Water Scarcity in the Americas:

Common Challenges – A Northern Perspective

Rosenberg International Forum on Water Policy

Buenos Aires, Argentina

November 2010

David H. Getches
Dean and Raphael J. Moses Professor of Natural Resources Law
University of Colorado Law School
401 UCB
Boulder, Colorado 80309-0401
lawdean@colorado.edu

I. Introduction: Common Problems, Common Solutions?

A. Mission for Conference: A Mutual Learning Experience

In many respects, the water problems of the world are shared by all, and scarcity is at the core. The wisdom of several Rosenberg Conferences in convening experts to study and debate problems lies in the commonality of problems and the potential for sharing solutions. Focusing on the Americas increases the potential for exchanging lessons learned and transferring knowledge. For North America, the scarcity problem is less likely to be for survival than it is for economic growth and environmental concerns. This is not to diminish the reality of entire communities being without potable water, at least temporarily, even in some places in the developed and developing countries of the northern hemisphere. It is true that north and south differ in the extent of scarcity for the most fundamental need for water – drinking and other domestic uses. But even that difference is less pronounced between the northern and southern hemispheres of the Americas than it is, say, between Europe and Africa.

Issues of policy related to climate change, urbanization, groundwater, indigenous rights, and transboundary allocation are the most critical water problems in North America. They are the determinants of scarcity at local and regional levels, and they are typically inextricably linked to one another. This paper explains each of these policy issues as they occur in the United States of America. It then goes on to illustrate how they are interrelated using the case study of the Colorado River. While the issues vary in their relative seriousness as between the Northern and Southern Hemisphere – as indeed they do within the Northern Hemisphere – they are pervasive throughout the continents in being driving forces in water scarcity, and they are the greatest water policy issues of our time. It is likely that the experiences of one region – mistakes and

struggles, as well as successes– will be useful in enhancing the capacity of experts to address these challenges as they arise in another. At a minimum, the paper should illustrate the complex policy nexus of water problems and the need for integrated consideration of major issues rather than attempting to solve water scarcity problems in isolation as simply supply and delivery issues.

B. USA Allocation and Administration Systems

To set the backdrop necessary for explaining the future challenges for water policy it is helpful to understand the basic elements of the legal and institutional context. Rather than address the several systems of North America, this paper focuses on the United States. The challenges identified are not the result of the allocation and administration systems in the United States but the ways in which they have been addressed – or not – has been affected by the assumptions and practices that have grown up under these systems.

1. Two historically different water allocation systems converge

The United States has multiple water allocation systems, with each of the fifty states setting the rules for allocating and administering available water supplies. Generally, those legal systems emanate from two distinct approaches – riparian rights and prior appropriation. Although the historical roots are different, and each state maintains its particular nuances, almost all the states now have permit systems that operate with more similarities than differences.

In its simplest terms, the riparian doctrine affords rights to water to those whose land borders watercourses. Thus, water rights are linked to land ownership. Although in its purest form the doctrine did not allow water to be used on non-riparian land (land not contiguous to a stream), that impractical rule was overtaken by exceptions.

Eventually most riparian jurisdictions adopted permit statutes that require applications to be submitted to an administrative agency that grants rights to use particular quantities of water to individuals, cities, companies, and others. The agency applies criteria found in statutes to determine how to prioritize rights among water users. One of the criteria may be one's location near to a stream – a riparian value. But the criteria may also include consideration of historical use of water – a value that is fundamental to the appropriation doctrine discussed next. (Getches, 2009, pp. 103-07).

The prior appropriation system is the source of water laws in most of the western United States. It was based on the simple justice of the miners who, in absence of a formal legal system, were making claims on minerals based on who found them first. The "first-in-time, first-in-right" idea applied to water so that anyone could begin taking water and putting it to use for mining, farming, or any other "beneficial use" and thereby get a "water right" to continue using the amount originally put to use. The right was then good against anyone else who claimed a water right later, and was subordinate to rights claimed earlier. This system operated to enable full use of one's rights so long as there was water in the stream and the use did not interfere with uses by any other water rights holder. One of the great positive features of the system is that it allowed rights to be transferred to others.

The system could be criticized as protecting old uses that were highly inefficient and for eschewing sharing when water supplies are short. It is anomalous to see flood irrigation being used on western farms today when other, more efficient methods are available. And it seems inequitable to see a flooded field of an irrigator with senior rights next to a dry and barren field of a farmer with junior water rights. Moreover, the system historically paid no respect to

arguments that there should be enough water in a stream to maintain flows for fish and wildlife and recreation. (Wilkinson, 1992, pp. 231-35).

Today, prior appropriation has been modified by statutes recognizing the public's interest in instream flows, establishing recreation as a beneficial use, and allowing appropriations of water without diverting it from the stream in order to use it to maintain fish and wildlife habitat. Indeed, like the riparian states, most prior appropriation states now have permit systems. Those systems generally require new water uses to be in the "public interest." Although most water in the streams of the generally arid West is already appropriated and subject to existing rights, the public interest requirements apply also to changes to new uses when rights are transferred.

The permit systems that prevail in the prior appropriation states do, indeed, defer to the priority of existing water users in granting or administering water rights. But so do the permit systems in the riparian states. A variety of other considerations, including expansive and often discretionary public interest standards, are applied and substantially modify the common law system that developed in the 19th century American West. (Wilkinson, 1992, pp. 282-284).

