Arizona, and 4% to Nevada. Need for the action arose from the lack of specific criteria and from a recognition of California's Colorado River Water Use Plan to reduce its Colorado River water use to the originally agreed upon 4.4 million acre-feet. This plan is commonly referred to as the "4.4 Plan".

In this process the general public is consulted through public meetings and a public review of the Draft Environmental Impact Statement. There is federal agency coordination as well as coordination with state and local water and power agencies and non-governmental organizations. Indian Tribes and Mexico are consulted as well.

The completion and signing of the Interim Surplus Guidelines Record of Decision came in 2003, coincidentally, 4 years into the worst recorded drought in the 100-year record of the Colorado River (ROD, 2001).

Realizing that the original agreements lacked specific shortage criteria, the stakeholders went to work. Drought combined with increased demand fueled the drive for shortage guidelines. The first of 4 goals called for the adoption of specific criteria to declare shortages in the Lower Basin. Criteria led to delineation of circumstances for reducing water availability for consumptive use, defined coordinated operation under low reservoir conditions, and mechanisms for storage and delivery of conserved Colorado River system and non-system water in Lake Mead, as well as a modification in the substance and duration of the Interim Surplus Guidelines (ROD, 2007).

The geographic area covered began at Lake Powell and ended at the Southern International Border, with specific attention paid to Arizona water users in the Central Arizona Project, the Southern Nevada Water Authority, and the Metropolitan Water District.

The Preferred Alternative combined aspects of the Basin States Alternative and the Conservation before Storage Alternative. Shortages are used to conserve storage, coordination is emphasized, Intentionally Created Surpluses are expanded to 2.1 million acre-feet, and the Interim Surplus Guidelines are modified. The Preferred Alternative was chosen and the Record of Decision for Interim Shortage Guidelines was signed in December of 2007 (ROD, 2007).

CHAPTER 3

LITERATURE REVIEW AND ISSUE DISCUSSION

Policy analysis provides advice, either implicitly or explicitly. It ideally seeks to promote the common good while serving a client. Policy analysts provide the client rationales for government interference in private choice and potential Pareto improvements. In some instances, the analyst weighs the goal of Pareto efficiency against overall social welfare, equality, equity, and political feasibility. Public policy attempts to prevent government failure as well as market failure, as governments cannot be expected to promote social good in all circumstances. To achieve this, knowledge of generic policies helps to facilitate specific solutions to individual cases (Weimer and Vining, 1992) .

Sabatier (1999) identifies seven promising directions for policy analysis frameworks. The stages heuristic dominated the debate until recently. This conceptual framework of the policy process outlined the major phases on any act, including: intelligence, promotion, prescription, invocation, application, termination, and appraisal. This sequential review stands in direct contrast to
Kingdon's (1995) multiple streams approach, which seeks to answer three basic questions. How is the attention of policymakers rationed? How are issues framed? How and where is the search for solutions and problems conducted?

Punctuated-Equilibrium Theory, as described by True, Jones, and Baumgartner (1998), questions incrementalism in policy areas. They see programs as living in stasis for the most part, with the occasional occurrence of crisis.

Sabatier and Jenkins-Smith (1994) research the roots of change in policy. They explain the five basic premises of the Advocacy Coalition Framework. The theory explores the role of technical information, a time period of more than a decade, the policy subsystem, broadening the conception of policy subsystems to include additional categories of actors, and the implicit theories of programs about how to achieve their objectives. Innovation models in policy research focuses this trend by tracing government programs back to specific policy innovations (Walker, 1969).

Finally, the behavioral revolution shifted the focus of policy analysis from description of the institutions to analysis of their products.

Ostrom's (1994) writings on institutional analysis and development, which fall within the institutional rational choice framework, drive this thesis. The two main institutions underlying the paper are the prior appropriation allocation of water and the Colorado Compact, both of which will be discussed at length in Chapter 1. They are invisible, yet every water manager in the region would be expected to be intimately familiar with these arrangements. The institutions operate in political, scientific, and public spheres at all levels. After all, the discussion revolves around water, the most basic of all substances. Additionally, the relationships are configured in ways as to be inseparable. Ostrom's (1994) theory of common-pool resources provides the models necessary for evaluation of the policy. He outlines seven clusters of variables inherent to an action situation: participants, positions, outcomes, action-outcome linkages, the control that participants exercise, information, and the costs and benefits assigned to outcomes. For the purposes of this thesis, only participants and positions are examined.

To study the current situation in the Lower Colorado River Basin, most researchers begin with its history, specifically the initial stages of anthropogenic development of the region. Robert Adler (2007), among others, pointed to the attempts of the Anasazi and the Hohokam to practice irrigation. Adler continued by pointing out the possible impacts of the fur trading industry on upstream beaver populations and the associated loss of silt-reducing dams. He also attributed the increase of silt in the river as a plausible by-product of sheep herds grazing along the riparian areas.

Reisner (1993) focused on more recent events. He traced the current situation to the development of irrigated agriculture in Southern California and Mexico, as well as the population growth in Los Angeles and Las Vegas. Fradkin (1981) shared many of Reisner’s sentiments, but focused more on the urban development of the region at the expense of upstream agriculture and the environment.

The Colorado Compact, the Boulder Canyon Project Act, and numerous other legal documents punctuate the equilibrium of this history and create what is known as the “Law of the River,” to which is attributed the glacial rate of water policy change in the basin.

The current situation on the river is replete with issues. Due to the vast scope of the literature, as well as the less technical treatments, and because this chapter is both a literature review and a presentation of issues, it will contain occasional references to non-scholarly sources. The four categories utilized in the survey will be presented here.

Allocation

The problem of allocation refers to both the historical development of water rights in the region, as well as the mechanisms used to reallocate those rights. Prior appropriation, the mechanism often used in the Southwest, is regionally referred to as "first in time, first in right." The first person to put the water to beneficial use "owned" the right to that amount of water each year. Prior appropriation, compacts, agricultural versus municipal and industrial uses, and economic rationale all factor in to the historical and contemporary decision-making institutions.

Tarlock (2001) traces the origins of water allocation in the West. He writes that water played a central role in the development of the West. The fear of inadequate, unreliable supplies distinguished the West from other regions of the country. Water institutions were central in politics and culture.

Today, prior appropriation stands as the primary institution, yet under stress. Beginning in gold mining camps of California and Colorado, as well as Colorado irrigation settlements, it provided a simple system to divide small streams for mining, livestock grazing, and eventually irrigation. It also created private rights in a public resource, all while convincing those responsible that they had a clear rule to follow in times of shortage, priority, and beneficial use.

This was the basis for a system to allocate unused water, to protect third parties, and to assert public interest. The federal government, under prior appropriation, provided water at subsidized rights to water rights holders. The evolution from livestock grazing, mining, and dry farming to large-scale irrigation and urban development resulted from the creation of multi-purpose dams and aqueducts providing carry-over storage and hydroelectric power.

In the New West, prior appropriation faces a gap between its formal and actual practice. As the most highly urbanized region of the country, it falls behind in environmental protection and economic rationalization of irrigated agriculture. The federal government now serves to protect Indian water rights, enforce the 160-acre limitation, abate pollution, and conserve endangered species. Water now flows from rural to urban areas, often through water marketing.

The future of prior appropriation may lie as a default rule to resolve small-scale conflicts as a worst-case scenario for enforcement in complex allocation negotiations and as a rule of compensation when water is voluntarily transferred. Its enduring strengths are its presence as the law, its flexibility, and the apparent lack of realistic alternatives.

According to Henetz (2008), scrutiny of this system intensifies as the drought shows no signs of ending. Future reallocation awaits. Scientists see this as a permanent condition as temperatures rise, snow cover dwindles, soils bake under the increasing heat, and forest fires burn with increased intensity and frequency. Residents of the Upper Colorado River Basin, junior rights holders to those in the lower basin, read this as they would the apocalypse.

The river is in decline. Covering 1,450 miles, serving 30 million people, 3 1/2 million acres of farmland in 7 states as well as 34 tribal nations and Mexico, it is near exhaustion. Demand from city leaders, industry giants, oil drillers, farmers, fishers, ranchers, boaters, bikers, and hikers grows inexorably, not to mention silent pleas from the environment and wildlife. The population dependent on the river approaches 38 million.

California already faces a statewide shortage. The Upper Basin works tirelessly to put all rights to use, even to the extent of supporting some of the highest per capita use in the nation. The Metropolitan Water District, water supplier for 19 million people in six Los Angeles counties, shares Upper Basin fears, owning rights even junior to theirs. If California falls into a shortage, the MWD takes the hit first. In 2003, California cut back to 4.4 million-acre feet to comply with the original Compact agreement. The MWD suffered half of the cuts. In February of that year, a rationing plan debuted in Southern California. The area expected to add five million residents in five years, all on the eastern side, the hotter side.

A judge ordered California water managers to leave 30 percent more water in the Sacramento-San Joaquin Delta. More for the environment meant less for Los Angeles. Developers in Riverside, Kern, Santa Barbara, and San Luis Obispo must guarantee a 20-year water supply before they can build. The state brought back a 17 year-old water bank to allow cities to buy agricultural water. Orange County residents are "reclaiming" water, and in San Diego they plan to build a 300 million dollar desalination plant, though it will supply less than 9 percent of the city's current needs.

MWD consumers have already cut back to 185 gallons per day, Long Beach to 115. Utah residents average 291 gallons/day. This includes Salt Lake City at 255, Washington County at 350, and Kern County at 460. Sixty percent of this consumption applies to outdoor uses such as landscaping and agriculture. In California, agriculture consumes 85 percent of the state's water to support the fifth largest farm economy in the world. Utah's agriculture represents less than one percent of the state's economy.

No state wants to reopen the Compact. Fear stems from the knowledge that the Navajo Nation's rights are not yet quantified. The Colorado River is averaging only 11.7 million acre-feet per year this decade, and has dipped as low as 6.2 million acre-feet at Lee's Ferry in 2002. Lakes Powell and Mead are at a combined 57 percent of capacity. Projections are that by 2050, the drought will have reached 1930's Dust Bowl proportions. Increasing temperatures will reduce Colorado River runoff by 30 percent this century, dropping average annual flows to 8.2 million acre-feet. Currently, 9 million acre-feet per year must pass Lee's Ferry. Henetz' (2008) description of the situation sets the stage for the analysis of its roots.

The origins of these issues are often found in the compacts signed to "fairly" allocate a limited resource. Gelt (1997) describes the impact of historical public policy, specifically water policy, on current water issues in the basin. He traces the Colorado Compact, the larger "Law of the River", the growth of California, and the right of prior appropriation forward to the current state of water scarcity.

Options for water sharing are dependent on the existing resources, institutions and economies. As these factors change, or come under greater demand, or stress, changes take on an air of conflict. Howe (1996) discusses the obstacles to changing existing water-sharing agreements and the options available. He explains that change is often slow due to inertia and a desire to maintain the status quo, and to the influence of special interests.

The transfer of water from irrigated agriculture to urban uses is difficult, particularly in water short areas. Howe points out that the economic costs of the failure to make these changes have been estimated at as much as 200 million dollars a year in California, not to mention the increasing demand for environmental quality. Opportunities for change are inhibited by public projects providing subsidized water, conservative state water agencies, and the near absence of market allocation. Institutional arrangements such as regulatory systems (riparian versus prior appropriation) also hinder adaptation. Understanding that water systems naturally involve interdependency, market allocations, with oversight from government agencies to protect the public interest, might provide a more efficient and adaptable system for water sharing.

Livingston (2005) attacks the same problem of change in water institutions at two economic levels. At the micro level, individuals weigh the benefits of organizing to influence the structure of rules governing water. The meso level analyzes the structure and sequencing of actual change.

He defines institutions as the laws, policies, and administrative rules governing water allocation and use in a particular context. The goals are efficiency, equity, and overall social welfare. Historically water has been managed by physical structural projects. More recently, this emphasis has shifted to demand management, conservation, and pricing. Currently, the focus is on the institutions.

The economics devoted to water policy is both new and primitive. It requires interdisciplinary research in hydrology, earth sciences, politics, history and culture. While there is a need for innovation and efficiency, there are economic consequences for actual or potential change. Livingston states that micro level rules are difficult to change, but easier to evaluate. Inversely, meso level rules are easier to change, yet more difficult to evaluate. The article examines the role of the economist in determining the feasibility of change and then exposing the necessary changes to those in power to push for their enactment.

The original agreements further complicate developing issues in water management. Westcoat, Jr. (2005) discusses the effects of federal salinity control policy on water allocation in the Colorado River Basin. After project construction was initiated, a description of efforts was necessary. This was needed to understand the institutional barriers to conservation and to guide the social distribution of water conservation benefits.

Water rights issues exist within water control institutions and depend on spatial patterning and relative seniority of water rights holders. The salinity control project in Colorado took place in the absence of property rights reform and with the introduction of new regional water markets. This project will serve to highlight existing tensions in the water allocation system. Water diversion rates will remain excessive and interstate water agreements will falter, as water quality considerations will be poorly integrated within Western water law.

Finally, completion of planned development projects exposes the inaccuracies in past projections.

Kenney et. al.,(2010) present a game theoretical study done in the mid-1990's to find out if it accurately predicted the results of a severe sustained drought on the

Colorado River, and to predict the future in the face of the current drought. The study (Harding et. al., 1995) utilized data from a drought that occurred from 1579 to 1600. The conclusion was that such a drought today would more heavily impact the Upper Basin based on current agreements and usage, and that the impact would be minimal.

The current drought, which began in 2000, did not fulfill the predictions. Climate change has decreased mean annual flows by 1.5 million acre-feet and the Central Arizona Project, completed in 1994, has increased demand in the Lower Basin. The combination of the two factors brings demand near supply levels and means that any drop in supply places the system in a position of vulnerability. Solutions are being implemented to include Interim Surplus Guidelines, California's 4.4 Plan, Interim Shortage Guidelines, and Intentionally Created Surpluses. Intentionally Created Surplus is a program created by the Interim Shortage Guidelines and includes water conserved in tributaries to the Colorado River, water imported from non-Colorado River sources into the river, system efficiency projects to limit waste, and extraordinary conservation efforts that work to increase the amount of water in the system (SNWA, 2011).

Experts seek rational solutions, in the form of water markets that focus on the economic benefit of the resource to society as a whole. While these often marginalize environmental concerns, it appears to utilize water more efficiently. The 2006 UN Human Development Report painted a dismal picture of water scarcity (Hadjigeorgalis, 2006). Increasing pressures on agricultural water supplies led many to believe the demand side was more effective than supply side and to be skeptical of water markets as management. This belief contrasts with successful water markets in the U.S.

Brookshire et. al. (2004) explains how market prices contain information about supply and demand and allocate the resource to higher valued resources. Four scenarios are analyzed for comparison and evaluation of market pricing: the Central Arizona Project, Big Thompson, the state of Colorado, and New Mexico's Rio Grande Conservancy District. In the state of Colorado, the water market is well developed, with many trades and rising prices that respond to market conditions. New Mexico's water market is developing well. Prices are lower, yet there exists some response to supply and demand. Arizona is the least developed, showing few trades and low prices. Markets are becoming more efficient in those regions despite considerable institutional and historical impediments to the evolution of water markets.

Matthews (2010) also discusses water markets and reallocation in the West. He labels it both important and contentious, explaining that water reallocation within the same use is not very controversial, while to a different use immediately provokes negative reactions. Such is the case when water is transferred from agriculture to urban use.

Matthews argues that there are two options for reallocation, the market and legislation. In the market water is treated as a property right, though transfers must not impact third parties. There are transaction costs and there are often many rights to the same water as it passes through the hydrologic cycle.

The public interest may not be represented in a market transaction, for example in-stream flows. Legislation fills this void. The Endangered Species Act, Wild and Scenic

Rivers Act, Clean Water Act, as well as state legislation protect the public interest, though restrictions may become unconstitutional when it involves the taking of property.

People generally react negatively to proposed reallocation as in the cases of Las Vegas versus Lincoln, Nye, and White Pine counties. The question that needs to be addressed then is, how to reduce these conflicts. In the end, reallocation must be at the center of the debate on western water.

The Natural Resources Defense Council (NRDC, 2001) attacks the system and its emphasis on agriculture. The environmental organization argues California's rivers and wetlands are threatened by excessive diversions for agricultural, municipal, and industrial uses. Industrial agriculture soaks up 80 percent of California's developed water supply, yet produces only 2 percent of the state's income.

Alfalfa is the biggest water-using crop, consuming 25 percent of California's irrigation water, while producing only 4 percent of the state's agricultural revenue. One farm utilizes 240 acre-feet per year to show a 60 thousand dollars profit. A semi-conductor plant withdraws the same amount of water for 300 million dollars in profit. The farm employs two workers, whereas the above-mentioned plant engages two thousand.

Alfalfa covers more land than any other resource. Twenty percent of California's water goes to support alfalfa, accounting for only one-tenth of the state economy. The question is one of efficiency. Twenty-six percent is grown in desert areas, most of that by flood irrigation.

Seventy percent of the crop feeds dairy cows. Central Valley dairy farms' waste equals the waste of a city of 21 million people. Seven thousand gallons of water per day are required to raise one cow that shows only a thirty-dollar daily return on investment. Water subsidies serve only to exacerbate the situation.

While alfalfa provides certain environmental benefits such as soil health, habitats, and erosion prevention, it is currently being produced at unsustainable levels. Even a modest reduction would yield enormous water savings. More efficient irrigation systems, water transfers, alternative crops, and subsidy limitations offer options for the necessary reductions.

State and local water management agencies face unique challenges. They face conflict over rights between uses and users at the most basic level. Issues discussed in vague terms and in large numbers are dealt with specifically and to the gallon on a daily basis at this level. The Southern Nevada Water Authority (SNWA, 2009) publishes its annual operating plan to outline the resources at its disposal and the limits of each. When discussing the Colorado River, the SNWA recognizes the futility of renegotiating their allotment and the inability of that resource to fulfill its growing needs. The document provides an excellent overview of the issues faced by individual water districts in dealing with allocation, and the potential changes.

Officials and stakeholders often haggle over what seem like miniscule amounts of water. George Knapp (2009) reported that business owners met with agency officials at a secret meeting at Lake Mead to address concerns over the dropping lake level. Harry Reid, Pat Mulroy, and stakeholders met to explore options available after the signing of the 2007 Shortage agreement. The Bureau of Reclamation transferred foot of water from operational requirements, and that foot means Calville Bay did not have to move the marina again. Stakeholders were satisfied that they had at least been consulted in the process and had a chance to voice their concerns. The meeting, the result of efforts by Senator Reid, opened lines of communication between the businessmen and water resource managers.

As a statewide issue, water conflicts are magnified. Gardner-Smith (2008) noted four looming threats to regional rivers in Colorado. They are oil shale production, population growth, climate change, and the Colorado Compact. Oil shale production presents potentially one of the largest users of water, as much as 400 thousand acre-feet per year by 2050. This would be the amount required to produce up to 1.5 million barrels of oil per day. This level of production would require 14 new power plants with an average output of 1,274 megawatts.

Even if this resource doesn’t reach its full potential, combined with oil and gas it will consume 50 thousand acre-feet per year by 2030. In preparation for this, the energy sector in the state has collected an extensive portfolio of conditional and absolute water rights. The fear that downstream states will demand their share of the water is, in the opinion of those here concerned, ‘pretty damned small’. However, such an occurrence would present the equivalent of a natural disaster.

The potential lingering of the current multi-year drought could complicate the delivery of both the 7 1/2 million acre-feet per year required by the Compact and the fulfillment of post-1922 water rights in Colorado. Legal requirements for Compact compliance might lead to a curtailment of the latter rights. This, however, would not likely happen suddenly and would follow the near emptying of Lake Powell. The current response plan to such an occurrence is to convince present perfected rights holders to share their allotments and to possibly lease 200 thousand acre-feet per year from the Blue Mesa Reservoir on the Gunnison River. Water from the Blue Mesa could prevent a curtailment by allowing more water to be diverted to the Front Range.

The Front Range's thirst is expected to grow. Colorado's population, currently approximately five million, may hit ten million by 2050. Eighty percent of that population lives on the eastern slope, while eighty percent of the water is on the western slope. Continued growth would demand more trans-basin diversions from the Frying Pan and Roaring Fork.

Temperatures, resulting from Climate Change may rise two and a half to four degrees. Higher temperatures mean less water from declining runoffs in the twenty-first century. Colorado cities will need as much as 215 thousand acre-feet per year more from the Colorado River by 2030. This increase includes calculations for aggressive water conservation, reduced irrigation, and additional Front Range water delivery projects. The Front Range has already demonstrated a resistance to residential growth controls. State agencies must produce sustainability models that are inherently deficient without controlled growth.

Viewed collectively, these local conflicts demonstrate the connections created by the river. Wright (2008) states that Phoenix, Las Vegas, and Los Angeles could leave Ouray County high and dry. The Colorado River Water Conservation District Board, created to protect Colorado River Water for Colorado, wishes to avoid cutbacks and a "call" on the Compact. If upstream states fail to fulfill water delivery obligations to the states downstream, it can result in a 'call'. The upstream states would then, by contract, be forced to forego diversions for their own uses until downstream obligations were met. Downstream users would like to reopen negotiations, while upstream users, lacking population and clout, fear such a process.

Climate change and urban growth are growing threats, already producing a shorter run-off season. Innovative ideas have been suggested to mitigate the impending conflict. Water banking, planned fallowing, and the purchase of pre-perfected rights are all on the table as portions of an overall solution. The recent 2002 drought nearly elicited the dreaded 'call'.

The role of the federal government in mediating these conflicts expands as the stress on the resource increases and groups fight to retain established rights, or seek to enter the discussion. The Interim Surplus and Interim Shortage Guidelines (ROD, 2001 and ROD, 2007), discuss the methods by which the states come together to address surplus flows and droughts or reductions in the system. Each is a temporary solution, to be reviewed at the end of specified time frames and include flexibility and, in the case of shortages, benchmarks to reallocate the resource.

Augmentation

A region built on growth refuses to accept any limitations. For this reason, politicians and managers choose to seek additional sources of water, known as augmentation, rather than take measures to limit consumption, which might entail limited growth.

Service (2006) portrays worldwide efforts to provide clean, fresh water for all as simply not working. Globally, one billion people do not have access. Over two billion live in water-stressed areas, and that number will grow to three and one half billion by 2025. The global population is growing by 80 million per year. Wealthy countries are not immune. Groundwater dwindles, and the remaining supplies turn increasingly brackish. Environmental concerns limit dam building, making desalination a fast-growing alternative.

Gertner (2007) indicates that in a hotter world, fresh water is the other water problem. A decrease in mountain snowpack signals diminished supplies of fresh water and a crisis more serious than slowly rising seas. Recently, the snowpack in the Sierra Nevada was at its lowest in twenty years. Even optimistic models predict thirty to seventy percent of snowpack will disappear. A two-thirds chance of disaster is the best scenario. Catastrophic reductions in Colorado River flow loom. This has long served as a thought scenario for water engineers. Higher temperatures lead to greater evaporation, thirstier crops, and a lack of availability in other basins.

Tavares (2009), from an interview with Pat Mulroy, general manager of the Southern Nevada Water Authority (SNWA), delineated the issues faced by the SNWA in providing water to the area. These include over-allocation and climate change. Mulroy also presents possible solutions such as water banking and the construction of a “third straw”.

Brean (2009) reveals the Southern Nevada Water Authority has established a direct link between a proposed multi-billion dollar pipeline project and the Lake Mead water level triggers in the 2007 agreement. At elevation 1075, the board of the SNWA will be asked to give the go-ahead for the pipeline. Elevation 1075 represents a level not seen since the initial filling of the lake in the 1930's.

Even if the board agrees to go forward, it will require three years to construct the pipeline. Initially drawing from Delamar and Dry Lake Valleys in Lincoln County, it later stretches to Cave Valley in Lincoln County and Spring Valley in White Pine County. SNWA seeks an additional 16 billion gallons annually from Snake Valley, enough for 100 thousand homes. Construction requires anywhere from ten to fifteen years. The associated pipes, pumps and reservoirs will stretch 300 miles north of Las Vegas and cost somewhere between 2 and 3 1/2 billion dollars.

Further downstream, salinity further threatens quantity. Desalination claims to return already existing resources to the basin for reuse, adding water without a transfer of rights. Conflicts over salinity with Mexico led to the construction of the Yuma Desalination Plant. The Arizona Water Resource (2006) describes how the 1972 Clean Water Act, Section 303, called for water quality standard specific to salinity. This inspired the creation of the Colorado River Salinity Control Forum.

The Forum established the following standards along the Lower Colorado River. Acceptable salinity levels in mg/L were as follows: from Hoover Dam to Parker Dam, 723; from Parker to Imperial Dam, 747; and at Imperial Dam, 879.

In 1961 the filling of Lake Powell and the additional drainage from the Welton-Mohawk Irrigation District drastically raised salinity levels below Imperial Dam. Mexico filed a formal protest. An ensuing set of agreements led to the 1974 Colorado River Basin Salinity Control Act, which diverted Welton-Mohawk I.D. water to the Cienega de Santa Clara and authorized the construction of the Yuma Desalting Plant. The Yuma Desalination Plant operated for nine months after its completion (McKinnon, 2003).

The Cienega profited from the excess water in the form of reestablished wetlands, expanding 450 acres of wetlands to 14 thousand (Blank, 2008). Recently, pressures from drought and Arizona reopened the Yuma plant.

United States Water News (2007) detailed the renewal of the Yuma Desalination Plant, initially completed in 1992. It restarted in March of 2007 for a 90-day low-power trial run to test capacity, cost, and the effects on the Cienega de Santa Clara. It presents a test case for the politics of water, pitting water managers against conservationists. As water managers push to stretch Colorado River water, conservationists refer to a “use it up” attitude that threatens wetlands. Efforts to augment supplies in the lower basin complement conservation efforts, seen by many as insufficient in and of themselves.

Conservation

Conservation describes the variety of ways in which the consumption of Colorado River water is reduced. As mentioned earlier, irrigation efficiency and financial incentives offered by municipal authorities to support water conservation exemplify efforts to reduce demands on the resource. The limits of available resources for augmentation and the economic and political challenges in the way of their exploitation enhance the value of past and future conservation efforts. These efforts receive additional support from current projections of diminished flow in the Colorado River Basin.

The Environmental News Network (2007) asserts there is a 50/50 chance that Lake Mead will be dry by 2021 if usage is not cut. This is according to the Scripps Institute of Oceanography at the University of California, San Diego. There is a 10 percent chance it will be dry by 2013. Tim Barnett, the author of the study, was reportedly stunned by the results. He attributed it to a number of factors: climate change, strong human demand, evaporation, and the uncertainty associated with natural fluctuations. Lake Mead, the source of 90 percent of Las Vegas' water, is half full. While urban conservation has been encouraged, Southern Nevada is calling on the agricultural sector, to shoulder their share of the load.

While not entirely contradicting Barnett's findings, the Summit Daily (2008), quoting from a study conducted by Brad Udall, maintains the dry-up of Lake Mead could take decades. There is less than a 5 percent chance that Lake Mead will dry up by 2021 according to University of Colorado scientist Brad Udall. However, there is as much as a 40 percent chance that it will be dry any year after 2050. The study suggests 5 percent is significant, 20 percent very high, and 40 percent is off the charts. In any case, the populace takes more than Mother Nature puts in, according to Tim Barnett of the Scripps Institute.

Eighty percent of the average annual flow of the river is dedicated to agriculture. Thus, any efforts at conservation must include measures in this sector. Pimentel (1996) puts this into global perspective when he states that population grows geometrically and pressures arable land, water, energy, and biological resources to provide adequate food supply. Currently, between one and two billion people are malnourished as a result of insufficient food, low income, and inadequate food distribution. More people means less land per person.

Water is the other half of this crisis. One hectare of corn transpires 5 million liters of water in one season. Greater than 8 million liters must reach the crop, and 87 percent of the world's fresh water is used by agriculture. The competition for water resources intensifies. Forty percent of the world's people live in regions that directly compete for shared water resources. Water resources critical for irrigation, are being diverted to cities.

This competition impacts water quality, in addition to quantity. The Colorado River Basin Salinity Control Program (2009) represents a 2.5 percent 'earmark' as a national priority under U.S. Department of Agriculture's Environmental Quality Incentive Program. Some argue "national priority" status be discontinued. The Natural Resources Conservation Service (NRCS) proposes reducing federal cost share from 75 to 50 percent. These two actions would affect water quality, downstream users, and the environment.

One of the focuses of the program is to encourage efficient irrigation for the purpose of conserving water. This effort alone removes 772,627 tons of salt per year and reduces total dissolved solids by 65mg/L. It saves downstream users 88 million dollars per year in treatment costs and there is even more untapped potential in the program. Utah has 127,000 more acres that could be treated to reduce salinity. Improved irrigation efficiency has saved over 87,600 acre-feet per year of water while showing increased crop production.

Schwabe (2006) shares the concerns of the NRCS on irrigation and salinity. He describes the necessity of and difficulties associated with drainage. He also considers reuse of water and land retirement as options to enhance agricultural output.

The remaining 20 percent of the water in the basin feeds municipal and industrial needs. Conservation projects there gain momentum as water managers calculate the increasing disparity between supply and demand. Woodka (2008) describes drought-planning policies to counter the effects of climate change that will take years to assimilate, but could reduce the rate of change. Water supplies are currently threatened by drought, climate change, and population growth. At the 2008 (Colorado) Governor's Conference on Managing Drought and Climate Risk there was a new emphasis on planning for drought. This included a new energy economy with Vesta wind turbines and investments by ConocoPhillips into the climate and energy research center. According to the Colorado Governor, "water touches everything." In a new report (2008) by the Colorado Water Conservation Board and the University of Colorado, Boulder, predictions ranged from less intense winters and less snowpack, to more reliance on rainfall, longer growing seasons, and higher temperatures.

Only 27 percent of state water suppliers have drought plans, while the state population is projected to double by 2050. Energy development to support this will also require more water. The Statewide Water Supply Initiative predicts an 18 percent gap in meeting future needs. Oil shale, uranium, coal, and natural gas exploitation will all increase demands on water, while flows are expected to decrease by 20 percent.

Climate change will affect quality as well. More reservoirs will be impaired by pollutant loading and temperature change. Less snowfall and more rainfall will contribute to higher salinity as runoff from cities includes contaminants from streets and parking lots. The potential for reusing this runoff for agricultural purposes is tempered by the fear of its impacts on production. Erosion will also increase as wildfires reduce ground cover.

Deacon et. al. (2007) focus the impacts of population growth on water use locally. Las Vegas is the subject of the case study. The authors analyze per capita use, the ensuing decline of the water table, and its effects on springs and biological diversity. They go on to explore planned development in the area and its potential effects. Finally, they close with a prescription for sustainable water use.

Their conclusions are supported on a regional scale by Pierce (2008). The West, including Colorado, Arizona, Nevada, Utah, and New Mexico could realize a population increase of eleven million by 2040. Already, observers are referring to the area as the "New American Heartland." Its economies and presidential votes affect the entire country. Cities such as Denver, Salt Lake City, Las Vegas, Phoenix, Tucson, and Albuquerque are centers of rapidly expanding regions and represent urbanized chains of development. Growth is the issue and is politically focused on quality growth with quality neighborhoods at the heart. Scattered-site, auto-dependent communities provide the model. The states look to Washington to address one concern: water. It is the West's most contentious issue, and the Colorado River is not getting any larger. The 1922

Compact dates to the time of the Treaty of Versailles. In the absence of decisive steps, it is headed to disastrous results. Water shortages resulting from population growth, climate change, and regional drought all demand solutions such as dramatic conservation and recycling efforts. So, how does Washington fit in? Key inputs would include funding, creative collaborative region-wide water agreements, and sponsorship of basic science research to provide improved data and models.

The National Resources Defense Council (2004) elucidates the proportional relationship between saving water and cuts in energy use. Conserving water and improving efficiency saves energy, cuts electricity bills, and reduces pollution from power plants. The California State Water Project is the state's largest energy user, using from two to three percent of the state's energy for such things as water pumps and wastewater treatment. San Diego needs an additional 100 thousand acre-feet per year. Conversely, water conservation could save 767 million kilowatt-hours per year. Desalination, as a means of providing extra water, will only increase power consumption. Irrigation consumes 80 percent of the state water supply. One solution proposed is to retire drainage-impaired land. The transfer of the conserved water to other uses would increase energy use. On the other hand, simple conservation would provide energy for an additional 18 thousand homes.

Later, existing conservation programs will be discussed. Canal lining, additional reservoirs, desert landscaping, pool covers, and technologically advanced irrigation systems all figure into recent attempts to conserve water.

Environmental Protection

Attempts to reduce salinity, control invasive species, and protect endangered species characterize environmental protection in the basin. The relatively recent emphasis on environmental protection in the region highlights stress on water resources as conservationists demand that more is left in the rivers for plant and animal species that depend on it, as well as for the health of the river system, itself.

The Surplus Environmental Impact Statement (ROD, 2001) analyzes the distribution of potential surplus flows from an environmental perspective, focusing on the Long Range Operating Criteria and the Annual Operating Plan. Based on this background, the statement outlines the purpose and need for an interim agreement, its relationship to the United States-Mexico Treaty, as well as other related and ongoing actions. The document describes, in detail, 6 alternatives reviewed in the decision and the potential environmental impacts of the chosen alternative. Additionally, it addresses other National Environmental Protection Act (NEPA) considerations. Finally, the consultation and coordination process is explained.

The Environmental Impact Statement for the Interim Shortage Agreement (ROD, 2007) details the purpose and need for the Interim guidelines for shortages in the Colorado River. The report describes available alternatives and the affected environment, as well as potential environmental consequences. It further adds other considerations and potential cumulative impacts. Finally, it explains past, present, and future possibilities for consultation and coordination with local interest groups, experts, and government entities.

Emphasis on agricultural and municipal uses of Colorado River water pushes salinity issues to the forefront. Immediate and easily accounted for impacts such as diminished soil fertility and corrosion of infrastructure highlight the effects. Pillsbury (1981) offers an in-depth discussion of salinity in river systems. The author addresses the sources of salinity, as well as the way in which the development of river systems, mainly for irrigation, affects salinity levels. Using both the Nile River and the Colorado River as examples, the article describes the advantages of irrigation agriculture for food production, and the impact it has on water resources. Lastly, the author argues that the original flood/drought cycle of the river system managed the salt levels far more efficiently.

Kaushal et. al., (2005) uses salinity data from the area surrounding Baltimore to evaluate the impact of human activity on salinity levels in the water systems. They discuss rising salinity levels in rural streams, the creation of impervious surfaces and their contribution to long-term salinity, as well as additional ecological implications.

The Colorado River Basin Salinity Control Program (2008) describes the impacts of high salinity on water consumption, crop yields, plumbing, and water treatment. It also discusses actions taken to mitigate the impact including the Federal Water Pollution Control Act, Minute 242 of the U.S.-Mexico Treaty, and the Salinity Control Act.

Bali (2008) centers his discussion on salinity and the Salton Sea. He pinpoints the source of salts, mainly agricultural runoff, that raise salinity levels in the Salton Sea to levels greater than the ocean. Bali also argues that while these levels are increasing by

1% per year, a reduction in agricultural drainage would actually lead to a more rapid increase.

Brownell (1975) outlines the bill to implement the agreement between the United States and Mexico that included a $280 million desalination plant in Yuma, Arizona. The problem involved the language of the 1944 agreement stipulating water from “any and all sources.” In 1961, the pumping of highly saline Welton-Mohawk water, coupled with intensified regulation and use of flows within the U.S. led to a spike in salinity in the Colorado River water delivered to Mexico. Welton-Mohawk water often registered 6000 ppm and pumped waters contained saline accumulations in the underground aquifer. The two events combined raised the salinity of water delivered to Mexico from 800ppm to 1500 ppm. Mexico protested.