2. Federal system: state allocation; federal regulation

Although the state systems are surely dominant in terms of most issues of allocation and administration, the federal government also has a role. Under the United States Constitution, federal legislation is supreme, preempting the operation of state law to the extent that it might interfere with fulfillment of a federal purpose. For instance, federal law – the Clean Water Act – demands the achievement of certain water quality standards for streams. A state law that makes water quality goals subordinate to the ability of water users to exercise their water rights could apply to state water quality laws but would be preempted if the exercise of water rights resulted in degrading water quality contrary to federal law. Similarly, the federal Endangered Species

Act (ESA) prevents water users from diverting or damming a stream – even if they hold a state water right to do so – if it would imperil a species of fish protected under the ESA (*Riverside Irrigation Dist. v. Andrews*, 1985).

Another way in which federal laws and policies impact state water laws is through congressional designations of uses for federal lands. About a third of all lands in the United States are owned by the federal government. Where federal law "reserves" those lands for specific federal purposes that require water, state-created water rights may not interfere with the purposes of setting aside those federal lands. For instance, if national legislation creates a Wild and Scenic River, a person holding state water rights cannot use those water rights to defeat the federal purpose. Similarly, if a wilderness area is created by federal law to preserve the natural character of a forest, and a free-flowing river is a critical part of that forest, a water user with a right to dam the stream before it flows into the wilderness area may not be able to do so.

Comment [AT1]: High Country Citizens Alliance v. Norton or Potlach Corp v. United States as an example?

The protection of federal purposes for reserving federal lands from conflicting water uses is called the reserved rights doctrine. It was created by the United States Supreme Court as a means of reserving sufficient water to fulfill the purpose of creating Indian reservations. Often reservations were created to ensure that tribes had a territory where they could subsist, usually by farming. In other cases tribes needed enough water to keep streams flowing through their reservations to preserve habitat for fish, which allowed them to continue traditional fishing rights. The tribes are considered to have reserved water rights to sufficient water to fulfill such purposes. State-granted water rights are subordinate to reserved rights and cannot be exercised if they interfere with the fulfillment of the reservation purposes. The realities of this system of reserved water rights are discussed below. (Tarlock et al., 2009, pp. 861-862).

C. All Water Problems are Policy Problems

Water issues are typically discussed as physical problems: finding and managing a natural supply and the need to construct delivery systems, dams, and purification systems. But essentially all water problems have a policy nexus. It is rare that a water problem cannot be solved if public policy can be harnessed and directed effectively. And the problems are far more expansive than matters of supply and delivery. If water problems were ever that simple, finding sustainable solutions today requires far wider consideration.

Individual competition for water, and later competition among or within sectors – cities versus farmers, cities versus cities – state water problems simplistically. Addressing them in this way implicates self-interest. Self-interest often inhibits making the "wisest" choices. Water is cheap; I will use all I want. If our city gets the water first and puts it fully to use, we will get the tax base from faster growth. And so on. But public policy must intervene if water is to serve more and varied interests inasmuch as water is a public good.

Another inhibition to making "wise" choices is that values may differ among those making the decisions. For instance, an obvious conflict is among different types of water uses, all of which are rational and important but more or less so in the minds of different people: e.g., agriculture versus municipal or industrial uses. There are times when people who share broad policy objectives have conflicts too – where all objectives are desirable but honoring one trumps the other: we want enough water for a vibrant community and we want a viable, flowing stream for fishing, but the fishing stream will be depleted if the stream is developed.

Choices continually have to be made among reasonable goals. Sometimes society can count on individual values and ethics to restrain water uses that cause damage to others or long-

term deterioration of natural conditions. But, in the end, behaviors must be guided not by self-restraint alone, but also by regulation and market forces. Public policy governing water allocation, development, use, and conservation therefore must utilize regulatory mechanisms and market incentives as well as providing information to help people make wise and ethical choices.

II. Challenges for Water Policy Today

A. Climate Change

Experts in the once-uncertain field of climate change research are reaching agreement on certain principles that portend serious concern for water planners and suppliers. Although there is a wide range of estimates of the average temperature changes that will experienced due to climate change, and the various climate models differ on localized impacts, most scientists have now reached a consensus that changing global climate patterns will impact the timing and quantities of water supplies. Temperatures generally are rising due, in part, to the concentration of greenhouse gases in the atmosphere.

The 2007 report of the Intergovernmental Panel on Climate Change (IPCC) estimates the probable distribution of impacts in North America based on the most widely accepted climate change models. According to the report, over the last 60 years streamflow has decreased by about 2% per decade in the central Rocky Mountain Region while showing increases in the eastern United States. (Field et al., 2007). Overall, the fraction of precipitation falling as rain instead of snow increased in the western mountains of the United States and Canada. Glaciers throughout North America are melting.

Much of the discussion of global climate change is about how to stem the human causes, and that sets off a debate about the extent to which human activity is responsible for the

phenomenon. From the perspective of water experts, this debate is largely moot. The only action within the grasp of water managers is how to cope with the effects. Any mitigation through reduction in the emission of greenhouse gases will take decades to achieve. Indeed, the IPCC stated that adaptation "will be necessary to address impacts resulting from the warming which is already unavoidable due to past emissions." (Parry et al., 2007, p. 25).