Other articles focus on the environment in ways more familiar to the reader. Depletion of native plant and animal species threaten the ecosystem as a whole. Ogdan (2005) depicts the Salton Sea as a large, saline lake and the largest permanent inland water body in the Colorado River Delta region. The sea and adjacent agriculture support enormous diversity and abundance of bird life. Floods inadvertently formed it in 1905. The region historically hosted ephemeral lakes through cycles of flood and drought over millennia. The Salton Sea is now maintained by inflows from agricultural and municipal waster waters. This process leads to eutrophication, or bloom of phytoplankton resulting from inordinately high amounts of nitrates and phosphorus, and high salinity. Consequently, the lake witnessed mass die-offs of birds and fish in the 1990’s. Increased demand for diversion of water from agricultural to urban uses to support exponential population growth in the area have created for the Salton Sea and associated habitats a complex conservation challenge.

Vanishing wetlands provide visible evidence of the consequences of increased salinity. Their loss, or restoration, demonstrates victories or defeats for the environmental movement. Cohn (2001) explores the scope of Colorado River restoration, attempts made to begin that process, and the success or failure of those attempts. He details the impacts of development on the river. Cohn also lists elements necessary to restoration. They are as follows: adequate, available water supply, proper approach, and changes in the current flow regime. Lastly, Cohn asks what role the United States should play in restoration on the Mexican side of the border.

Glenn (1996) illustrates the effects of water management on wetlands in Mexico. The Lower Colorado River Delta has been severely affected by upstream use. No water has been historically appropriated to support wetlands. Large marsh areas still exist below agricultural fields. These are supported by floodwater, agricultural drainage, municipal sewage effluent, and intertidal zone seawater. From 1973 to 1993, the amount of land covered by anything from freshwater to brackish marsh grew from 58 hundred to 63 thousand hectares.

Opportunities still exist to restore wetlands. In the presence of full reservoirs and floods, flood control structures channel water directly to the sea. Effluent waters are deposited in evaporation basins. Conversely, if the Yuma desalting plant becomes operational and Rio Hardy wetlands drain, wetlands could shrink to less than two thousand hectares. Preservation will require a bi-national water management plan that would maximize benefits to wetlands of floods and irrigation return flows, and minimize flood risks.

The Colorado River was once a great desert estuary composed of riparian, freshwater, brackish and intertidal wetlands. 200 to 400 species of vascular plants thrived. Human activity greatly altered the landscape. All waters were apportioned for upstream uses such as irrigation and municipal use. Wetlands received no allotment. Historically these wetlands covered as much as 780 thousand hectares and two depressions, the Salton Sea and the Laguna Salada. The upper delta is now irrigated farmland and the two depressions are hypersaline evaporation basins for irrigation return flows, floodwaters and municipal sewage. Formerly vegetated areas are now barren mud or salt flats. Wildlife habitat has been drastically reduced, as has the number of indigenous peoples as they struggle to maintain their traditional livelihoods.

The delta was assumed to be a dead ecosystem, yet it simply lacks water. The myth that the delta receives no water due to upstream consumption is false. The main wetlands are in the Rio Hardy, recipient of Colorado River flood waters, the Cienega de Santa Clara, product of the Welton-Mohawk Irrigation District main outlet drain, and the El Doctor wetlands, engendered by artesian springs. The remaining brackish wetlands are incidental creations of water management decisions in the United States and Mexico.

The only time the delta was thoroughly documented was between 1891 and 1935 by Sykes, who predicted the decline of the delta following the construction of Hoover Dam. Water flows in the delta ranged from 0 to 6000 cubic meters per second. Annual flows averaged 20.7 billion cubic meters (approximately 17 maf) per year from 1896 to

1921. From 1931 to 1940 this diminished to 14.5 million cubic meters (approximately 12 maf) per year. Coincidentally, diversions for agriculture began in 1896.

Between 1905 and 1907 there was an accidental diversion due to a canal break. The flows carried silt as well as water. This product is now much reduced as it is trapped behind dams, and the past 50 to 60 years have seen more movement to erosion as opposed to accretion in the area. Consequently, land in the delta is projected to decrease. After dam construction, water flow into the delta was drastically reduced. Mexico's treaty allotment of 1.8 billion cubic meters (1.5 maf) per year represents 10% of average annual river flow. It is used for irrigation in Mexicali and San Luis and, in normal years, there is no surplus for the delta.

From 1963 to 1980, storage capacity was unlimited in the basin. Lake Powell was not yet full and Mexico received only her treaty allotment. Since 1981, flood events have brought large quantities into the delta. The 1983 releases caused property damage on both sides of the border.

While wetlands and native species decline, invasive species propagate freely to fill the void. Olden (2006) tells of fish invasions and extirpations in the Lower Colorado River basin. The research examines mechanisms by which non-native species successfully invade a new regime and their consequences for native fauna. Also identified are rates of spread and contraction and overlapping life history strategies produced by anthropogenically-altered adaptive landscape. Non-native species locate throughout the adaptive surface and often surround the ecological niche volume of a native species pool.

Native species show the greatest decline when they demonstrate a strong life history overlap with non-native species, or when they possess a periodic strategy that is not well adapted to present-day modified environmental conditions. Non-native, rapidly expanding species occupy vacant niche positions in the life history space. Niche opportunities are often exposed by human created environmental conditions.

Busch (1995) exposes the decline of woody species in a western North America riparian ecosystem function that was transformed by anthropogenic influences on riverine environments. Modified flood frequency, duration, or intensity, depressed floodplain water tables, and increased alluvium salinity contribute to this transformation. The invasion of Tamarisk Ramosissima resulted directly from development. Compare the Colorado River (highly regulated) with the Bill Williams River (less perturbed). The Colorado proves more xeric and saline.

Environmental restoration generally involves the reduction of man-made infrastructure to allow the natural system to recreate the balance. Living Rivers (2005) tendered the One Dam Solution report in response to ongoing negotiations over future shortages in the basin. The report indicated that climate change and population growth upset the balance. Further, federal laws and water projects regulating water resources do not reflect the imbalance. Current laws allocate more water than the river provides. More dams exist than are needed leading to as much as 13 percent in wasted water resources. Sediment backup represents millions of dollars wasted in failed environmental management. Powell and Mead cause the loss of 10 percent of rivers annual flow, and their filling is unlikely.

The Grand Canyon exemplifies a devastated ecosystem. Four fish species are extinct, one is in jeopardy, and one is of special concern. Glen Canyon Dam traps the sediment required to create habitats and beaches. Measures to mitigate damage directed by Grand Canyon Protection Act (1992) have failed. Glen Canyon Dam, built in part to reduce silt at Hoover Dam, now faces its own silt issues, including the loss of available storage area in Lake Powell.

The Living Rivers report provided a number of recommendations, including 1) reduce above ground storage, increase aquifer storage, and minimize evaporation, 2) use of regional aquifers with greater capacity than Powell and Mead combined, 3) use Lake Mead as primary storage and distribution facility. Lake Powell is surplus and contributes to losses, 4) employ Lake Mead to distribute sediment, and 5) update federal laws to reflect Colorado River realities.

CHAPTER 4

FINDINGS AND THEIR IMPLICATIONS

The purpose of this study is to identify issues affecting water allocation in the Lower Colorado River Basin, and to locate consensus among stakeholders on those issues. This first required identification of the pertinent issues by examining the current literature on water allocation in the basin. The next step was to write a set of statements expressing those issues. The topics naturally fell into four categories: allocation, augmentation, conservation, and environmental protection. Each category included six statements.

The methodology was drawn from Prothro and Grigg (1960). Their work studied the connection between an individual's belief in abstract democratic principles and its relationship to concrete applications. In this study, the initial statement in each of the 4 categories addressed a more abstract concept followed by 5 statements describing more specific concepts or actions in that area.

Each statement was attached to a Likert scale, and incorporated into a survey. The last section of the survey asked three demographic questions. Do you consider yourself primarily a water resource manager or user? As a manager or user, what is the primary use you are associated with? The response options for this question were agricultural or domestic. What state do you primarily work/live in? Options were Arizona, California, or Nevada.

The focus group for this survey was the Colorado River Water Users Association. Members are stakeholders in water in the Colorado River Basin. They include representatives from local, state, and federal government agencies, local water districts, agricultural, municipal, and industrial users, and nongovernmental agencies.

The survey was conducted in two stages. The first stage entailed the distribution of a paper survey at the annual meeting of the Colorado River Water Users Association, December 15 to 17, at Caesar's Palace in Las Vegas. At that time, 350 surveys were distributed. Completed and returned surveys numbered 42. Stage 2 distributed the same survey electronically. Over the period of one week in January, 450 surveys were emailed to members of the same organization, and 43 were completed and returned.

The total sample of 85 completed surveys provides a representative sample. The Colorado River Water Users Association includes representatives from every major interest group in the Colorado River Basin. Additionally, officials from the government agencies and water districts maintain membership in the association and participate in regular meetings and conferences. Of these 85 surveys, the groups derived from the demographic questions were fairly evenly represented, understanding that the groups are not mutually exclusive. Table 1 supports this assumption.

Table 1 Respondents	Number of Respondents (N)
Total Sample	85
Managers	54
Users	27
Agriculture	24
Domestic	51
Arizona	33
California	22
Nevada	13

The data analysis necessitated the filtering of the groups from the total sample. Utilizing the three demographic questions, groups emerged representing Managers, Users, Agriculturalists, Domestic users, and residents of Arizona, California, and Nevada.

Following Prothro and Grigg's (1960) methodology, 75% was chosen as the number representing consensus either in agreement or disagreement. This could represent any one response (i.e. strongly agree) or the combination of two positive or negative responses, but not neutral. The numbers, with the exception of the column labeled "N", indicate percentages.

An example of one of the statements and the resulting data is provided in Table 2, as follows.

Statement/Issue: Environmental Concerns will play an even greater role in future water resource management decisions.

Table 2 Example	Strongly Agree	Agree	Neutral/Unsure	Disagree	Strongly Disagree	N
Total Sample	25.3	59.0	6.0	7.2	2.4	85
Managers	22.2	59.3	7.4	7.4	3.7	54
Users	34.6	57.5	0.0	7.7	0.0	27
Agriculture	20.8	62.5	4.2	12.5	0.0	24
Domestic	26.0	60.0	6.0	4.0	4.0	51
Nevada	15.4	69.2	15.4	0.0	0.0	33
Arizona	9.1	81.8	0.0	9.1	0.0	22
California	47.6	38.1	9.5	0.0	4.8	13

In this case, the data from the column labeled "Strongly Agree" (22.2) is added to the data in the column labeled "Agree" (59.3) for a group such as Managers. 22.2 + 59.3

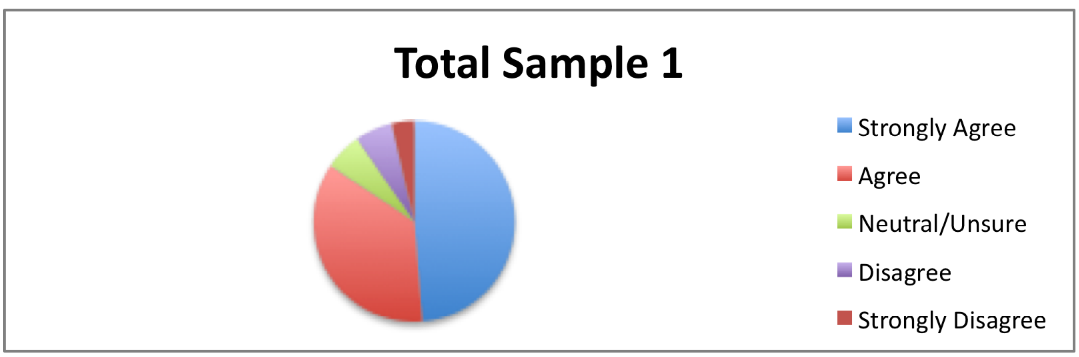
= 81.5%, or more than the 75% needed for consensus. In this particular case, the data make the case that Managers, as a group, believe that environmental concerns will play a greater role in future water resource management decisions. This same calculation can be performed in each demographic group to provide a comparison with Managers and with every other group.

The resulting data was then analyzed to locate consensus within any one group, and to find consensus between groups on an issue or category of issues. Following this, the relevant literature to each statement was analyzed and compared to the responses as the source of the findings and implications of the thesis.

Allocation

The first six statements comprise the section devoted to quantitative allocation of the Colorado River. The section begins with the general assumptive statement that more water is allocated than actually exists in the river. It then proceeds to address a number of specific allocation issues. These include the original agreement and efforts to revisit it, the mechanism used to allocate water, priority of one use over the others, the level of flexibility in the agreement, and the potential mechanism for reallocation.

Statement/Issue: The Colorado River is Over-Allocated.



This statement reflects the general assumption of many in the region that more water is allocated annually than is actually produced by the river. The assumption is that it will elicit general agreement, which it did as evidenced below.

Table 3 Overallocation	Strongly Agree	Agree	Neutral/Unsure	Disagree	Strongly Disagree	N
Total Sample	48.8	35.7	6.0	6.0	3.6	84
Managers	51.9	31.5	3.7	7.4	5.6	54
Users	46.2	38.5	11.5	3.8	0.0	26
Agriculture	58.3	29.2	8.2	4.2	0.0	24
Domestic	42.0	40.0	4.0	8.0	6.0	50
Nevada	53.8	30.8	0.0	15.4	0.0	13
Arizona	51.5	36.4	12.1	0.0	0.0	33
California	45.5	36.4	4.5	13.6	0.0	22

The data indicate consensus among all groups as pertains to this statement. This comes as no surprise, as many recent books and studies on the topic begin with this statement as the major assumption. The group at large, managers and users, agricultural and domestic consumers, and representatives of Arizona, California, and Nevada all agree that the river is over allocated. The literature supports this consensus.

The Colorado Compact, as discussed earlier, estimated annual flows of the Colorado River at 17.5 million acre-feet (Reisner, 1993). A minimum of 8.23 maf were to be delivered to Lee's Ferry, the dividing line between the basins, annually, if available (Adler, 2007). The 17.5 maf originated out of about 18 years of stream flow measurement. Roughly thirty years later, the data was already questioned by both Raymond Hill and Royce Tipton, two respected scientists in the field. Hill stated in 1953 that the discharge at Lee's Ferry had averaged only 11.7 maf since 1930. Tipton, in 1965, further argued that there was not enough water in the river to meet the compact obligations (Reisner, 1993).

The United States Geological Survey, responsible for measuring stream flow in the river, reported that the years used to formulate the Compact allocation had been the wettest period in nearly 800 years. The National Academy of Sciences estimated that the annual flow over the past century was 14 maf, and tree ring data lowered that estimate to around 13.5 maf (Living Rivers, 2005). The flow is highly variable, ranging from 4.4 to 24 maf per year (Adler, 2007). The situation grows worse if one accepts that most climate models suggest future declines this century, as described in Appendix U of the Environmental Impact Statement (ROD, 2007). Even a modest decline of 10% would mean a reduction of 1.5 maf/year in average annual supplies (Kenney et. al., 2010).

An additional fact that many overlook is that the Compact failed to account for rights that predated it, such as the Winters Doctrine allocating water to Native American groups, the estimated 1.5 maf/year allotted to Mexico in 1944, and the estimated 1.5 maf/year lost in evaporation (Reisner, 1986). The end result is that more Colorado River water is allocated than the river actually produces (Living Rivers, 2005).

The data match the view from the literature that the river is over-allocated. The generalized statement sets the stage for specific statements below addressing discrete issues in Colorado River water allocation.

Statement/Issue: The Colorado Compact allotments are now reviewed periodically and interim agreements address shortages and surpluses adequately.

The first of the specific statements, it addresses the capacity to review and revise the original agreement. The assertion probes the respondents for their level of confidence in the recently signed interim agreements.

Table 4 Compact	Strongly Agree	Agree	Neutral/Unsure	Disagree	Strongly Disagree	N
Total Sample	11.8	48.2	21.2	12.9	5.9	85
Managers	16.7	51.9	18.5	9.3	3.7	54
Users	3.7	37.0	29.6	18.5	11.1	27
Agriculture	12.5	54.2	16.7	12.5	4.2	24
Domestic	13.7	45.1	21.6	13.7	5.9	51
Nevada	7.7	46.2	30.8	15.4	0.0	13
Arizona	9.1	51.5	18.2	18.2	3.0	33
California	13.6	54.5	18.2	9.1	4.5	22

The data for this statement reflect full dissensus. No group fully agreed or disagreed with the statement. The lack of agreement may reflect a lack of confidence in the ability of the recently signed agreements to address future shortages, or the belief that the system requires a major overhaul in the face of current and future realities.

When the seven states met with Secretary Hoover to allocate the waters of the Colorado River, they relied on data from the United States Reclamation Service (predecessor to the Bureau of Reclamation). The USRS estimated average annual flow at 17.5 maf. They based that figure on about 20 years of stream flow measurement with instruments that by today's standards lacked precision. During that period, the river flowed at or above averages every 3 out of 4 years. Not once in that time did the flow dip below 10 maf, as it had often done during the Great Drought of the 1930s. By 1953, Raymond Hill stated that the river had averaged only 11.7 maf since 1930. In 1965 Royce Tipton estimated average annual flows at no more than 15 maf. Annual river flows varied from 4.4 to 24 maf. Subtract 1.5 maf each for evaporation and obligations to Mexico, and one is left with not a lot of water (Reisner, 1993).

The basin states negotiated the Compact at the end of the wettest ten-year period on record (1914-1923), during which average annual flows reached nearly 19 maf. They felt comfortable allocating 16.5 maf/yr. The rest of the 20th century proved much drier. Average flow from 1896 to 2004 was less than 15 maf. In 1976, Charles Stockton and Gordon Jacoby studied 450 years of tree ring records and calculated the longer-term average at 13.5 maf/yr (Adler, 2007). The Department of Energy predicted 14 percent decline in flows by 2010, and 18 percent by 2040, due to climate change (Living Rivers, 2005).