Adaptation begins with planning that incorporates the most reliable and current estimates of climate change impacts on water supplies. Planners must anticipate drier, warmer conditions and differently timed precipitation patterns. Variations in climate may be more pronounced; floods and droughts may be more frequent and more severe. One of the most troubling consequences of changing climate is that the systems of water collection, storage, and distribution were designed based on precipitation patterns and resulting river flows derived from data collected in the late nineteenth and early twentieth centuries. The IPCC concluded that current water management practices are "very likely" to be inadequate in reducing the negative impacts of climate change on "water supply reliability, flood risk, health, energy, and aquatic ecosystems." (Bates et al., 2008, p. 127). It called for greater incorporation of climate variability into water management. This means that water managers must reconsider the hydrological assumptions on which their predecessors premised the locations, sizes, and operating regimes for reservoir systems. It also means that managers and political leaders must take action to reduce water demand. Moreover, the legal systems for allocating water and for controlling water quality may have to be examined. Until recently, few states required any consideration of climate change in water resources planning. One of the exceptions is in California where the legislature adopted the sweeping Global Warming Solutions Act, which includes a Water-Energy subgroup.

(CDWR, 2008, p. 8). In 2007, the California legislature passed Assembly Bill 662, which specifically addresses water conservation in the face of climate change.

B. Urbanization

Much of the American West suffers from a scarcity in natural water supplies. Yet it is the part of the country that has experienced the greatest population growth over the past half century. Western states experienced a 20% population growth in the 1990s compared to a national average of 13%. (Travis, 2007, pp. 51-55). Nevada, Arizona, Colorado, Utah, and Idaho grew at 37% during the same period. Projections are that the West will add 28 million people by 2030. Rarely, is the cost of water a significant factor in locating housing and so urban and suburban growth has followed lifestyle preferences and employment opportunities without regard to the difficulty of acquiring or transporting water.

The western United States is characterized by open spaces – forests, mountains, and deserts. Remarkably, however, the West is the most urbanized area in the nation. That is, most of the population is concentrated in urban areas. (National Research Council, 2007, p. 17). And therefore the fastest growing demand for water is for municipal supply. Similarly, municipal water demands are the greatest concern in the eastern United States. Urban areas are confronted with the reality that nearly all water in the West is allocated under prevailing systems of water rights and, even in the East, shortages are occurring with greater frequency.

Historically, the earliest demands for water in the West were for agriculture, which can use large quantities of water, especially in arid or semi-arid areas. Thus, the annual flows in most of the West's relatively meager surface streams were legally allocated to agricultural use. Today, agriculture uses about 62% of all surface water withdrawn. (Kenny et al., 2009).

To meet the growing demand for urban water with an essentially static supply requires reallocation from existing uses to accommodate population expansion. Water has greater economic value in urban uses than for almost any agricultural purpose. Thus, market forces attract water away from farms and to the cities. This has caused the decline of rural communities in some areas as water that once fueled local economies is transported to distant cities.

Economic forces promote the movement of water to cities that once was used for irrigation and leading to a decline of rural economies that were supported by agriculture. The United States has not yet faced the issue of how loss of agricultural production can be reconciled with a growing population. Transfers of water to cities from farms may nevertheless be politically unpopular, causing cities to seek alternatives to drying up agriculture to secure a water source. There are methods for mitigating the impact on agriculture, however, while firming or expanding urban supplies. For instance, a city can enter into a dry year lease allowing for water to be removed from irrigated lands in a drought but leaving the water on the farm in other years. (National Research Council, 1992, pp. 30-34).

By reducing demand, cities can also avoid the expense and political opposition that sometimes come with importing new supplies from distant areas. Mandatory conservation measures can be highly effective. Today, most newly constructed buildings must have low water demand toilets and showers. But because most urban demand comes from outdoor uses, the type and extent of outdoor planting such as grass lawns must also be limited. Some cities limit lawn size and planting, but the most effective way to reduce outdoor usage is to limit lot size. This requires consideration of water demand in urban planning. Measures to control the size of subdivisions also help to prevent sprawl. Nevertheless, it is rare for local government or state mandated land use plans to require water conservation measures such as limiting lot size or even

requiring that developers secure long-term water supply. (Hirt et al, 2008). There are exceptions such as Arizona, which requires a 100-year assured supply of water before approval of any new subdivisions. (ARS 45-576). Similarly, in California, two bills, SB 221 and SB 610 require developers to prove the presence of adequate water supplies before major subdivisions, commercial developments, or large-scale residential developments are built.

Cities are challenged by a lack of capital to install and maintain water systems. For new growth, some charge substantial "tap fees" that help to meet the costs of expanding systems. As new consumers are added to systems they eventually outstrip the capacity of water supplies and of water treatment facilities. The amounts charged for tap fees are often kept below the actual expense of expanding or maintaining infrastructure by political opposition to raising government revenues and by decision makers in local governments hoping to attract growth to a community. A dearth of financial resources for constructing and maintaining these systems results both in existing consumers facing higher rates and in the deterioration of existing facilities.

The infrastructure problem is serious for cities. The funding once provided by the federal government for water treatment plants has dwindled as government deficits have grown and as politicians have refused to raise taxes. Although the United States, like most of the developed world, could once boast the absence of problems of inadequate potable water for its citizens, in recent years there have been several reports of failing municipal water systems causing health threats to local consumers. The U.S. Environmental Protection Agency has stated: "[T]he nation's water systems hav[e] entered a rehabilitation and replacement era in which much of water utilities' existing infrastructure has reached or is approaching the end of its useful life." (USEPA, 2009, p. 3). Some experts estimate that the number of water-borne diseases in the U.S. exceeds 19 million annually. (Reynolds et al., 2008).

C. Groundwater Use

Groundwater is a primary source for agricultural or urban water supply in many areas of the country, accounting for about 20% of all water withdrawn in the United States, with 67% of that amount being used for agriculture. (Kenny et al., 2009). Groundwater is used to supply much of the nation's urban growth with half the population now drinking groundwater. With the waters of the West's rivers at or near their full capacity under water rights allocation systems, and their use facilitated by publically financed water projects, groundwater becomes a very attractive alternative. Relying on water supplied from aquifers also has the benefit of not being subject to evaporation and not fluctuating with precipitation.

It has long been argued by experts that groundwater and surface water should be used conjunctively, but state legal institutions have been slow to respond. One of the problems with the way the resource is used is that the state laws governing groundwater allocation treat water pumped from wells as if it comes from an entirely different source than surface water. Experts have concluded that states generally do a poor job of managing groundwater. (Leshy, 2008).

The varieties of groundwater laws often have little to do with the geology that produces the resources. Much groundwater is hydrologically connected to a river, i.e., "tributary" water. Laws concerning use of this water may or may not (more often not) respect the use rights of surface water users. Other aquifers are all or largely non-renewable resources. They are not replenished by precipitation or the flows of connected streams. A variety of widely differing laws governs non-tributary water. Some states embrace the quaint notion that the overlying landowner "owns" the water beneath the land area. That raises questions of just how much the owner is entitled to pump without injuring the rights of other overlying owners. The ownership idea has been tempered by a "reasonable use" rule in most states. In other places competing

pumpers may sue one another over interference with their presumed rights – such as when it becomes impossible or more expensive for one person to pump because another person's pumping depletes the water table. A few courts apply prior appropriation principles to protect earlier users from injury by the pumping of junior users – but only to protect a "reasonable" pumping level. The meaning of "reasonable" under rules using the term may depend on economic factors. In most jurisdictions groundwater is considered a public resource so that states are not inhibited in its regulation through legislation. The kinds of regulation include permit systems that take account of impacts on others and, like permit systems for use of surface water, consider public interest factors. Some states create special districts to deal with the management of depleting aquifers. Some allow a certain amount of water to be "mined" each year, effectively amortizing the resource. Property rights, torts, and public policy form the basis for the extensive variations of these rules. (Getches, 2009, pp. 267-284).

Today, aquifers in many parts of the country are being depleted to the point of crisis. Some states have allowed excessive use because of political pressure not to curtail economic activity, or because the aquifer underlies another state and the water would be pumped in the second state if it is not allowed in the first state. Of all areas of water law and policy, groundwater rules are the most incongruous with the physical nature of the resource and its importance to society.

D. Indian Rights

Indian tribes in the United States – like indigenous peoples elsewhere in the world – have cultures that depend on water use. Many are able to sustain their residence and subsistence in territories that have been limited in scope by dispossession of tribal lands by treaties, agreements, and federal legislation and the resulting encroachment of non-Indian communities into traditional

areas. Many tribes living on reservations that are vestiges of their former territories now depend on agriculture that requires irrigation. Some depend on fishing and hunting which requires streamflows and habitats to be maintained.

Recognizing the necessity of water to sustain Indian life on lands that were reserved to the tribes, the United States Supreme Court ruled that tribes have rights to water sufficient to fulfill the purposes of their reservations. In a 1908 case, *United States v. Winters*, non-Indian settlers had moved to areas formerly occupied by Indians and tribes were confined to defined reservations. (*United States v. Winters*, 1908). In that case, the non-Indians began irrigating and depleted the river that ran along the border of the Fort Belknap Reservation. Although the non-Indians argued that they had begun taking water out of the river before some of the Indian irrigation began, thus entitling them to water rights under the prior appropriation doctrine (described above in section IB1(b)), the Court found that the tribe had "reserved rights." Instead of tying tribes' water rights to the date of their first use, the Court said that Congress had manifested an intention to reserve sufficient water to fulfill the purposes of the Fort Belknap Reservation at the time it was set aside. The Court said this was a "necessary implication" to avoid injustice to the Indians.

In the century since the decision, non-Indians have been on notice that their uses of water sources proximate to Indian reservations – even if they obtain water rights under state law – are subject to being preempted by new Indian uses. This reality has been offensive to states who believe they have primacy in matters of water allocation notwithstanding the supremacy of federal law as discussed above in section IB2. And the uncertainty caused by the possibility of Indians asserting water rights after non-Indians begin using water threatens practical problems, including frustration of investment in farms and irrigation systems.

Historically, however, the practical consequences have not been serious. The non-Indians have expanded their water uses and most Indian tribes have had inadequate resources to develop their own irrigation systems and farms. The federal government has provided some funds for Indian reservation irrigation systems, but more typically the government has subsidized systems for non-Indians that use the waters of the same streams needed by the tribes, leaving less water for Indian uses. (DeCoteau, 2006). The reserved rights doctrine, though its benefits in practice have fallen short of the apparent promise of prior and paramount water rights, has allowed many tribes to develop farms and some to ensure streamflows for fisheries.