The United States Geological Survey monitors the snowpack in the Rockies and the flows in the Colorado River regularly. The allotments, however, are under nowhere near the scrutiny. The Interim Surplus Agreement of 2001 served as the first time in nearly 80 years that the allocations had been reviewed and only to allocate surpluses in flood years. The Interim Shortage Agreement of 2007 resulted from deep drought along the system and fears of a curtailment, or "call," on the Compact. While the agreement provides benchmarks for reductions in allocations, no concrete changes were made to the original Compact that would account for current flow data. Additionally, the new agreement is not due for full review until 2026.

Failing to demonstrate overwhelming agreement in either direction, the data do cluster in the "Agree" column. The lower numbers in the "Strongly Agree" column, and the relatively high figures in the "Neutral/Unsure" area prevent consensus. The lowest representation occurs in the "Strongly Disagree" section.

Statement/Issue: Prior Appropriation is an unfair system that rewards history and doesn't reflect the current situation on the river.

One mechanism dominates water allocation in the region. How do the various groups view that mechanism? Do its beneficiaries strongly support its continuance, and is there a movement among newcomers to the discussion to change the mechanism?

Table 5 Prior App.	Strongly Agree	Agree	Neutral/Unsure	Disagree	Strongly Disagree	N
Total Sample	10.6	16.5	21.2	28.2	23.5	85
Managers	7.4	13.0	22.2	33.3	24.1	54
Users	18.5	25.9	18.5	14.8	22.2	27
Agriculture	0.0	12.5	16.7	25.0	45.8	24
Domestic	15.7	19.6	25.5	25.5	13.7	51
Nevada	0.0	30.8	46.2	23.1	0.0	13
Arizona	9.1	12.1	21.2	36.4	21.2	33
California	13.6	27.3	18.2	13.6	27.3	22

Though the numbers lean toward disagreement with the statement. What should interest readers here is why no group agrees with the statement. One would imagine that domestic users and water managers seek to "upset the apple cart" to gain a measure of priority as they deal with increasing pressure to obtain rights to what appear to be diminishing water supplies. The only explanation for their resistance to change is the fear that any modification could mean even less water than they currently receive. Agriculturalists, expectedly, disagree with the statement. They stand in favor of prior appropriation, as the primary beneficiaries of the system. One possible reason for their failure to demonstrate more cohesion is that strict adherence to prior appropriation might limit their ability to negotiate water transfers and work against their own interests.

Tarlock (2001) provides an excellent review of the prior appropriation system and predictions for its future. Prior appropriation has been the primary institution for the development and use of western water. It is, however, under stress. Traced to gold mining camps in California and Colorado as well as early Colorado irrigation settlements, it functioned based on priority date of use and beneficial use. Developing into an administrative system, it served to allocate unused waters, protect rights of third parties, and assert the public interest. The system progressed from livestock grazing, mining, and dry farming to large-scale irrigation with urban oases supported by aqueducts and multi-purpose dams providing carry-over storage and hydroelectric power.

Today, water flows from rural to urban uses. A law of irrigation rights in a region where irrigation agriculture is stable or declining, prior appropriation faces change. Urban and environmental interests fight for new supplies and water markets emerge. The "New West" supports commodities such as climate, mountain and desert wilderness areas, scenery, free-flowing rivers, open space, and the infrastructure to sustain this high quality of life. The region is less dependent on irrigated agriculture (Tarlock, 2001).

Prior appropriation contains definite drawbacks. The definitions of "beneficial," "reasonable," and "waste," vary by state. Interpretations of type of use, necessity of diversion, means of diversion, amount of water for a specific purpose, and place of use depend on customary standards of use for that area. Limits on change, inefficiency or non-use, reuse and disposal, and injuries to other users can be different according to location. Permit systems and the lack of articulation between surface and groundwater laws often hinder justice and compensation (Westcoat Jr., 2005).

Changes to prior appropriation occur more in practice than in form. Water allocation is no longer a federal-state negotiation. These two entities now join other stakeholders to distribute the resource. In a post-modern economy of rapid growth, the hydrological foundations of the region are shifting. Global climate changes create early spring run-offs that evaporate faster and result in drier than average conditions. Solutions no longer appear in the form of simple allocations. Markets and basin-specific institutions now drive allocations. The future of prior appropriation presents it as the default solution to small-scale conflicts, a worst-case enforcement scenario, a rule of compensation in voluntary transfers, and to inform constitutional analysis in involuntary reallocations (Tarlock, 2001).

Interestingly, only Agriculture approaches unity on this issue. One would expect unity from this sector that has so richly benefitted from the prior appropriation system of water allocation. More surprising is the lack of unity in other sectors. An argument could be made, in light of predictions of a drier future, that current allocations, as one-sided as they might be, may be better than the allocation of a greatly reduced resource where all parties are forced to reduce their share. The opposing argument would be that future allocations might more equitable divide the resource to reflect the current realities of population growth and urbanization. The two sides potentially explain the diffusion of responses across the Likert scale.

Statement/Issue: Agriculture is the highest priority for water use in the Lower Colorado River Basin.

Owning 80 percent of water allocations in the Lower Basin, agriculture historically dominates any discussions in the area. What is the future of that dominance?

Do agriculturalists, and those from other sectors foresee changes in that disparity? These are the underlying questions hidden in this articulation.

Table 6 Agriculture	Strongly Agree	Agree	Neutral/Unsure	Disagree	Strongly Disagree	N
Total Sample	15.5	29.8	21.4	26.2	7.1	84
Managers	16.7	31.5	14.8	27.8	9.3	54
Users	15.4	19.2	34.6	26.9	3.8	26
Agriculture	20.8	29.2	25.0	25.0	0.0	24
Domestic	10.0	26.0	22.0	30.0	12.0	50
Nevada	7.7	38.5	23.1	15.4	15.4	13
Arizona	12.1	30.3	24.2	30.3	3.0	33
California	18.2	22.7	22.7	31.8	4.5	22

This statement found discord in every group, including the agricultural users. This defies logic, as it is widely known that over 80 percent of the water in the Colorado River is devoted to agriculture (ENN, 2007). Furthermore, the history of the development of the river traces itself directly to agriculture. Over one quarter of the respondents labeled themselves as agricultural users as opposed the more than half of the respondents who chose to be identified as domestic users. Those representing other sectors understandably lack unity. Changes in the region, specifically population growth and urban expansion, threaten the continuing dominance of agriculture in water allocation negotiations. Perhaps these responses are a reflection of a growing awareness of that fact.

More than 25 million Americans rely on the Colorado River as their primary water source. This number escalates as the population of Arizona alone grew by 40 percent in the 1990s. “The basin is going to face increasingly costly, controversial, and unavoidable trade-off choices," according to Ernest Smerdon, former dean of Engineering at the University of Arizona (MSNBC, 2007). Agriculture consumes as much as 90 percent of the developed water resources in the state of Colorado, and the vast amount of use is consumptive. Most urban use is non-consumptive.

The difference between consumptive and non-consumptive is hydrological. Consumptive uses, for example agriculture or urban landscaping, remove water from the system semi-permanently. The water used to grow crops or grass does not immediately flow back into the river from whence it came. Water used in a toilet, shower, or sink, or even as a coolant in a power plant or factory often flows immediately, through sewage treatment centers, back into its original source (Gertner, 2007).

In California, 80 percent of the state's water supply feeds agriculture, which produces but 2 percent of the state's income. For comparison, a 240-acre farm employs 2 workers and shows a 60 thousand dollar profit each year. The same 240 acres occupied by a semi-conductor plant employs 5 thousand workers, each earning approximately 60 thousand dollars per year, for an income of 300 million dollars (NRDC, 2001)

Colorado, Arizona, Nevada, Utah, and New Mexico expect 11 million more people by 2040 (Peirce, 2008). Population explosion combined with climate change threatens system users (Wright, 2008). Las Vegas chooses to fight this impending disaster by constructing 300 miles of pipeline to tap groundwater north of the city. The pipeline requires 10 to 15 years and 2.5 to 3 billion dollars to complete, but will eventually provide 134 thousand af/year, enough to support 270 thousand homes. The groundwater originates from an aquifer that currently supports ranchers in Lincoln, Nebraska, and White Pine counties, and stretches underneath the state line into Utah. These two facts have placed enormous obstacles in the path of its construction (Brean, 2009).

Population growth and prior appropriation battle for preeminence as water supplies shrink in the region. Heated and ongoing negotiations continue as the two interests seek creative solutions. The data reflect this conflict. Clustered in the middle with few reaching strong agreement or disagreement, the numbers demonstrate a lack of assurance for future agreements.

Statement/Issue: Fixed allotments limit the flexibility necessary to adapt to climate change.

Probably the most important word in the above statement is change. Much like the discussion of prior appropriation, vested interests resist change in a system, even if that system is not as efficient or equitable as another. The greatest fear is that any change in the current system will mean less water for all involved.

Table 7 Allotments	Strongly Agree	Agree	Neutral/Unsure	Disagree	Strongly Disagree	N
Total Sample	7.2	26.5	15.7	36.1	14.5	83
Managers	1.9	26.4	15.1	34.0	22.6	53
Users	19.2	26.4	15.1	34.0	22.6	26
Agriculture	4.3	17.4	13.0	43.5	21.7	23
Domestic	8.0	32.0	18.0	32.0	10.0	50
Nevada	0.0	50.0	16.7	25.0	8.3	12
Arizona	6.1	21.2	21.2	39.4	12.1	33
California	13.6	31.8	9.1	31.8	13.6	22

This statement evoked dissonance. The literature points to resistance from both social and political sectors as opposition to change. One might expect resistance from established wealth, income, and geographic locations. Changes in allocation mechanisms would impact each of these in unknown ways. One would predict consensus in agreement with the statement among managers and domestic users who seek new ways to insure their future. As junior rights holders, in many cases, the current allocations do not favor them. Also, one could logically predict consensus in opposition to the statement among agriculturalists who would support the current system as the major beneficiaries of prior appropriation allocations.

Continued population growth, climate change, and the Colorado Compact threaten the future of the West. Even with good planning, shorter run-off seasons, temperature increases of 2.5 to 4 degrees, and greater demand all conspire to squeeze existing water supplies (Gardner-Smith, 2008). The region faces disastrous results unless decisive steps mitigate ensuing water shortages (Peirce, 2008). Markets and negotiated settlements replace fixed allotments created by state and federal water policy. They increasingly fade into a shadow framework as water moves to urban and environmental users (Tarlock, 2001). Washington assumes a new role, which must sponsor the basic science necessary to model future climate, water, and energy challenges (Peirce, 2008). Serious shortages from natural or climate-change induced drought strain current allocations and force different adaptation patterns (Tarlock, 2001).

Water markets, as a replacement for existing allocations, evolve slowly. Inexperience combined with social and political resistance account for the pace. Change necessitates redistribution of water rights and their associated wealth. Increasing water rights transfers encourage the emergence of water markets that will continue to develop as pressures mount. While the opposition to change in the system is evident, the change is inevitable, at least in the eyes of the experts. (Tarlock, 2001 and Howe, 1996)

The data are uniquely balanced across the board. California and Nevada residents demonstrate the balance vividly. One would assume this presents populations divided between those in favor of updating the system to reflect current realities and those preferring to retain the old system for fear of reduced allocations.

Statement/Issue: Water transfers between uses and between basins provide an additional tool in dealing with water scarcity.

Already commonly practiced, water transfers introduce flexibility into an otherwise rigid system of water allocation. Often seen as in the best interests of both sides of the transaction, they appear to accomplish reallocation in the least painful way possible. The intent of this declaration is to gauge the support they receive from stakeholders as a whole, and by sector.

Table 8 Transfers	Strongly Agree	Agree	Neutral/Unsure	Disagree	Strongly Disagree	N
Total Sample	27.4	60.7	6.0	0.0	6.0	84
Managers	27.8	61.1	3.7	0.0	7.4	54
Users	25.9	59.3	11.1	0.0	3.7	27
Agriculture	25.0	62.5	8.3	0.0	4.2	24
Domestic	27.5	60.8	5.9	0.0	5.9	51
Nevada	7.7	92.3	0.0	0.0	0.0	13
Arizona	27.3	57.6	12.1	0.0	3.0	33
California	36.4	59.1	4.5	0.0	0.0	22

The data indicate strong accord on this statement. The respondents as a whole;

managers and users; agricultural or domestic; residents of Arizona, California, and Nevada all agreed that water transfers were an acceptable way of managing water scarcity. The literature supports this consensus.

A water transfer occurs through a variety of mechanisms and across numerous boundaries: geographical, legal, and administrative. The mechanisms include, but are not limited to; water banks, bulletin board markets, options markets, and water trusts (Hadjigeorgalis, 2006). The California State Water Bank, allowing water transfers between Sacramento Valley farmers and Southern California utilities, and the Southern Nevada Water Authority/Arizona agreement to bank Nevada water in Arizona serve as examples (Henetz, 2008).

The transfer may be from groundwater to surface; from agricultural use to urban; between states, basins, and even across international borders. Supporters reason that water scarcity results not from physical deficiency. Rather, distribution issues and institutional and political failures in water management engender these conflicts. Water transfers, or markets, address these failures through a demand-side approach. Transfers from agricultural uses to urban and environmental needs generate incentives for efficiency in agricultural use (Hadjigeorgalis, 2006).

Predictions of a drier future motivate cities to strike more deals with farmers for water supplies (MSNBC, 2007). A pipeline from areas as far as 300 miles north of Las Vegas to pump groundwater into Lake Mead still lacks complete authorization from area farmers, neighboring states, and the courts. A pipeline from Lake Powell to the area around St. George, Utah, faces similar issues (Henetz, 2008).

Everything is negotiable as the state of Colorado compensates owners of pre-1922 rights for their willingness to share water in the event of a curtailment in Colorado River supplies. The same communities lease 200,000 acre-feet of water from the federal government at Blue Mesa to prevent future shortages (Gardner-Smith, 2008).

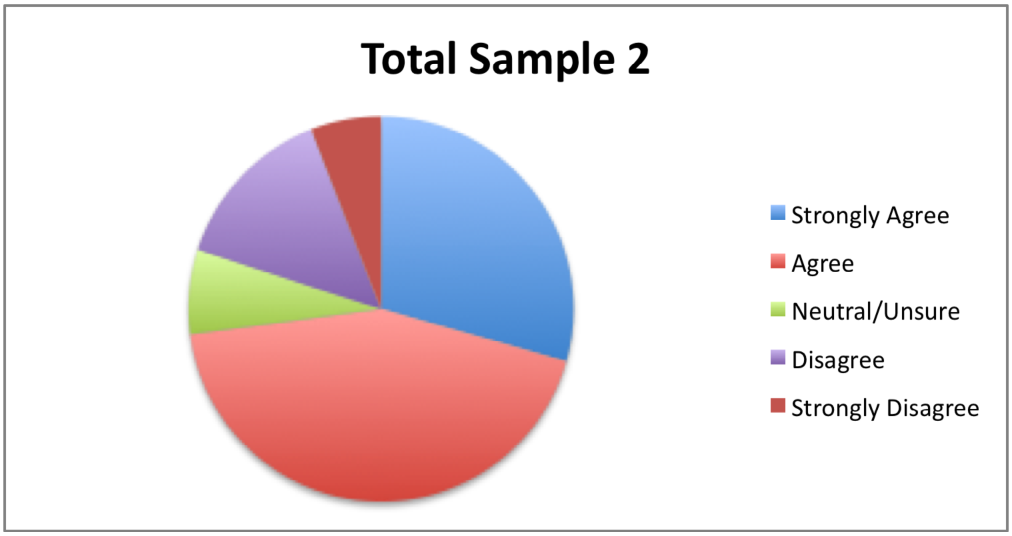
Many more examples exist of water transfers, or water marketing in the region. As supplies tighten, communities and agencies responsible for water supplies seek reliable sources as insurance against potential shortages. Few incentives exist for water conservation in the region. The support for water transfers, as exhibited in the data, demonstrates a desire to provide those incentives to encourage the conservation of water by existing users to be transferred to new and existing users in the future.

Augmentation

Shortages in the Lower Colorado River Basin are well documented. The initial allocations based on inaccurate estimates, population growth, the potential impacts of climate change, and failure to include allocations for Native American groups and the environment all contribute to a seemingly unsustainable system. Water managers, while incorporating water conservation schemes into their planning processes, argue that they are simply not enough. Where can they get more water?

Options include groundwater importation, canal lining, desalination, additional reservoirs, and cloud seeding. Respondents initially verify their level of agreement with the assumed shortage and then provide their opinion of the various solutions.

Statement/Issue: There simply isn't enough water in the Colorado to support the needs of the region and additional sources must be sought to augment supplies.



This general observation sets the stage for any discussion of augmentation. If the Colorado River sufficed, there would be no need for any additional water. The question demands that respondents validate this assumption.

Table 9 Augmentation	Strongly Agree	Agree	Neutral/Unsure	Disagree	Strongly Disagree	N
Total Sample	29.4	43.5	7.1	14.1	5.9	85
Managers	33.3	44.4	5.6	13.0	3.7	54
Users	22.2	40.7	7.4	18.5	11.1	27
Agriculture	20.8	45.8	12.5	16.7	4.2	24
Domestic	35.3	41.2	3.9	13.7	5.9	51
Nevada	7.7	61.5	0.0	23.1	7.7	13
Arizona	30.3	51.5	9.1	9.1	0.0	33
California	40.9	31.8	4.5	13.6	9.1	22

Managers, Domestic Users, and Arizonans agreed with this statement. One would argue that these are the three groups most affected in a shortage situation. None of the three maintains senior rights and all are at risk of reductions in case of a shortage. This is especially true for Arizona as a result of the agreement signed with California.

Until recently, Arizona lacked the infrastructure necessary to divert its water allocation in the Lower Basin. The Central Arizona Project filled that void and provided water for the rapidly expanding Phoenix metropolitan area. However, the project required congressional support for passage. The agreement provided California congressional support for the Central Arizona Project. In return, Arizona would take California's shortages in case of a drought.

No other group found consensus. Whether other groups feared that augmentation meant a reduction in their particular use, or they simply were not clear as to what was meant by augmentation, they responded with no apparent unity.

The options vary, and in some cases stretch the imagination. Las Vegas has already purchased and continues to acquire ranch land north of the city to obtain the associated water rights. This would entail a 300-mile pipeline to carry the water from its current location in underground aquifers to the Virgin and Muddy Rivers, where it can flow into Lake Mead (Brean, 2009).

The lining of the All-American and Coachella Canals prevents loss through seepage. The conserved water supports communities in Las Vegas and Los Angeles without a transfer of reduction of rights somewhere else (Keene, 2005).

The Yuma Desalination Plant, idle since 1992, runs under a pilot program to test its efficiency in recycling agricultural wastewater. Water from the Welton-Mohawk agricultural district, recently draining into the Cienega de Santa Clara, now fulfills obligations to Mexico under the 1944 treaty. In question are the potential impacts on the Cienega (USWN, 2007).

Often, water users request deliveries that can take days to arrive. Meanwhile local precipitation eliminates the need for these deliveries. The water is not diverted as planned and continues on into Mexico. As Mexico has not requested the water, they are not responsible for it and it is not applied toward their allotment. It is, in a sense, wasted. The Drop 2 reservoir diverts these waters into two basins along the All-American Canal, and stores them for future deliveries (Vandevelde and Palumbo, 2010).

Cloud seeding and iceberg dragging remain in the experimental and theoretical stage. States currently fund cloud seeding, with only minimal hope of gains, to prevent future shortages (Griffith and Solak, 2006).

These options represent the attempt to utilize every last drop of Colorado River water. They often overlook environmental requirements in favor of the short-term and long-term interests of agriculture and growing cities. The efforts acknowledge the limits of the resource and the need to plan ahead as the situation will, most likely, not improve in the future. The fact that the data from three groups demonstrate agreement, and the near agreement of all other groups, indicates a high level of awareness of the realities in the basin.

Statement/Issue: The pipeline proposed by the Southern Nevada Water Authority will provide water necessary for the future without damaging the environment or agricultural interests upstate.

The proposed SNWA pipeline offers water supplies both for future growth and to offset potential shortages in the basin. Environmentalists and ranchers resist the project, fearing it threatens local ecology and wells used for livestock. Respondents are asked to weigh both sides and decide if the project can add water to the system without negatively impacting other interests.

Table 10 Pipeline	Strongly Agree	Agree	Neutral/Unsure	Disagree	Strongly Disagree	N
Total Sample	4.8	16.9	48.2	22.9	7.2	83
Managers	7.5	18.9	43.4	24.5	5.7	53
Users	0.0	14.8	55.6	18.5	11.1	27
Agriculture	4.2	8.3	66.7	12.5	8.3	24
Domestic	6.0	22.0	42.0	24.0	8.0	50
Nevada	15.4	46.2	15.4	15.4	7.7	13
Arizona	0.0	12.1	66.7	21.2	0.0	33
California	9.5	19.0	42.9	14.3	14.3	21

Responses to this statement reflect discord. Not one group demonstrated consensus. This might be attributable to the fact that it is a relatively local issue, with seemingly small impacts on other basin states. Additionally, the project remains in the planning phase, and construction has no start date.

The plan is to tap a regional deep carbonate aquifer. The aquifer extends across central and southern Nevada, from Utah to California (Deacon et. al., 2007). It will extend into Lincoln, Nye, and White Pine counties, as far north as 300 miles from Las Vegas. Requiring 10 to 15 years and 2.5 to 3 billion dollars to build, the project promises 16 billion gallons/year (134,000 af), or enough to support 270,000 homes (Brean, 2009).

As the level of Lake Mead continues to drop, Las Vegas desperately seeks other water sources. Lake Mead supplies 90 percent of the water for the city. At elevation 1075, the planners have the go-ahead to begin construction. At that elevation, Las Vegas has already agreed to reduce its Colorado River diversion by 13,000 af/yr (ROD, 2007).

The pipeline and associated groundwater project threaten Great Basin spring systems. These springs support regional diversity, including 20 species and subspecies listed under the Endangered Species Act (Deacon et. al., 2007). Ranchers are concerned that any drilling and pumping will impact the flow to existing wells and springs used by wildlife, livestock, and crops. The water is underground and unseen, which heightens uncertainty (Berkes, 2008).

The data symbolize more limited awareness than agreement either way. The "Neutral/Unsure" category collected a majority of the respondents in three separate groups. As Nevada presented the smallest respondent group, this is not wholly unexpected.

Statement/Issue: Lining earthen canals threatens water supplies to wetlands in order to satisfy developed water resource obligations.

Earthen canals diverted the river to water users. The seepage emanating from them supported wetlands and wildlife habitats. Their lining promises to leave more water in the system, at the potential expense of the wetlands. Respondents again weighed the trade-offs to determine the value in this form of augmentation.

Table 11 Lining	Strongly Agree	Agree	Neutral/Unsure	Disagree	Strongly Disagree	N
Total Sample	7.1	31.0	20.2	32.1	9.5	84
Managers	7.4	35.2	11.1	31.5	14.8	54
Users	7.4	22.2	37.0	33.3	0.0	27
Agriculture	8.3	29.2	16.7	41.7	4.2	24
Domestic	7.8	27.5	21.6	29.4	13.7	51
Nevada	0.0	30.8	23.1	38.5	7.7	13
Arizona	3.0	27.3	24.2	39.4	6.1	33
California	13.6	22.7	22.7	22.7	18.2	22

Again this statement provoked dissension. No group fell completely for or against its implications. One can question the awareness of the group as a whole of the Southern California issue. Even Californians responded across the board, from strongly agree to strongly disagree, and everything in between. A quick look at the table finds most of the respondents lumped in the middle. One could interpret that as no strong feeling either way.

The All-American Canal delivers Colorado River water to the Imperial and Coachella Valleys. The system includes the Imperial Dam and Desilting Works, the 82-mile All-American Canal, and the 123-mile Coachella Canal. Estimates suggest 70,000 af/yr seep out of the All-American Canal, all from a 23 mile section. The Coachella Canal loses 32,350 af/yr from a 33.2-mile section.

U.S. Public Law 100-675 authorized the lining of the two, but no funding. Agreements with the Metropolitan Water District, the Coachella Valley Water District, the Imperial Irrigation District, and the Palo Verde Irrigation District rectified this situation. The lining aided California in fulfilling the "4.4 plan", its attempt to bring consumption back into line with the 1922 agreement.

Initially, Metropolitan Water District agreed to sponsor the lining of the Coachella Canal at $74 million. The Imperial Irrigation District would finance the All-American Canal, $126 million. Projections for water conservation from the Coachella Canal reached 26,600 af/yr and 67,700 af/yr from the All-American Canal (Keene, 2005).

By 2008, the San Diego County Water Authority agreed to assume financial responsibility for the lining of both canals, in return for the rights to purchase billions of gallons of water from farmers. The agreement with the Imperial Irrigation District provided water for 112,000 households, valid for 110 years. It also provided 11,500 af/yr to 5 San Luis Rey Indian tribes, enough for 23,000 homes (Conaughton, 2006).

Mexican business leaders and California environmentalists filed suit on the agreement. They claimed it threatened wetlands and endangered species, as well as farmlands in Mexico (Conaughton, 2006).

The data fall nearly evenly into the “Agree” and “Disagree” columns with a relatively high number of neutral/unsure responses. The two extremes are underrepresented. The absence of strong feelings corresponds to the complexity of the issue and the lack of a clear winner in any case.

Statement/Issue: Desalination, while expensive, provides water necessary to augment supplies in the region.

Current desalination discussions revolve around the existing Yuma Desalination Plant. While there plans for potential plants in San Diego and in Mexico, they are not yet completed. Yuma offers the possibility of reusing agricultural water to fulfill obligations to Mexico. It is expensive, and requires the reduction of flows to recreated wetlands in Mexico. Respondents chose between augmented supply and economic and environmental impacts.

Table 12 Desalination	Strongly Agree	Agree	Neutral/Unsure	Disagree	Strongly Disagree	N
Total Sample	25.0	57.1	8.3	8.3	1.2	84
Managers	25.9	64.8	3.7	5.6	0.0	54
Users	18.5	44.4	18.5	14.8	3.7	27
Agriculture	25.0	50.0	12.5	12.5	0.0	24
Domestic	25.5	58.8	7.8	5.9	2.0	51
Nevada	15.4	61.5	7.7	15.4	0.0	13
Arizona	24.2	57.6	12.1	6.1	0.0	33
California	36.4	45.5	4.5	9.1	4.5	22

When the combined data from those who agree and strongly agree are presented, we find consensus from the total sample. The same holds true for agricultural and domestic respondents, managers, and respondents from Arizona, California, and Nevada. While User data failed to reach the established benchmark for consensus, they exhibited a high level of agreement.

Salinity in the Colorado River Basin begins in the mountains. Waters there contain a mere 50 parts per million (ppm) of total dissolved solids. Carbonates, chlorides and sulfates of calcium, magnesium, and sodium represent the majority of the salts found in the water. Weathering carries the salts from the rocks, via the waters, all the way to the ocean. Evaporation distills the water along the way, leaving behind the salt. By the time the water reaches Yuma, it averages 740 ppm (Pillsbury, 1981).

The Yuma Desalting Plant resulted from a dispute over water quality between the U.S. and Mexico. The dispute began in 1961, when the Welton-Mohawk Irrigation and Drainage District began draining agricultural wastewater into the Colorado River, below Imperial Dam. Salinity levels in Mexicali, Mexico, spiked to nearly 2000 ppm. When

Mexico protested, American officials pointed to the 1944 treaty, which made no provision for the quality of the water delivered.

By 1974, a new agreement had been signed, guaranteeing the same quality of water to Mexico as was delivered to farmers in the Imperial Valley. In the agreement, a desalting plant at Yuma was authorized to treat Welton-Mohawk for delivery. The Yuma plant was not completed until 1992, a relatively wet period on the Colorado. It functioned for nine months and was shut down due to design flaws. The Welton-Mohawk water was diverted to the Cienega de Santa Clara, where it helped reestablish wetlands along the Gulf of California in Mexico (Nathanson, 1978).

In 2007, the plant reopened for a 90-day, low-power test run. The test sought to evaluate the functioning of the plant, as well as to monitor effects on the Cienega de Santa Clara (USWN, 2007). Updating the structure required $30 million, not including the $24 to $30 million annually needed to maintain it. Engineers projected a return of 25 billion gallons per year of desalted water, 0.6 percent of the flow of the Colorado, at a cost of $311 per acre-foot. This equals about 30 times the cost of water to Yuma area farmers. Alternatives, such as leasing water or paying farmers to fallow land, would cost $54 million a year, and water banking around $40 million a year (McKinnon, 2003).

Cost and environmental impact probably account for any lack of agreement on this subject. Water managers and users in agricultural sectors demonstrate strong support of these programs. If Yuma succeeds in supplying water without impacting the environment in a way that attracts a great deal of attention, one may see similar projects initiated on the coast.

Statement/Issue: The Drop 2 reservoir will increase available water for users at the expense of the Delta's ecological balance.

Unclaimed deliveries flowing into Mexico often fed the Colorado River Delta. They supported endangered species and local fisherman. For a water accountant, they appeared on the ledger as a loss. Respondents to this statement balance system efficiency with environmental awareness.

Table 13 Drop 2	Strongly Agree	Agree	Neutral/Unsure	Disagree	Strongly Disagree	N
Total Sample	4.9	14.6	28.0	36.6	15.9	82
Managers	1.9	18.9	18.9	41.5	18.9	53
Users	11.5	7.7	50.0	26.9	3.8	26
Agriculture	8.7	21.7	21.7	30.4	17.4	23
Domestic	2.0	12.0	34.0	40.0	12.0	50
Nevada	0.0	8.3	33.3	41.7	16.7	12
Arizona	3.0	15.2	21.2	45.5	15.2	33
California	9.1	9.1	31.8	36.4	13.6	22

The respondents exhibited dissent here. Potential impediments to consensus might be lack of program awareness, or of possible impacts. One might expect water managers to be more unified here; as three separate water districts fund it. Californians might also be more supportive of the project, considering their water woes.

Reservoir storage is needed here to catch over-deliveries. Often, agricultural districts will request water in the area, only to receive rain soon after. The water is no longer needed; there is no place to store it once it has been released from Hoover, Davis, or Parker dams; and it flows into Mexico. As Mexico has not requested the water, it is not counted toward their allotment and essentially goes unaccounted for.

The project envisions two 4,000 af capacity storage cells, a diversion structure from the All-American Canal, a 6.5-mile inlet canal to carry diverted water to the reservoir, and a .25-mile long canal/siphon system to carry water back to the canal. It will cost an estimated $172 million, largely paid for by the Southern Nevada Water Authority, with contributions from the Central Arizona Water Conservation District and the Metropolitan Water District. Southern Nevada Water Authority stands to receive up to 400,000 af, as much as 40,000 af/yr until 2036. CAWCD and MWD will see a possible 100,000 af, a maximum of 65,000 af/yr until 2036 (Vandevelde and Palumbo, 2010).

There are challenges to the project. Michael Cohen (2011) of the Pacific Institute presented a number of them in a letter to Lorri Gray, the Lower Colorado Regional Director of the Bureau of Reclamation. He asked some very poignant questions. The water conserved through the construction of the reservoir is treated as an Intentionally Created Surplus. However, the three sponsoring districts may begin withdrawing water immediately, before it is even conserved.

The initial report on the efficiency of the project is not due until the end of 2017. Would the Bureau of Reclamation have the authority to diminish or stop deliveries in the meantime? If the project was less efficient than projected, and the parties concerned refused to make changes, what options would the Bureau have?

The reservoir is predicted to conserve 70,000 af/yr. MWD and CAWCD project 40,000 af/yr. In view of recent droughts and current flow data, these estimates are optimistic. Would the parties be charged overruns in the event of diminishing efficiency? Would the system absorb the overruns?

Initial costs of the project were estimated at $80 million, increased to $146 million by 2007, and most recently to $172 million in 2008. SNWA is responsible for everything up to $206 million. If that figure is exceeded, who will pay (Cohen, 2011)?

The data lean toward disagreement with the statement, though larger than normal percentages fall within the "Neutral/Unsure" column. Does this represent unfamiliarity with the project, or growing awareness of environmental impact? Perhaps, stakeholders are yet unconvinced that the benefits outweigh the costs.

Statement/Issue: Cloud seeding and iceberg flotation, as well as other innovative measures must enter the discussion as future water sources for a thirsty region.

The search for any and all sources of water in the region leads water managers to explore areas viewed by many as science fiction. Others argue that cloud seeding could potentially add as much as 10 percent of average annual flow to existing supplies. Respondents determine whether they support programs that lack scientific evidence to combat future shortages.

Table 14 Cloud Seeding	Strongly Agree	Agree	Neutral/Unsure	Disagree	Strongly Disagree	N
Total Sample	11.0	41.5	22.0	22.0	3.7	82
Managers	15.1	43.4	20.8	20.8	0.0	53
Users	3.8	38.5	23.1	23.1	11.5	26
Agriculture	13.6	45.5	22.7	18.2	0.0	22
Domestic	9.8	39.2	23.5	21.6	5.9	51
Nevada	0.0	69.2	23.1	7.7	0.0	13
Arizona	18.2	39.4	24.2	18.2	0.0	33
California	4.8	28.6	23.8	33.3	9.5	21

Although the data, when strictly interpreted, indicate dissensus, there is one interesting anomaly. 69 percent of Nevadans responding agreed with the statement. None strongly agreed, but 23 percent chose neutral/unsure as their response. Only about 8 percent disagreed and no one in that group strongly disagreed.

As the situation grows more extreme, and shortages become imminent, solutions that might otherwise be discounted become part of the discussion. There were no iceberg flotation programs found in the literature, so this section will focus on cloud seeding. Among practitioners, it is generally referred to as weather modification and dates back to the late 1940s.

Secretary of the Interior Gale Norton announced in 2005, about five years into the current drought, that the Colorado River Basin would be exploring new management techniques to address potential shortages. The Upper Colorado River Commission asked the North American Weather Consultants, Inc. to prepare a "white paper" on the potential for weather modification as a means of augmenting supplies in the Colorado River Basin (Griffith and Solak, 2006).

The paper reported that precipitation in mountainous areas could be increased by 10 percent, though proof in the strict scientific sense is elusive. The consultants focused on new or existing, winter programs in Arizona, Colorado, Utah, and Wyoming. They predicted increases in new programs of 650,500 af of annual runoff, 576,504 af from augmented existing programs, for a total of 1,227,004 af. There would be variance between wet and dry years. An additional 154,000 could be produced in the Lower Colorado Basin portions of Arizona, bringing the total to 1,381,004 af. The cost of these new and augmented existing programs would be $6,965,000, or $5 per acre-foot (Griffith and Solak, 2006).