It is difficult to quantify tribal reserved rights that are defined in case law as being in amounts "sufficient to fulfill the purpose" of the reservation. The "formula" for determining how much water is required to fulfill the purpose of an Indian reservation requires looking first for the purposes revealed in the documents creating the reservation and next using experts to calculate how much water that will take. One major case announced that the water needed for reservations established for agriculture would be set based on the water needed for irrigation of all "practicably irrigable acreage." (*Arizona v. California*, 1963). In that case and others, litigation was pursued to establish the relative priority dates and quantities of reserved rights that pertain to a particular reservation. Because of the costliness of litigation, the states and non-Indian users, as well as the tribes, have been diverted from litigation to processes leading to negotiated settlements to quantify and resolve tribal water rights.

Over the past 25 years, the rights of more than 30 reservations have been decided through negotiation, typically followed by an Act of Congress ratifying the terms. This approach is generally considered less burdensome than litigation and can create incentives for non-Indians to cooperate in the process. Still, a negotiated settlement can take many years and requires the

involvement of many divergent interests along with their lawyers and experts, making the process cumbersome and costly.

Although each reserved rights settlement is distinct, there are common features. Nearly all have guaranteed a quantity of water to the tribe and most have provided funds in trust to be used for water development or generally for economic development. The funds are usually federal, with some state contributions. Most settlements have allowed for the tribes to lease or sell water to be used by non-Indians on, and sometimes off, the reservation. Because appropriation of funds is involved and so many different interests have to be satisfied, implementing legislation is no simple matter. Today, almost as many settlements are in various stages of negotiation as have been concluded. (Tarlock et al., 2009, pp. 925-927).

Quantifying and implementing an Indian reserved water rights settlement is difficult and time consuming but it does start from the premise that tribes have significant water rights and it has – after the expenditure of time and money – produced substantial benefits for tribes. The reserved rights doctrine itself appears here to stay, although in some modern cases, the Supreme Court has seized the opportunity to narrow the doctrine, for instance, by limiting the reservation purposes to "primary" purposes. (*United States v. New Mexico*, 1978). Compared to legal treatment of water rights for indigenous peoples in other countries, the reserved rights doctrine appears to be relatively advantageous.

E. Environmental Protection

Before the 1970s, water was developed and used without much concern for impacts on the environment. Dams were built and streams were depleted with sometimes damaging consequences for fisheries and habitat, and streams were degraded by depletion and pollution.

Since then, far-reaching federal legislation has been enacted to protect stream water quality, drinking water, wetlands, endangered species, and other environmental values. Today, the greatest concern for water suppliers attempting to develop new sources is complying with environmental laws. It is very difficult to divert and transport water from any source to the place of use without encountering major legal obstacles designed to protect the environment.

Nearly all water use and development affects water quality; even the extraction of water from a stream leaves less water flowing in the stream to dilute pollutants added by others. There are more dramatic impacts as streams are dried up, obstructed, and polluted by the return of water to the stream after it has been polluted by municipal, irrigation, or industrial uses. Nevertheless, state laws concerning allocation of water rights generally have operated without regard to the environmental consequences of diminished water quality. In fact, some states actually have laws saying that water quality protection laws must yield if they would inhibit the development of water under state water rights.

Comment [AT2]: Other than this paragraph, the section seems focused on federal/state environmental protection laws. Having a paragraph on quality breaks up the flow. Could it go somewhere else or at the end of the section? Also, some of it repeats information at pg. 4.

In the United States, the most protective environmental laws are federal. Because water rights are created under state laws the conflict between the two sets of laws sets off federalism debates. The ideal of federal deference to state water law is often recited, but in practice it is more myth than reality. (Getches, 2000, pp. 6-18). Invariably, potential conflicts are resolved in favor of federal law, which is supreme under the Supremacy Clause of the Constitution so long as Congress is clear about its objectives when it passes legislation. The federalism conflict after all, derives from the historical response of the national government to public demand for better environmental quality as state laws proved too weak even to provide protection of human health. The most formidable federal environmental laws are a wetlands protection law prohibiting the placement of any structure in waters of the United States without a federal permit and the federal

Endangered Species Act that prohibits actions that would "jeopardize the continued existence" of a threatened or endangered species. (Doremus, 2001)

The most significant state laws protecting the environment are instream flow protection laws. These laws take several forms, but generally attempt to ensure that there is sufficient flowing water in streams, or water levels in lakes, to sustain fisheries. One type of law allows the state to prevent the depletion of a stream below a certain level. Another model lets the state appropriate water for instream uses – fish or recreation. The latter type of law treats the instream flow right as just another water right that can prevent junior water rights holders from interfering with the flow needed for the right, but which can be defeated by the exercise of senior rights held by others. Because these instream flow laws were passed in the late twentieth century, the rights appropriated under them are usually junior to most rights in a stream, the exercise of which can dry up the entire stream. These rights can interfere with water development, however, even if they are junior to the rights for a water development project if the senior rights were formerly used for another purpose and are being changed to the new use. Yet, such instances are rare. (Amos, 2006).

F. Transboundary Issues

The ability of each state to allocate waters running through its territory creates the possibility of conflict when a stream flows through or along the border of more than one state. What happens when all or nearly all the water of a river that crosses a state line is allocated for use in an upstream state? Or if a downstream state on such a river allocates water to water users before there is demand in a slower developing upstream state? These problems have arisen many times in the United States and have been addressed in a number of ways.