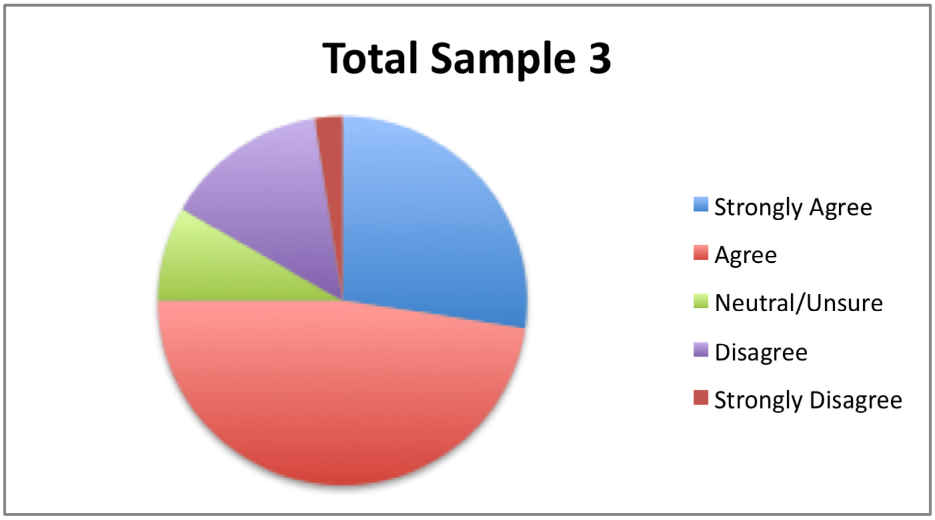
Professors Alpert, Levlin, and Halfon of the Tel Aviv University Department of Geophysics and Planetary Sciences deny the effects of weather modification. Reviewing 50 years of data comparing periods of seeding and non-seeding, as well as areas of seeding and non-seeding, they found that increases were attributable to changes in weather patterns. In one six year period, they identified a specific type of cyclones in mountainous areas that increases precipitation. The same increases were found in a non-seeded mountainous area nearby. They did, however, identify one probable place where cloud seeding could be successful. Orographic clouds that develop over mountains and have a short life span could accelerate the formation of precipitation through weather modification (Science Daily, 2010).

The general discord in the data is not as negative as the reactions found in the literature. Cloud seeding fails to earn the respect of scientists for reliability and results. There are proponents of the process, but they are few.

Conservation

Accepting the fact that 75 percent of water used in flood irrigation never reaches the plant, and that 40 percent of the water used in our homes is flushed down the toilet, conservation suggests a natural solution to potential water shortages. Water reclamation in urban areas and drip irrigation for farmers afford opportunities to reuse, or use less. Water Banking furnishes an additional method to store water in wet years. Intentionally Created Surpluses grant long-awaited incentives for conserved water. Financial incentives to homeowners for conservation landscaping and technology motivate resistant consumers.

Statement/Issue: Conservation has not been fully exploited as a means of extending the life of current water supplies.



The Southern Nevada Water Authority experienced explosive population growth and flattened demand, pointing to the potential for conservation methods and policy in the region. The question respondents were asked was whether these methods have been utilized to a point where they are reaching diminishing returns.

Table 15 Conservation	Strongly Agree	Agree	Neutral/Unsure	Disagree	Strongly Disagree	N
Total Sample	27.4	47.6	8.3	14.3	2.4	84
Managers	20.4	51.9	9.3	14.8	0.0	54
Users	40.7	37.0	7.4	14.8	0.0	27
Agriculture	33.3	54.2	4.2	8.3	0.0	24
Domestic	27.5	43.1	9.8	17.6	2.0	51
Nevada	23.1	46.2	15.4	15.4	0.0	13
Arizona	21.2	54.5	15.2	9.1	0.0	33
California	36.4	31.8	0.0	31.8	0.0	22

Data find consensus among the Arizonans, users, agriculture and the total sample. While the other groups' data do not reach the 75 percent threshold, they are all within 5 to 10 percent of that mark. When asked about conservation measures, water managers in the region describe the programs in place and then explain the limits of conservation in the face of tightening supplies on the Colorado River. These results suggest that the rank and file see more potential in this sector than is currently exploited.

Efforts at water reclamation date back decades and support agricultural and outdoor landscaping uses. In some areas, detailed below, they have been expanded to support potable water uses. Farmers implement efficient irrigation systems with financial support of urban water districts and fear of future shortages. States and local water agencies bank water in underground aquifers as a hedge against climate change and drought.

The Intentionally Created Surplus, a product of the 2007 Interim Shortage Agreement, offers incentives to water districts to conserve water and have it available in the future. Finally, local water agencies provide financial incentives to residents willing to install water-saving technology, or alter landscapes to conserve.

There remain large areas refusing to accept the limitations of the resource and to convert dated systems to more environmentally friendly, and more specifically, water-friendly utilization.

The data support the belief of stakeholders in wider efforts at conservation. Water managers, whether due to obstacles such as cost or implementation, failed to demonstrate agreement, though they were within 5 percent. In fact, all groups indicated a high level of agreement with the assertion.

Statement/Issue: Water Reclamation will reduce the pressures on current water supplies.

As mentioned earlier, water use in the home is often inefficient. The potential for this water to be recycled and reused presents another opportunity for conservation. Respondents decided whether or not this technology would conserve enough water to stretch current supplies.

Table 16 Reclamation	Strongly Agree	Agree	Neutral/ Unsure	Disagree	Strongly Disagree	N
Total Sample	20.7	59.8	12.2	7.3	0.0	82
Managers	15.1	66.0	9.4	9.4	0.0	53
Users	30.8	46.2	19.2	3.8	0.0	26
Agriculture	31.8	54.5	13.6	0.0	0.0	22
Domestic	13.7	62.7	13.7	9.8	0.0	51
Nevada	30.8	38.5	15.4	15.4	0.0	13
Arizona	18.2	57.6	21.2	3.0	0.0	33
California	19.0	66.7	4.8	9.5	0.0	21

Every group but the Nevadans demonstrated consensus in their responses to this statement. Nearly 70 percent of Nevadans agreed or strongly agreed with the statement. While they accept reclamation in the survey and practice it occasionally in agriculture and outdoor landscaping, the idea of drinking reclaimed water still offends many.

Opponents refer to Indirect Potable Reuse (IPR) as “toilet to tap.” Los Angeles shut down a $55 million dollar program due to protests. That program projected enough water for 12,000 homes. San Diego faces similar resistance to IPR. The area imports 90 percent of its water, much of that from the dwindling Colorado River. The bulk of the rest originates in the San Joaquin Delta, under stress due to environmental impacts.

Three million people now reside in a region with enough water for about 10 percent of them. Construction began in 2009 on a desalination plant that would provide 50 million gallons/day at a cost of $800 to $2,000/acre-foot. Recycled water costs $525/acre-foot. Desalination uses more energy, kills marine organisms, and produces a brine by-product laced with chemicals that flow back into the ocean (Zimmerman, 2008)

Experts worry that pathogens escape treatment processes. Recent analysis of San Diego water treated traditionally found traces of ibuprofen; the bug repellent, DEET; and the anti-anxiety drug, meprobamate (Zimmerman, 2008). Supertreated wastewater is clean enough to drink immediately, which has been done in Namibia for years. Its quality is often better than existing drinking water, and quality may even decline when it is passed through the environment. Cities such as El Paso, TX (40%) and Fairfax, VA (5%) already incorporate IPR into their water sources.

Sewage water from Costa Mesa, Fullerton, and Newport Beach now passes through $490 million worth of pipes, filters, and tanks for purification, to lakes near Anaheim, where it seeps through clay, sand, and rock into aquifers in the groundwater basin. Months later, the water flows back into the homes of more than 500,000 Orange County residents (Zimmerman, 2008). This describes the world's largest wastewater purification system for Indirect Potable Reuse (IPR).

The 3-step process moves from microfiltration to reverse osmosis and finally through ultra-violet light with hydrogen peroxide. Operating since January 2008, it produces 70 million gallons per day of freshwater used for more than just the kitchen faucet. The water replenishes groundwater basins, creating a seawater intrusion barrier. It decreases dependency on the San Joaquin Delta and the Colorado River. It is drought resistant and protects the environment by reusing the resource. Equally, the system reduces wastewater dumped into the Pacific Ocean and uses half the energy required to transport water from Northern and Southern California, one-third the energy needed for desalination. The program diversifies water supplies, limits the impacts of natural disasters, climate change, and drought, and is designed to be expanded (Markus et. al., 2011).

This statement evoked overwhelming agreement in every group but one. Nevadans failed to demonstrate consensus, but were within 5 percent of the bar. The technology often meets opposition initially. Considering the alternative may be doing without water, it gains support.

Statement/Issue: Improved irrigation techniques (for example, drip irrigation) are cost-prohibitive and will not drastically reduce the use of water in agricultural areas.

The amount of water lost to evaporation in agriculture is staggering. It is even more so when done at a time of drought. The resistance traditionally derives from the initial costs involved in installation, and their relation to the costs of subsidized water. As stakeholders realize the tightening supply and increased demand, efficiency rises in importance. Respondents decide whether they can afford to invest in improved irrigation, or live without the water lost to evaporation.

Table 17 Irrigation	Strongly Agree	Agree	Neutral/Unsure	Disagree	Strongly Disagree	N
Total Sample	2.4	13.3	12.0	53.0	19.3	83
Managers	1.9	7.5	9.4	58.5	22.6	53
Users	3.7	25.9	18.5	37.0	14.8	27
Agriculture	4.2	25.0	4.2	50.0	16.7	24
Domestic	2.0	8.0	16.0	54.0	20.0	50
Nevada	0.0	0.0	8.3	75.0	16.7	12
Arizona	3.0	15.2	18.2	57.6	6.1	33
California	4.5	9.1	9.1	40.9	36.4	22

Data from California, Nevada, and Managers, indicate consensus here. All groups except users approach unity in disagreement with the statement. The fact that over 66 percent of those from the agricultural sector disagree with the statement argues that those labeled as users are generally not from this sector and are unaware of the underlying issues.

Agriculture is the largest user of Colorado River water, and the largest contributor to the salinity problem, accounting for 37 percent of river salinity. The use of recycled water for irrigation, crop shifting, and a shift from flood irrigation to drip irrigation offer the potential to dramatically reduce both water usage and salinity in the near future. The phased move to drip irrigation over the next twenty years could be accomplished as a cost-sharing venture between farmers and the federal government. Long-term benefits from increased production and profits outweigh the minimal short-term financial impacts (MIT, 2011).

Crop shifting refers to the cultivation of less water intensive, but highly profitable fruits and vegetables, saving 362,000 af/year. Drip irrigation could save 445,004 af/year in Arizona. Additionally, consumptive water losses realize a reduction from 30 percent currently to 5 percent. The combination of the two strategies reduces water consumption by 807,000 af/year. The Lower Basin could potentially reduce consumption by 2 million af/year, reduce salinity, and release more water for environmental needs (MIT, 2011)

The Imperial Valley irrigates 500,000 acres, 80 percent of which grows field crops. Alfalfa uses 35 percent of the total water used by crops in the valley (Bali, 2011). The Imperial Irrigation District (IID), owner of the rights to 3.25 million af/yr of Colorado River water, has made attempts to conserve. Over the last few decades, farmers in the district have lined canals and farm ditches, installed tile drains, leveled farmland, implemented canal seepage recovery programs, built regulating reservoirs, built interceptor canals, and undertaken many non-structural measures to achieve the high level of conveyance and distribution efficiencies. Some of the water conserved is now being transferred. Agreements with the San Diego County Water Authority deliver 200,000 af/year of IID water there, and another 103,000 af/year to the Coachella Valley Water District and Metropolitan Water District in return for billions of dollars in payments.

Consensus in the data, or near consensus in some cases, corresponds to the literature. Room for improvements in agricultural water management furnish enormous potential for water savings. Stakeholders are generally aware of this and support the changes.

Statement/Issue: Water banking is an acceptable method of water storage for use in exceptionally dry periods.

The existence of underground aquifers in the region offers room to store water in wet years for future use. The additional benefits of filtration and diminished evaporation enhance arguments for this type of storage. The question posed to respondents addresses the ability of water to be stored across state lines and, in essence, transferred or exchanged for water rights elsewhere.

Table 18 Banking	Strongly Agree	Agree	Neutral/Unsure	Disagree	Strongly Disagree	N
Total Sample	32.1	52.4	8.3	4.8	2.4	84
Managers	37.0	51.9	3.7	3.7	3.7	54
Users	22.2	51.9	18.5	7.4	0.0	27
Agriculture	41.7	41.7	12.5	4.2	0.0	24
Domestic	29.4	54.9	7.8	3.9	3.9	51
Nevada	38.5	46.2	7.7	0.0	7.7	13
Arizona	36.4	51.5	9.1	3.0	0.0	33
California	36.4	50.0	9.1	4.5	0.0	22

Every group except the Users demonstrated consensus in the data. Even 74.1 percent of users agreed with the statement. The existence of numerous "water banks" and systems for their exploitation creates a high level of awareness. Water banks seemingly present no threat to the environment; another fact that garners support. Lastly, no individual appears to feel the immediate pain of water conserved for banking.

Southern Nevada Water Authority maintains three separate water "banks." Underneath the city of Las Vegas lies an aquifer. SNWA pumps treated Colorado River water, through wells, into that aquifer. Over the past several years, 320,000 af have been stored as artificial recharge in that basin for use in exceptionally dry periods. An additional 9,303 af of permanent recharge are stored in the same basin to support well users, maintain stable water levels, and reduce the likelihood of subsidence (SNWA, 2011).

SNWA maintains a water bank in California through an agreement signed with the Metropolitan Water District. Under the terms, Nevada can recover up to 30,000 af/year with six months of notice given to MWD. Currently, 20,000 af of Nevada water is “banked” here (SNWA, 2011).

Finally, SNWA negotiated an agreement with the State of Arizona to bank water in underground aquifers in Arizona. SNWA stores as much as 1.25 million af, of which 20,000 af was available in 2007 and 2008, respectively; 30,000 af each year for 2009 and 2010, and after that 40,000 af per year until the bank is exhausted. For that privilege, SNWA paid the State of Arizona $100 million in 2005, and began paying $23 million/year each year for the next ten years. To withdraw, SNWA simply pumps water out of Lake Mead, and Arizona pumps the equivalent amount out of the aquifers (SNWA, 2011).

The Arizona Water Banking Authority was established in 1996. The state realized that the Central Arizona Project maintained some of the most junior rights on the Colorado River and, as such, was vulnerable to curtailment. Additionally, the state had yet to develop all of its water rights on the river and feared they might be reallocated unless they were somehow put to use. They chose instead to drain the water through the CAP onto areas where it would drain down into natural aquifers for future withdrawal.

Soon after, Nevada sought to "bank" water in Arizona aquifers. Arizona resisted, but awareness of diminishing water supplies on the river, combined with a lack of financial means to "bank" their own water, pressured the state into accepting the deal. Nevada pays the CAP to deliver, store, and recover water for CAP customers.

Essentially, all groups exhibited overwhelming agreement with water banking as a policy. Users fell less than one percent short of the 75 percent benchmark. Water banking already occurs in all three Lower Basin states and is pointed to in the literature as a means of water marketing that can help to address shortage issues.

Statement/Issue: Intentionally Created Surplus does not provide enough incentives for water users to conserve water.

Intentionally Created Surplus refers to a program created within the Interim Shortage Agreement of 2007. The program offers water credits to current users who engineer tributary conservation, water imported from sources other than the Colorado River, system efficiency improvements, and projects that establish extraordinary conservation. Respondents must decide whether the program's incentives instill adequate motivation for increased conservation.

Table 19 ICS	Strongly Agree	Agree	Neutral/Unsure	Disagree	Strongly Disagree	N
Total Sample	4.8	26.2	33.3	32.1	3.6	84
Managers	1.9	25.9	33.3	35.2	3.7	54
Users	11.1	25.9	29.6	29.6	3.7	27
Agriculture	4.2	45.8	20.8	25.0	4.2	24
Domestic	3.9	19.5	37.3	35.3	3.9	51
Nevada	0.0	15.4	53.8	30.8	0.0	13
Arizona	3.0	30.3	24.2	39.4	3.0	33
California	13.6	13.6	27.3	40.9	4.5	22

The data exhibit discord here. In fact, neutral/unsure received an unusually large number of responses in each group, often eliminating the chance for consensus. The most likely explanation for this is the lack of public awareness of the program.

Intentionally Created Surpluses arose from the Interim Shortage Agreement of 2007. ICS's divide into four categories. Tributary Conservation allows for the transfer of pre-1922 rights along Colorado River tributaries into the Colorado River for credits. SNWA's rights on the Virgin and Muddy rivers fit this category.

Imported ICS's allow Colorado River contract holders to convey non-Colorado River water to the Colorado River for credit. The pipeline planned by SNWA will utilize this category to augment the system.

System efficiency surpluses enable a user to fund a system efficiency project that would conserve Colorado River water. The project must increase the amount of water available in the U.S. and a portion of the conserved water would be credited to the user. The Drop 2 reservoir, funded by the SNWA, fulfills these requirements.

Extraordinary Conservation permits a water user to implement a project, such as land fallowing or canal lining, to conserve water through extraordinary measures, which would increase Lake Mead levels (SNWA, 2011).

MWD planned with the Bureau of Reclamation to leave 50,000 af of water in Lake Mead in 2006, and an additional 200,000 af in 2007. The water resulted from an existing land management, crop rotation, and water supply program with the Palo Verde Irrigation District and met the definition of extraordinary conservation (ROD, 2007).

A consortium of environmental groups recommended the expansion of the program in 2007 (Gillon et. al., 2007). They argued that with the river over-allocated, the best way to accommodate new and existing municipal and industrial uses is to reallocate the water. The ICS program provided the tool. Within the agreement, water could be transferred between a seller/lessor and a buyer, could be stored over time in Lake Mead, and could be delivered upon request.

Basin states, however, hoped to limit this option to current contract holders. The consortium pushed for the inclusion of federal agencies, state agencies, private entities, nongovernmental organizations, Mexican federal agencies, and Mexican water users and nongovernmental organizations. The group pointed out the potential benefits. More water remains in storage decreasing the probability of shortages and increasing hydropower generation. New opportunities arise to create and improve Colorado River riparian habitats.

Mexico gains the ability to improve Colorado River management, with the opportunity to store water in Lake Mead. Also, the U.S. enters negotiations with Mexico over Colorado River shortages with something to discuss beyond unilateral imposition of shortage guidelines.

The inability to locate agreement in the data may indicate program deficiencies. Conservation efforts require awareness and support to be beneficial. If only a few groups are availing themselves of the benefits of conservation, how much more water could be saved through greater program awareness and participation?