The first method used to resolve such problems has been litigation. Although an individual in one state who wants to challenge the use by an individual in another can sue the user in the other state, this is rarely done. (*Bean v. Morris*, 1911). This may be effective where the differences in laws between the two states are not great and where the parties all can agree to submit the case to the jurisdiction of one state.

More typically, a state acting for the benefit of its citizens will sue another state to protect what the first state believes to be an interference with the amounts of water it is entitled to allocate for use of its citizens within its boundaries. Such cases are within the "original jurisdiction" of the United States Supreme Court, meaning that the case starts there. Fourteen rivers of the United States have been the subject of such interstate litigation. The Supreme Court is not equipped to try cases, hear evidence, and find facts, so the Court assigns the case to a special master who writes a report that the Court reviews and accepts all or parts of the report within its decision.

Interstate litigation over the rights to use water has produced a set of legal principles that the Supreme Court applies. The first is that the Supreme Court will not decide the case unless the complaining state can show the existence or likelihood of present harm. The general principle for deciding such cases is known as equitable apportionment, where fair allocation rather than fulfilling expectations of the parties or following one state's law or the other's is the standard. Thus, the Court will look at factors such as climate and other physical conditions, present consumption of water from the river, established uses and economies, availability of water storage, wasteful uses, and damage to upstream areas compared to downstream areas if upstream uses are curtailed. (Tarlock et al., 2009, pp. 437).

Another approach to interstate disputes over the waters of a stream claimed by one or more states is by negotiating a compact. This is essentially a contractual arrangement, which, under the Constitution, requires congressional ratification. Compacts have been used many times and deal not only with allocating quantities of water but also with water quality, navigation, and other matters of common interest. Some of them call for the creation of compact commissions that have authority to interpret compact provisions and to administer water allocation between compacting parties. Although the terms of some compacts were based on mistaken facts or have inherent ambiguities that cause difficulties, and in some cases litigation has commenced anyway, they provide an orderly, more predictable, and less costly alternative to litigating rights to interstate rivers. (Wolf, 2005, pp. 138-140).

There are a few rivers in North America that cross international borders, raising issues similar to those raised by interstate rivers in the United States. The law for allocation of the waters and resolving other international river disputes is strikingly similar to the U.S. law concerning interstate rivers. In the few cases in which disagreements have reached international forums, they have essentially applied equitable apportionment principles.

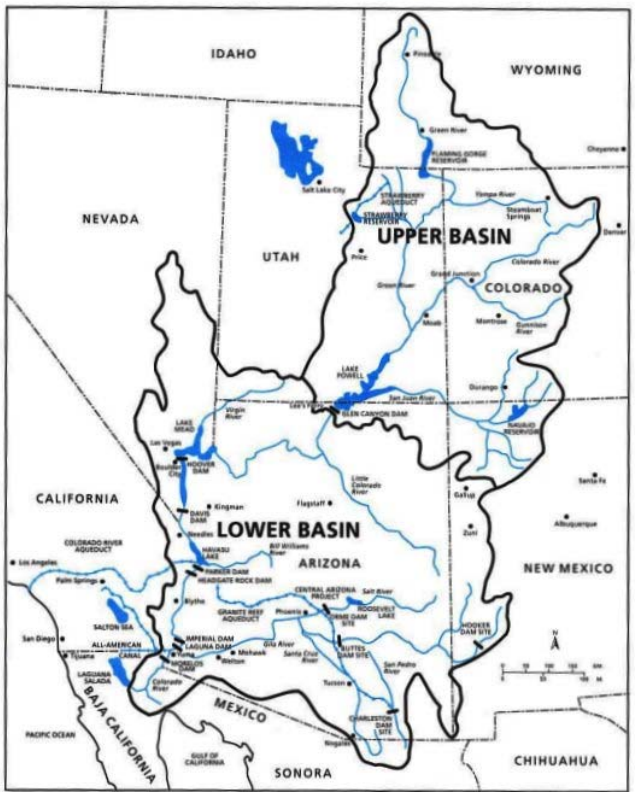
As rivers within one state or nation are subjected to greater demands, transboundary disputes become inevitable. Tempering provincial concerns and narrow self-interest is a chronic problem. Individual jurisdictions and water users within them continue to insist on using as much water as possible and pressing their individual interests. So long as the doctrine of equitable apportionment can be applied fairly by a competent entity – or the parties are willing to negotiate in good faith to such equitable ends – these disputes can be managed. Interstate or international bodies can be created to deal with the problems that inexorably arise over a finite resource as demands continue to grow. This is not unlike the role of public interest

considerations in applying the law of prior appropriation in individual states' allocation decisions.

III. A North American Case Study: the Colorado River

The six challenges posited by this paper as the greatest concerns for North American water policy are brilliantly exemplified by the Colorado River. This case study is offered as an illustration of how each of the challenges has arisen and been dealt with – though not necessarily as a model for addressing them. The six challenges intertwine in a century of history of the Colorado River, and each of them remains a challenge today.

Figure 1
Map of the Colorado River System



The Colorado is an interstate, international river. As Figure 1 shows, it is shared by seven states and between the United States of America and the Republic of Mexico. Early in the twentieth century it became apparent that the growing economies of the states along the river would need its water to sustain their growth. Most notably, California was growing rapidly in population, especially in the Los Angeles area. The city had for a time used copious artesian wells but exhausted their capacity. It expanded its boundaries to capture the economic benefits of a larger tax base and to respond to the pressures of powerful development interests. Clandestinely, the city's water department bought farmland far north of the city in Owens Valley in order to transport the water that was being used to irrigate farms there to support development in the city. (Reisner, 1993, ch. 2).