Statement/Issue: There need to be more and greater financial incentives throughout the region, similar to those utilized by the Southern Nevada Water Authority to encourage desert landscaping.

Colorado River water is free. Consumers pay delivery costs only. The esoteric benefits of a more sustainable lifestyle may inspire a few, they will not likely motivate the majority. Financial incentives appeal to nearly everyone. Every water use inherently contains opportunities for conservation that can be fiscally driven. Will financial incentives increase conservation in the basin? Respondents weighed in.

Table 20 Incentives	Strongly Agree	Agree	Neutral/Unsure	Disagree	Strongly Disagree	N
Total Sample	15.7	57.8	10.8	13.3	2.4	83
Managers	7.5	71.7	1.9	15.1	3.8	53
Users	33.3	37.0	18.5	11.1	0.0	27
Agriculture	20.8	70.8	4.2	4.2	0.0	24
Domestic	14.0	50.0	12.0	20.0	4.0	50
Nevada	15.4	84.6	0.0	0.0	0.0	13
Arizona	9.1	60.6	12.1	15.2	3.0	33
California	28.6	42.9	4.8	23.8	0.0	21

Managers, Agriculturalists, and Nevadans demonstrated consensus in favor of financial incentives. There was greater opposition to them in other groups. Whether that was due to funding issues, or a lack of familiarity with them, is unknown. Assumably, one might argue that point, as the three groups that indicated consensus would all have experience with financial incentives.

SNWA offers a number of incentives to promote water conservation in the valley. These programs flattened demand, while population grew exponentially. The Water

Smart Landscapes Rebate offer $1.50/sq.ft. for turf removed, up to 5,000 sq.ft. per property per year. Beyond 5,000 square feet, the rebate decreases to $1.00/sq.ft., with a maximum payout of $300,000 per property.

Rain sensor Instant Rebate Coupons encourage irrigation systems that shut down during and after rain with a payment of $25 or 50 percent of the cost, whichever is less. The systems can save as much as 500 gallons in one day.

Pool covers conceivably conserve from 10,000 to 15,000 gallons/year by reducing evaporation. The rebate offered is $50 or 50 percent off the purchase price, or $200 or 50 percent off of a permanent pool cover.

Smart irrigation controllers automatically adjust watering schedules, and are reimbursed at $200 or 50 percent off of the purchase price (SNWA, 2011).

San Diego offers $65 incentives for the smart irrigation controllers, and claims to have saved 182 million gallons in the first year of the program, and 2 billion gallons over the next 5 years (Residential Programs, 2011).

Prescott is much more aggressive. The city offers incentives for irrigation conversion, certified irrigation audits, rainwater catchment, turf grass removal, rotator sprinkler head technology, leak repair, low-flow or HET toilets, low-flow shower heads or water smart retrofit devices, and commercial 0.8 gallon/flush or waterless urinals. Thus far, the city has conserved 236 af, or 30,614,258 gallons, at a cost of $356,604 (City of Prescott, 2011).

Though only three groups, Managers, Agriculturalists, and Nevadans, displayed consensus in the data, the majority of responses appeared on the agree side of the table.

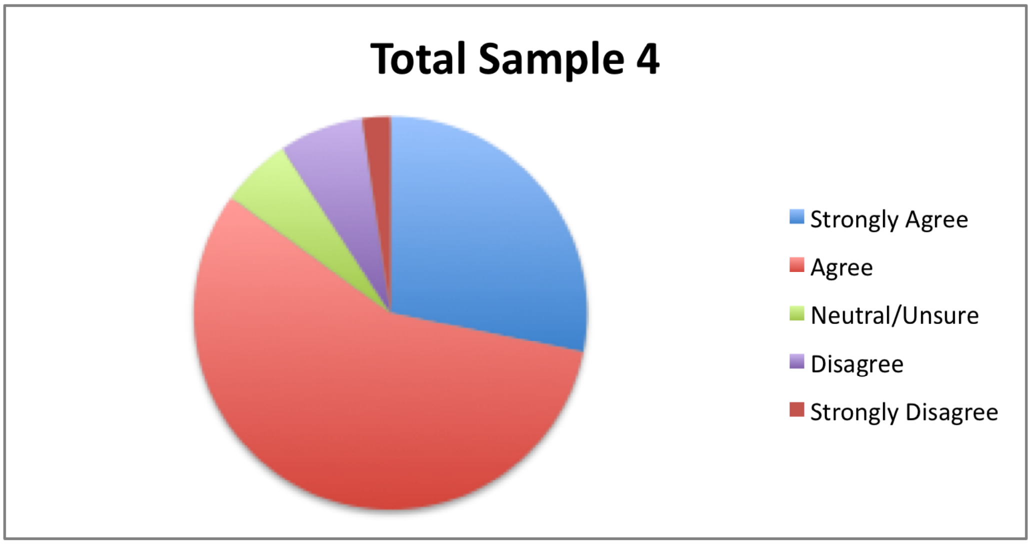
Existing programs in both urban and agricultural areas attest to the success of financial incentives. Managers question the limitations of conservation, perhaps out of self-interest, but continue to implement new methods to encourage water savings. The literature cited affirms these assumptions.

Environmental Protection

Allocations apply to nearly every group in the basin with the notable exception of the environment. Water management decisions require an environmental impact statement, but no explicit amount of water flows to the flora and fauna of the basin without being claimed by some other entity. As quantities diminish and demands increase, surplus waters that until now have fed the environmental needs vanish. Efforts to protect these interests vie with established stakeholders for the rights to Colorado River water.

Invasive species thrive under current water management strategies and impact water quantity, quality, and native species. Reduced supplies concentrates already high levels of salts in the water, damaging crops and infrastructure. Wetlands, the beneficiaries of past surpluses, choke on diminished supplies and higher salinity. Invasive species and water management decisions threaten already endangered species. Attempts to recreate flood regimes, though well intentioned, fail to achieve desired results. These issues provide a sampling of the variety of environmental issues created by water management decisions and exacerbated by drought and consumption.

Statement/Issue: Environmental Concerns will play an even greater role in future water resource management decisions.



As environmental awareness increases, so does the appreciation for the impacts of water management decisions on daily life. This appreciation inspires greater participation in the political sphere to ensure one's interests are served. Heightened awareness of and appreciation for environmental protection require greater transparency in decision making in the Lower Colorado River Basin. Will decision makers be responsive and incorporate environmental concerns into future agreements? Respondents answered this question.

Table 21 Environment	Strongly Agree	Agree	Neutral/Unsure	Disagree	Strongly Disagree	N
Total Sample	25.3	59.0	6.0	7.2	2.4	83
Managers	22.2	59.3	7.4	7.4	3.7	54
Users	34.6	57.7	0.0	7.7	0.0	26
Agriculture	20.8	70.8	4.2	4.2	0.0	24
Domestic	14.0	50.0	12.0	20.0	4.0	50
Nevada	15.4	84.6	0.0	0.0	0.0	13
Arizona	9.1	60.6	12.1	15.2	3.0	33
California	28.6	42.9	4.8	23.8	0.0	21

Consensus described the Total Sample, Managers, Users, Agriculturalists, and Nevadans for this statement. Considering that any new program must endure the process of an environmental impact statement, this is not surprising. The recent Surplus and Shortage agreements attest to this and surely left an indelible image on the minds of the participants and observers. The most surprising number in the table is the number of Californians (23.8%) disagreeing with the statement. In a state that is as progressive as any on environmental issues, one would expect more agreement with the statement, regardless of one's support or opposition to the movement. It is important to revisit the history of environmental protection to answer this question.

The National Environmental Protection Act of 1969, followed soon after by the Endangered Species Act of 1973 changed the stakes in water resource management. Programs required environmental impact statements and protection of species prior to authorization and funding. Existing structures faced increased scrutiny and pressure to conform to the new legislation.

Invasive species such as the quagga mussel and the tamarisk threaten native fauna and flora and receive the attention and funds of numerous federal, state, and nongovernmental agencies. Salinity, a basin issue highlighted as early as 1961 in an international dispute with Mexico, remains a constant battle in the region. Wetlands continue to fight for existence and the water necessary to maintain them. Numerous endangered species survive on a day-to-day basis under threat from water management decisions, invasive species and altered flows of the river. Recreated flow regimes succeed only marginally.

These are only a sampling of the environmental issues facing the Lower Colorado River Basin. They paint a picture of man at war with the environment rather than in peaceful coexistence. Conflict resolutions vary depending on political will and the presence of funding. More importantly, they wait for the same thing everyone else does, more water.

The data attest to consensus among most groups and near consensus among the others. Even the surprising number of objectors in California falls short of negating the nearly overwhelming agreement with the statement. The fact that more than 90 percent of the agricultural group agreed with the declaration is a statement in itself. Traditionally a group at odds with environmentalists, the farmers and ranchers are admitting to the established presence of an environmental interest group.

Statement/Issue: Efforts to control invasive species such as the quagga mussel, and the tamarisk have been successful.

As early as 1997, researchers believe the quagga mussel had invaded Lake Mead. The tamarisk dates back much further than that. The two represent a changing ecology that threatens native species, water quality, and infrastructure. Millions of dollars are spent each year to control invasive species. Respondents decided how successful these attempts had been.

Table 22 Species	Strongly Agree	Agree	Neutral/Unsure	Disagree	Strongly Disagree	N
Total Sample	0.0	8.3	38.1	41.7	11.9	84
Managers	0.0	11.1	25.9	51.9	11.1	54
Users	0.0	3.7	59.3	25.9	11.1	27
Agriculture	0.0	4.2	33.3	54.2	8.3	24
Domestic	0.0	11.8	41.2	35.3	11.8	51
Nevada	0.0	7.7	23.1	69.2	0.0	13
Arizona	0.0	9.1	45.5	36.4	9.1	33
California	0.0	9.1	36.4	40.9	13.6	22

Data find dissensus in the pertinent responses. If anything, they lean toward disagreement with a large group in the neutral/unsure category. While these issues have received a fair amount of publicity, they fall in the shadows of the crisis over quantity of water available.

Riparian lands are vital to western ecosystems. They maintain water quality and quantity, provide groundwater recharge, control erosion, and dissipate stream energy during floods (Birken and Cooper, 2006). Anthropogenic activities and invasive plant species have reduced water quality, altered river regimes, and impacted ecosystems and habitats (Di Tomaso, 1998).

The quagga mussels are a recent arrival in the system. Small, freshwater bivalve mollusks, they grow to 1.6 inches and are related to the zebra mussels. Native to the Dneiper River in Ukraine, scientists first identified them in the U.S. in Lake Erie in 1989. Recreational boats carried them to Lake Mead. Their ability to attach to hard surfaces and survive for long periods out of water aids their dispersal. They are filter feeders, eating phytoplankton. Predators include some fish and diving ducks. These cannot control populations of mussels in high densities. Chemical toxicants used to eradicate them would impact other species, and mechanical and chemical controls can be used only in limited areas. Biological controls are ineffective. Quaggas alter the food chain. They remove phytoplankton, increasing water clarity. This enables aquatic plants to proliferate, thereby impacting the ecosystem. The mussels block water intakes, affecting municipal water supplies, agricultural irrigation, and power plant operation. They cost the power industry $3.1 billion from 1993 to 1999, and the overall economy $5 billion for the same time period (NDOW, 2011).

Scientists from the University of Nevada, Las Vegas, the National Park Service, the Bureau of Reclamation and many others currently monitor to determine what limits the reproduction of the species and how to contain it. Their impact on water quality, a matter of concern, is as yet undetermined (UNLV, 2011). While there has been no difference in water quality yet, by 2012 scientists expect that to change by 2012 (Tavares, 2009).

Quaggas absorb toxins and heavy metals such as mercury, selenium, polychlorinated biphenyls (PCBs), and polycyclic aromatic hydrocarbons (PAHs) in a process known as bioaccumulation. They later expel these chemicals and metals in the form of highly concentrated pellets, which drop to the bottom of the water. Bottom feeders eat the pellets, predators consume the bottom feeders, and when in turn humans eat the predators we call it biomagnification (Tavares, 2009).

Quaggas also eat algae, however, only certain types, not cyanobacteria. Cyanobacteria are the algae often responsible for “blooms” or excessive algae growth.

Quaggas lower the nitrogen to phosphorous ratio, further promoting cyanobacteria growth (Tavares, 2009).

A total of 54 species of Tamarisk, or Salt Cedar, are native to North Africa, the Mediterranean, and the Middle East. First imported to the U.S. as ornamentals and erosion control, they quickly spread into natural wetlands. The tree displaces native cottonwoods, willow, and mesquite and has thus far overrun more than one million acres of wetlands. Adapted to arid climates, it thrives in very saline and nutrient poor soil. Tamarisk out-compete native plants for water, increase the salinity of soil, and are extremely difficult to eradicate (GCNP, 2011). The tree also increases wildfire frequency. Scientists from the U.S. Department of Agriculture, Agricultural Research Service are developing a biologically based, integrated weed management program for the salt cedar. Classical biological control using host-specific natural enemies and re-vegetation with desirable plants, herbicides and cultural controls, combined with a leaf-eating beetle show some signs of success in combating the Tamarisk.

The absence of unity and the large number of neutral/unsure responses point to deficiencies in stakeholder awareness. The fact that the responses lean toward disagreement does place them in a direction that corresponds with the literature on this issue.

Statement/Issue: Salinity, already a basin wide problem, will only be exacerbated by future droughts and water scarcity.

Evaporation and agricultural use contribute to high salinity rates in the Colorado River water. Greater quantities help to dilute the water and control salt content.

Diminishing quantities leave behind the original salt content minus the diluting power of water.

Table 23 Salinity	Strongly Agree	Agree	Neutral/Unsure	Disagree	Strongly Disagree	N
Total Sample	22.9	50.6	16.9	8.4	1.2	83
Managers	22.6	49.1	17.0	9.4	1.9	53
Users	25.9	48.1	18.5	7.4	0.0	27
Agriculture	17.4	52.2	21.7	8.7	0.0	23
Domestic	27.5	45.1	17.6	7.8	2.0	51
Nevada	15.4	69.2	7.7	7.7	0.0	13
Arizona	12.1	60.6	21.2	6.1	0.0	33
California	52.4	23.8	14.3	9.5	0.0	21

Californians and Nevadans agreed with this statement to the point of consensus. All other groups were within 5 to 10 percentage points of consensus in agreement. The ubiquitous presence of water softeners and the efforts in agricultural sectors to confront salt accumulations and impacts on crop production raise the awareness of stakeholders to the issue.

Negotiations over salinity with Mexico led to a treaty in 1974. The Clean Water Act of 1972 inspired the creation of the Colorado River Basin Salinity Control Program. Salinity impacts the lives of all water users in the Lower Colorado River Basin.

Knowing that agriculture consumes 80 percent of Colorado River water, it is only logical to start there. Pillsbury (1981) reminds us that ancient civilizations often developed by diverting rivers and irrigating lands for agriculture. These civilizations collapsed due to salinity and the inability of the soil to support crops. There is one notable exception to this rule, which is the Nile. Crops here are not irrigated, in the strict sense. Annual flooding replenishes both water and soil. The water prevents salts from accumulating, which maintained a salt balance, at least until the construction of the Aswan Dam. The region now deals with the same salinity issues that plague other irrigated areas.

Salts result from geological processes described as weathering. Exposed to water, salts are carried downstream. Additionally, evaporation removes some water, yet leaves behind nearly all of the salt. This is most apparent in agriculture. For every acre cultivated, 1 to 5 acre-feet of water are applied. Three quarters of this evaporate. The remaining 25 percent holds nearly all of the original salt. This salt either finds its way into underground aquifers or drains into nearby rivers or sinks. The Imperial Valley withdraws water from the river containing approximately 800 ppm of total dissolved solids, but runoff from the valley often reaches 3,200 ppm (Pillsbury, 1981). Reservoirs confront evaporation issues. An estimated 1.5 maf evaporates in the Colorado River Basin each year, the majority of that from Lake Powell and Lake Mead (Living Rivers, 2005).

Increased salinity levels impact agricultural, municipal, and industrial users. Farmers suffer decreased yields, added labor costs for irrigation management, and added drainage requirements. Urban users pay for frequent repair and replacement of plumbing and appliances. Industrial users manage reductions in the useful life of system infrastructure. Overall, millions of dollars are spent to prevent 1.9 million tons of salt from entering the river. The Environmental Protection Agency estimated the natural salinity levels of the river at 334 mg/L. Current estimates are twice that number. The addition of salts through water use and depletion or consumption of the resource cost the economy of the region approximately $300 million per year (CRBSCP, 2008).

Salinity and drainage management address source control, reuse, land retirement, and evaporation ponds. Source control involves changing crop mix, installing more uniform irrigation systems, and varying irrigation timing to meet plant needs more closely. Reusing drainage water on salt-tolerant crops reduces runoff. Retiring land of poor soil quality reduces drainage, and evaporation ponds prevent runoff from reentering the river system and increasing salinity levels.

Agreement among the Nevadans and Californians and the relative absence of disagreement signify the realization that salinity is a threat to be dealt with. It impacts every use and every user. Decreasing quantities of water in the river increase the impact of the problem.

Statement/Issue: Wetlands have been maintained or recreated along the Colorado River through the Multi-Species Conservation Program.

Wetlands in the Lower Colorado River Basin appear in two forms. The first group emerged incidentally as a result of agricultural runoff or seepage. Examples are the Cienega de Santa Clara and the area around the Salton Sea. Also, wetlands along the earthen All-American Canal benefitted from its seepage. The Multi-Species Conservation Program has intentionally recreated another group of wetlands to address environmental concerns. Respondents addressed the success of the latter group.

Table 24 Wetlands	Strongly Agree	Agree	Neutral/Unsure	Disagree	Strongly Disagree	N
Total Sample	9.5	53.6	32.1	4.8	0.0	84
Managers	13.0	57.4	25.9	3.7	0.0	54
Users	3.7	44.4	44.4	7.4	0.0	27
Agriculture	8.3	50.0	33.3	8.3	0.0	24
Domestic	5.9	37.3	27.5	23.5	5.9	51
Nevada	15.4	30.8	23.1	15.4	15.4	13
Arizona	0.0	27.3	48.5	21.2	3.0	33
California	18.2	36.4	27.3	18.2	0.0	22

The data concentrated responses between the neutral/unsure and agree columns. Few exhibited strong disagreement. The assumption here is that the existence of the Multi-Species Conservation Program, and its attempts at self-promotion have created an aura of success. Stakeholders have rare opportunities to observe the wetlands first-hand and are forced to rely upon statistical reports for knowledge.

The Colorado River Delta, prior to development, fed an estimated 2.5 million acres of wetlands. This acreage provided habitats for 400 species of plants and animals, and a livelihood for 20,000 Cocopah Indians. Since 1983, the river has reached the Gulf of California only 5 times, most recently in 1998. Those events successfully regenerated vegetation, fish, and wildlife species. The Delta supports a number of endangered species including the totoaba, vaquita, desert pupfish, southwestern willow flycatcher, and the Yuma clapper rail. Over 150,000 acres of wetlands have been converted into agricultural fields since the turn of the century. In 1993, Mexico declared 2.3 million acres of water and land in the area a biosphere. Of that, a core 400,000 acres were limited to research, small-scale shellfish harvesting, and low-impact eco-tourism (Newcom, 1999).

On the American side of the border, the U.S. Fish and Wildlife Service (USFWS) designated critical habitat for four endangered "big river" fishes: bonytail, razorback sucker, humpback chub, and Colorado pikeminnow in 1994. The Endangered Species Act prohibits federal agencies from authorizing, funding, or implementing actions that jeopardize the existence of endangered species. The USFWS and the Bureau of Reclamation agreed to issue a Biological Assessment in 1996, followed by a Biological Opinion in 1997, which contained Reasonable and Prudent Alternatives.

Of the 17 provisions included, one referred to the creation of the Multi-Species Conservation Program (MSCP). In January of that year, the steering committee for the MSCP was designated by the USFWS as an Ecosystem Recovery and Implementation Team (ECRIT), and authorized a budget of $4.5 million for MSCP plan development (White, 1997). Two environmental groups eventually bowed out of that steering committee on the premise that the program fell short of addressing environmental needs in Mexico. The Bureau of Reclamation responded that the agency had no jurisdiction as to how water was used once it crossed the border (Newcom, 1999). Implementation of the program began in 2005 with the signing of the Record of Decision by the Secretary of the Interior. One-half of the $626 million dollar program is paid for by the Bureau of Reclamation. The other half is paid for by the states of California, Nevada, and Arizona (LCRMSCP, 2011).

The relative newness of the program and its wide-reaching goals render estimation of success or failure premature. While the data project moderate agreement with the success of the program, the literature does little to justify that assumption. Time will do more to answer these questions.

Statement/Issue: The status of Endangered Species in the basin will only worsen as less water is left in the river after all contractual requirements have been met.

At the time of the signing of the Colorado Compact, the understanding was that a drop of water that reached the Gulf of California unused was wasted. The term "endangered species" had not yet been coined. Now every drop is not only claimed, there are not even enough drops to fill existing claims. It is precisely those endangered species who suffer the consequences. The question to respondents sought to ascertain whether they agreed that water should be left in the river to support native ecology.

Table 25 Endangered	Strongly Agree	Agree	Neutral/Unsure	Disagree	Strongly Disagree	N
Total Sample	7.1	32.1	34.5	21.4	4.8	84
Managers	5.6	35.2	22.2	29.6	7.4	54
Users	11.1	25.9	55.6	7.4	0.0	27
Agriculture	8.3	25.0	45.8	16.7	4.2	24
Domestic	5.9	37.3	27.5	23.5	5.9	51
Nevada	15.4	30.8	23.1	15.4	15.4	13
Arizona	0.0	27.3	48.5	21.2	3.0	33
California	18.2	36.4	27.3	18.2	0.0	22

The data indicate dissensus in this case. Not one group approached consensus in either direction. One must assume that familiarity with the topic of endangered species is limited to a demographic not well represented in the basin. Alternatively, the respondents' priorities focus on human consumption, and environmental advocates lack the political influence to change the focus.

There are numerous endangered species existing in the Lower Colorado River Basin. Many were mentioned earlier in the paper. In this section, the focus will be on the fish. They share common threats with other endangered species, and often their fates are intertwined.

The Colorado River Basin is home to at least 14 native species of fish. Four are endangered. They are the bonytail, razorback sucker, Colorado pikeminnow, and humpback chub. The bonytail can live as long as 50 years and is the rarest of the 4. They no longer reproduce in the wild and were listed as endangered in 1980. Listed in 1991, the razorback sucker's death rates among its young account for the presence of a preponderance of adults of that species in the river. Colorado pikeminnows can grow to 6 feet in length and 80 pounds. They have grown progressively smaller since the 1960s, averaging around 3 feet in length. Early settlers referred to them as "white salmon." They were listed as endangered in 1973. The humpback chub maintains only 6 known populations in the basin and was also listed as endangered in 1973. The threats to these species range from stream flow regulation, habitat modification, competition with and predation by nonnative species, species hybridization, degraded water quality, parasitism, pesticides and pollutants, and climate change (Defenders of Wildlife, 2011).

One might compare the data from this statement with those from the generalized statement at the beginning of the section on environmental protection. While nearly everyone agreed that environmental protection would have an impact on decision-making, the question of endangered species evoked general disunity. None could quite agree as to the potential impacts on endangered species of reduced flows. Possibly, an admission that reduced flows would negatively impact endangered species would require commensurate action to prevent that occurrence.

Statement/Issue: Attempts to recreate the past flood regimes along the river have proven effective.

Periodic releases from Glen Canyon Dam attempt to recreate historical floods through the Grand Canyon. One of the goals of this action is to establish sandbars necessary for the reproduction of native fish species. The statement intended to measure respondents' agreement with attempts to manage the river in ways that supported the environment.

Table 26 Floods	Strongly Agree	Agree	Neutral/Unsure	Disagree	Strongly Disagree	N
Total Sample	3.6	14.3	46.4	26.2	9.5	84
Managers	1.9	16.7	42.6	27.8	11.1	54
Users	7.4	7.4	55.6	25.9	3.7	27
Agriculture	0.0	12.5	45.8	33.3	8.3	24
Domestic	5.9	11.8	51.0	21.6	9.8	51
Nevada	0.0	0.0	84.6	15.4	0.0	13
Arizona	6.1	18.2	30.3	33.3	12.1	33
California	0.0	9.1	45.5	40.9	4.5	22

This statement evoked dissensus. An unexpectedly high number of respondents chose neutral/unsure as their response to this question. Is this a lack of awareness of the releases at Glen Canyon Dam, or a lack of knowledge of its impacts? More likely, the latter as the results are not highly publicized.

Most riparian vegetation in the Southwest now covers only a limited fraction of former historical range. Dams, discharge regulation, stream water diversions, livestock overgrazing, floodplain development for agriculture spreading urbanization, and watershed degradation all contribute to the decline. Aquatic ecosystems are severely reduced or damaged (Tiegs et. al., 2005). Researchers hope to identify natural flooding characteristics that must be protected or restored to maintain riparian ecosystems along rivers. Research suggests duration of flooding at or above 209 m^3/second is particularly important (Richter and Richter, 2000). Native plant species have benefited from flooding along the Colorado River in recent decades. However, research indicates that flood disturbance is less important than salt levels or drought stress in regulating riparian diversity. They emphasize that the most recent flood events "approximate" pre-dam conditions (Tiegs et. al., 2005).

Reporting data from releases out of Glen Canyon Dam, Hanna (2005) stated that under current dam operations, the river transports more sand out of the system than is supplied by tributaries. This prevents multi-year accumulation and contributes to erosion. The 2004 high-flow experiment created a robust increase in sandbar area and volume in Marble Canyon, an area usually receiving little sediment. Alternatively, the humpback chub continues to decline. Rainbow and brown trout (nonnative species) proliferate. Both prey on native species of fish. While one cannot attribute these effects directly to dam operations, operational reform (releases) have not produced anticipated restoration and maintenance.

These results resemble the results of the endangered species statement in that they indicate no strong feelings either way. In fact, there is even greater concentration in the middle here reaching its extreme in the Nevada group where 84 percent chose neutral/unsure as their response. Again, a possible explanations is a lack of familiarity with the results of the experimental flows. Considering the publicity surrounding the occurrence of the floods, it is hard to believe that stakeholders are unaware of their existence.

CHAPTER 5

CONCLUSIONS

Thus far this thesis has identified, from the relevant literature, a number of major issues in the Lower Colorado River Basin. This completed the first objective of this thesis. These issues were presented, in survey form, to members of the Colorado River Water Users Association, a representative stakeholder group. The members then selected their level of agreement or disagreement, on a Likert scale, with 24 statements describing current issues in the Lower Colorado River Basin.

The statements were divided into four general categories: allocation, augmentation, conservation, and environmental protection. Each category contained six statements. The initial statement in each category provided a general assumption reflective of that topic. From there, the following five statements described specific actions or implications pertinent to the issue.

The responses were then divided into representative groups of stakeholders. Groups included the Total Sample, Managers, Users, Agriculture, Domestic, Arizona, California, and Nevada. The separation was facilitated by the three demographic questions at the end of the survey.

Once filtered by demographic groups, the data was analyzed to determine existing areas of consensus. At the beginning of the thesis, discussion of consensus building argued for a strategy of initiating negotiations within existing areas of agreement in order to build relationships and trust. Issues of incomplete accord could then be addressed with some expectation of success and resolution. The most conflict-laden subjects would be dealt with last, in hopes that a track record of success and trust might have been established.

Each of the four major categories included statements that exhibited agreement in the data. Of the four, conservation enjoyed the highest rate of consensus, reaching that bar in five out of six statements. The remaining three categories found accord on only two statements each. It is important to note here that the two declarations that attained overwhelming agreement among all groups, were both found in the allocation category. This provides evidence of common ground in general principles.

One would predict that the specific assertions within each category might indicate less cohesion. A brief scanning of the data reveals that 11 out of 24 statements, nearly half, attested to some level of concurrence. Following the strategy described, an individual seeking to build consensus would begin with the two statements that reported strict consensus among all groups. The over-allocation of the Colorado River, and the use of water transfers were these two statements. Though neither provides a direct solution to the problem of over-allocation, they do offer a point of departure for further negotiations.

Three separate statements witnessed agreement among all groups but one. Desalination as a means of augmentation united every group except the Users, as did the subject of water banking. Water reclamation found resistance only in the group from Nevada. It is not hard to imagine that the majority of groups could exert enough political pressure on a lone dissenting interest group to promote policy change.

Over half of all groups, precisely 5 out of 8, agreed that environmental concerns would play a greater role in future water management decisions. Managers, Users, Agriculturalists, and Nevadans affirmed this assumption. The fact that one of those groups was the Total Sample indicates that possibly among dissenting groups, there were a large number of supporters. If negotiators succeeded in wading through the first five issues, those already demonstrating complete, or nearly complete consensus, one would believe that the road had been paved for additional consensus in this area. The absence of Californians from the majority group here does presence an obstacle. California, due to population, congressional power, and established water rights, carries disproportionate influence.

Half of the eight demographic groups agreed that conservation had not been fully exploited in the basin. The Total Sample, Users, Agriculturalists, and Arizonans concurred. Again, the existence of support from the Total Sample is encouraging to the consensus builder, as it evidences pockets of agreement within dissenting groups. The presence of Agriculturalists is important. Their near monopoly on water rights in the basin equips them with enormous policy influence.

Even at the point where consensus represents only a minority of demographic groups, the potential for collaborative decision-making exists. This is true primarily because the data demonstrate that where two or more groups agree on a particular topic, others are not far from agreement. The next three statements to be examined unified three separate groups in each case. The assumption that there simply was not enough water in the basin, and that additional sources were required, attracted the support of

Managers, Domestic users, and Arizonans. Describing improved irrigation techniques as expensive and of limited value drew opposition from Californians, Nevadans, and Managers. Financial incentives attracted Managers, Agriculturalists, and Nevadans. These statements will be examined together not only because they received the same level of consensus, but also for some other, very specific commonalities. These three observations are drawn from the augmentation and conservation categories, which in many ways are two sides of the same coin. Both present methods for increasing available water in the basin. Therefore, it is not surprising that managers support all three innovations. While Nevadans do not admit to a shortage of water in the basin, they do support improved irrigation and financial incentives. Californians, Arizonans, Domestic users, and Agriculturalists demonstrate consensus on one statement each. Users are completely absent as a group. It appears that the common goal is agreed need for more water. The means for achieving that goal is debatable. In any case, one could argue that enough consensus exists to initiate discussions, particularly if the foundation exists from prior negotiations in areas of existing agreement.

The final area of demonstrated concurrence is in the future risks of increased salinity. Salinity is not a new problem in the Lower Basin, and cooperative programs already exist to address it. Although only 2 of the groups exhibited consensus, California and Nevada, the others nearly met that standard. Here, the presence of California brings added weight and influence to any discussion of the matter. Together, California and Nevada form a two-thirds majority in the Lower Basin, with the potential strength to coerce Arizona into policy agreement.

From this point on, dissensus in the other areas appears manageable. Particularly in light of large numbers of neutral/unsure responses, movement in one direction or the other is no great stretch. A well-planned strategy in the beginning could bring a negotiator to this place in the discussions with strong relationships and high levels of trust and shared accomplishment. The remaining points of disagreement require only a clear description of goals from all sides and the flexibility to seek alternative solutions to impasses.

Described in these conclusions are points of existing consensus and the potential for consensus building. Based on the data collected in this study, agreement among stakeholders does not appear to be a lofty goal. Instead, the groups demonstrate more coherence than initially anticipated and are in position to increase unity on more controversial topics. Agreement in each of the categories and on each of the issues merits further study. The groundwork in locating agreement could enable more far-reaching and effective water resource management in the region. Predictions for the failure to do so are sobering.

APPENDIX I

PROTOCOL

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Protocol Logged In Notice
Social/Behavioral IRB

DATE: 11/17/2010

TO: **Dr. Steven Parker, Political Science**

FROM: Office for the Protection of Research Subjects

RE: Protocol Title: **Consensus on the Colorado River**
Protocol #: 1011-3652M

This memorandum is notice that the protocol named above has been entered into the OPRS protocol database system.

Please be aware:

- Although your protocol has been entered into the protocol database system, all documents required for review **MAY NOT** have been submitted with your package. The IRB can not review your protocol until all required documents have been received.

- **IF** your protocol package is incomplete, OPRS will contact you via email.

Please allow 14 days before contacting the OPRS staff regarding the status your protocol. You will be notified via email and/or campus mail after the protocol has been reviewed.

OPRS can be reached at OPRSHumanSubjects@unlv.edu or call 895-2794.

APPENDIX II

SURVEY

Statement	Strongly Agee	Agree	Uncertain	Disagree	Strongly Disagree
The Colorado River is Over-Allocated					
The Colorado Compact allotments are now reviewed periodically and interim agreements address shortages and surpluses adequately.					
Prior Appropriation is an unfair system that rewards history and doesn't reflect the current situation on the river.					
Agriculture is the highest priority for water use in the Lower Colorado River Basin.					
Fixed allotments limit the flexibility necessary to adapt to climate change.					
Water transfers between uses and between basins provide an additional tool in dealing with water scarcity.					
There simply isn't enough water in the Colorado to support the needs of the region and additional sources must be sought to augment supplies.					

Statement	Strongly Agee	Agree	Uncertain	Disagree	Strongly Disagree
Desalination, while expensive, will provide water necessary to augment supplies in the region. Lining earthen canals threatens water supplies to wetlands in order to satisfy developed water resource obligations.					
The pipeline proposed by the Southern Nevada Water Authority will provide water necessary for the future without damaging the environment or agricultural interests upstate.					
The Drop 2 reservoir will increase available water for users at the expense of the Delta's ecological balance.					
Cloud seeding and iceberg flotation, as well as other innovative measures must enter the discussion as future water sources for a thirsty region.					
Conservation has not been fully exploited as a means of extending the life of current water supplies.					

Statement	Strongly Agee	Agree	Uncertain	Disagree	Strongly Disagree
Water reclamation will reduce the pressures on current water supplies.					
Improved irrigation techniques (for example drip irrigation) are cost-prohibitive and will not drastically reduce the use of water in agricultural areas.					
Water-Banking is an acceptable method of water storage for use in exceptionally dry periods.					
Intentionally Created Surpluses do not provide enough incentives for water users to conserve water.					
There need to be more and greater financial incentives throughout the region, similar to those utilized by the Southern Nevada Water Authority, to encourage desert landscaping.					
Environmental Concerns will play an even greater role in future water resource management decisions.					
Efforts to control invasive species such as the quagga mussel, and the tamarisk have been successful.					

Statement	Strongly Agee	Agree	Uncertain	Disagree	Strongly Disagree
Salinity, already a basin wide problem, will only be exacerbated by future droughts and water scarcity.					
Wetlands have been maintained or recreated along the Colorado River through the Multi-Species Conservation Program.					
Attempts to recreate the past flood regimes along the river have proven effective.					
The status of Endangered Species in the basin will only worsen as less water is left in the river after all contractual requirements have been met.					

Circle the response that best fits you.

Do you consider yourself primarily a water resource manager or user?

Manager User

As a Manager or a User, what is the primary use you are associated with?

Domestic Agricultural Industrial

What state do you primarily work/live in?

Arizona California Nevada Utah Colorado Wyoming

New Mexico

Comments:
____

Thank you for your time in completing this survey. It is intended for use in the completion of a Master of Arts Degree in Political Science at the University of Nevada, Las Vegas. If you have any questions or suggestions, please contact me, Jeffrey D. Tilton, at swoop62@hotmail.com, or at (702) 292-3543.

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