Soon more water was needed for growth. The city turned to the Colorado River. By the first decade of the twentieth century large amounts of water were already being diverted into California's hot but fertile Imperial Valley for large farms. Politicians and business people in California beseeched the federal government to provide funding for dams and canals to deliver more Colorado River water to the state and to generate electricity for its use. They also cited the need for an "all-American" canal to the Imperial Valley that did not pass through a foreign country – Mexico. (Reisner, 1993, pp. 124-125).

Perceiving the thirst of California for what the Colorado River could produce, some of the upstream states became concerned. A young Colorado lawyer named Delph Carpenter was concerned that the growing city of Denver and other places outside California would not have any water to use from the river if the principles of prior appropriation applied as among water users in different states. So with the support of his state, he rallied other interests and by 1922 a meeting of commissioners appointed to represent each of the seven Colorado River basin states

was convened under the direction of a federal chairman. The states decided to divide the river into two "basins" – upper and lower – and to divide the presumed flow of the river so that the states of each basin collectively got half the water produced on average each year.

It was then up to the state legislatures to ratify the compact. The commissioners agreed, but Arizona refused to join the other six states in ratifying the compact.. Nevertheless, after seven years of waiting for Arizona, Congress passed the Boulder Canyon Project Act in 1928, which ratified the Compact. The Act also deemed it to be effective without Arizona's action. This legislation authorized federal construction of Hoover Dam and other facilities – a huge benefit to California. (National Research Council, 2007, pp. 31-34).

Fearing that California's use of the facilities would allow it to dominate use of the river, Arizona brought several original actions in the United States Supreme Court to try to stop the development and protect its right to future use. It even called out the state militia and tried to use force to interfere with construction in a comical but tragic episode. In one of the lawsuits the Supreme Court rejected Arizona's claim that the legislation was unconstitutional. Arizona lost the other suits as well, including an action seeking equitable apportionment of the river. The latter suit was dismissed because the United States was an indispensable party that, as a sovereign, cannot be sued without its consent. (Getches, 1985).

Arizona, wracked by a multi-year drought and experiencing growth of its own, eventually ratified the compact in 1935 as its only means of getting water from the vast federal water project that would otherwise be monopolized by California. Ratification opened the way to a federal contract for water, but Arizona had no facilities to deliver the water. The enormous Central Arizona Project (CAP) that was to be built for that purpose took decades for Congress to

authorize – over vehement political objections by California. It was finally authorized in 1968 on the condition that Arizona's water rights would be subordinate to California's. Another condition was that Arizona either had to begin responsible management of groundwater or not be eligible for federal contracts for water under the long-awaited project. Arizona had been overdrafting groundwater at a grossly unsustainable rate – withdrawing 4.8 million acre-feet of water per year from aquifers that recharged only 2.6 million acre-feet. (Larson et al., 2005).

Eventually and reluctantly Arizona complied by enacting a groundwater management act. It was an agonized process that pitted mining and municipal interests against agriculture. The law gave strong control of groundwater to the state and mandated the creation of "active management areas." Growing cities were required to demonstrate a 100-year guaranteed supply of water for new development. Surprisingly, this has not constrained development. Developers immediately pressed for legislative reform and in 1993, the Central Arizona Groundwater Replenishment District was formed. The CAGRD allowed developers to purchase surplus CAP water and inject it into the aquifer to create an assured supply. This process undermines the purpose of the GMA of reducing groundwater demand. Moreover, CAGRD acknowledges that by 2015 it will have to seek new water supplies to fulfill its obligations. (Hirt et al., 2008).

Some cities like Tucson have imposed commendably rigorous conservation requirements, controlling the growth of water demand for outdoor watering. But urbanization of this desert state has continued apace, at least until the economic downturn of the last two years.

Instead of shifting water use heavily to Colorado River water delivered by the CAP, Arizona cities have continued to stake their growth on groundwater pumping and farmers have continued to pump groundwater for irrigation. Groundwater still provides more than 50% of

water for irrigation and 35% of the municipal water supply in the state. (CAST, 2009). The cities were disappointed with CAP water quality as discolored water came out of taps, and some cities have reverted to using wells. Although CAP was conceived as a project for agricultural supply, the water proved to be too expensive for many farmers and so much of the state's entitlement remained unused and groundwater is still the source of choice. This allowed California to take the unused portion of water that was allocated to Arizona under the Colorado River Compact. Arizona's responded by creating a "bank" for underground storage of its unused entitlement so it could keep water from being used across the border in California and hold it so that future entitlements might be sold later. This was indirectly a subsidy to the farmers who would continue taking groundwater – now enhanced by injected CAP water – instead of buying the CAP water directly. It also was to provide a means to sell some of Arizona's Colorado River water to Nevada. (Megdal, 2007).

Meanwhile, farmers continue to use groundwater, some of which is actually CAP water stored underground at state expense, and so do some cities. The consequence is that in the most urbanized active management areas there is no agreement on how to achieve safe annual yield and groundwater overdraft in Arizona continues. The Arizona Department of Water Resources predicts that if no new water efficiencies are created, that groundwater overdraft in the Phoenix AMA alone will increase to 471,000 acre-feet by 2025, an increase of over 30% from 1995. (ADWR, 1999, ch. 11). The will to use the power of the state to curtail this overdraft is lacking as the economic force of urbanization and sympathy for farmers allow easily accessible groundwater to be mined.

Urbanization has continued apace in Southern California and Nevada as well. Each of these areas, like the cities of Arizona, is essentially arid and depends for growth entirely on

imported water. Until recent economic stresses, the gambling city of Las Vegas was the fastest growing metropolitan area in the nation. Growth in these areas has not been constrained by the lack of natural water supplies; as always, people move to an area without considering the reliability of future water supply and, because the cost of domestic water is such a small factor in the cost of housing, they assume that investments will be made by responsible authorities, and that water will be provided. It always has been. Southern California depends on importing Northern California water through a state water project as well as importing Colorado River water. But the safety valve for new growth has been the Colorado River, which it has tapped for quantities well beyond its legal entitlement to Colorado River water.

California's share of water from the river, like the shares of Arizona and Nevada, was set in the 1928 Boulder Canyon Act. Congress, in authorizing dams and facilities and ratifying the 1922 Colorado River Compact carved up the share of water that was supposed to be used in the lower basin states according to that Compact. The idea was that the federal dams would make this water use possible and the federal government would manage the water produced by these facilities by contracting with water users in the various states. But the assumption under these laws was that if one state, or one basin, did not use all the water allocated to it, others could use it until the states that were not using their shares had demand for it. (Reisner, 1993, p. 124-125).

So, California as the fastest growing state could soak up the water not needed by the slower growing upper basin states and which could not be used in Arizona because of its lack of delivery facilities, at least until the CAP was built. By the end of the twentieth century, California was using 5 million acre-feet, about 15% more than its legal entitlement of 4.4 MAF. During years of negotiation the seven states of the Colorado River hammered out complex plans for how California would begin to reduce demands on the river, reining in slowly, the overuse of

water that has slaked the thirst of growing cities in Southern California. Some adjustments were made in how water would be used – and shared among states – in drought, effectively modifying the apparent hard edges of the Compact. Part of California's "soft landing" in a forced curtailment of Colorado River use was tied to conservation measures that allowed huge agricultural districts to sell saved water to growing urban areas of Southern California.

A 2003 Quantification Settlement Agreement (QSA) was intended to resolve long-standing tensions among agricultural and municipal suppliers as well as to curtail overall use of Colorado River water in Southern California. The irrigation districts' use was to be reduced by modernizing their irrigation systems and cutting back on irrigation of the least productive lands. One feature is lining two vast canals that take river water through desert sands to irrigated district lands. (Erie, 2006, pp. 140-43).

The QSA took many years to negotiate and will require billions of public dollars to implement. It has not really quelled some of the hostilities among users and its practical effectiveness has not been tested. At a minimum, the approach illustrates the difficulty of reducing the dependence of an urban area on a water supply to which it has become accustomed. Moreover, its fate is complicated by the fact at, as of this writing, the QSA has been invalidated by a 2010 California trial court decision that is being appealed.

The quest to reduce California's overuse of the river illustrates the persistence of transboundary competition for water notwithstanding the existence of a compact, multiple legislative acts, the investment of billions of federal dollars, and extensive interstate litigation. The upper basin states of Colorado, Utah, Wyoming, and New Mexico have struggled to force

California to reduce its use so that if and when those states collectively are able to put their share of Colorado River water to use, it will be available.

The Colorado River, of course, is shared by Mexico through which it passes before reaching the Gulf of California (also known as the Sea of Cortez). The Colorado River Compact allocated no water to Mexico, saying only that if it were later determined that Mexico was entitled to water from the river the obligation to deliver it would be shared equally by the four upper and three lower basin states. By the 1930s, Mexico had registered its strong views that it needed validation of a right to water from the river. Finally, in 1944 the United States and Mexico signed a treaty assuring Mexico of 1.5 million acre-feet per year. This marked a shift in the United States' longstanding position that under the doctrine of absolute territorial sovereignty it owed Mexico nothing and could use the river to extinction within the United States. The change of position coincided with increasing anxiety over maintaining friendly relations with Mexico, a neighbor with an extensive shared border, during World War II. (Mumme, 2000).

The Colorado River basin's first major environmental problem to cause legal issues – though not the last – was salinity. It was manifested as another international transboundary problem, and it arose under ambiguities left in the 1944 Treaty. Following the building of Hoover Dam and associated facilities the other basin states campaigned relentlessly for federal investment in projects to benefit them. Many were authorized by Congress and by the 1960s some had been built. The most significant was Glen Canyon Dam. With a capacity of 27 million acre-feet, it is about the same size as Hoover Dam. Together they could store about four years' annual flow of the river. During the many years it took the reservoir behind Glen Canyon Dam (called Lake Powell) to fill, only the bare minimum flows required under the treaty reached

Mexico. By the time the water left the United States, much of it had been many times diverted, used, and returned to the river increasingly laden with salts picked up from the irrigated soils.

Mexico protested, arguing that the water left over for Mexico's farmers was too salty to use – such that it actually killed some crops. This was alleged to be a violation of the Treaty with Mexico. Again, the U.S. was firm with Mexico in its resistance, at least at first. It simply replied that the treaty guaranteed delivery of water, not water of a particular quality. Eventually the two countries worked out an amendment to the treaty, Minute 242, that required that salt concentrations in the water delivered to Mexico be close to salt levels in the water being diverted for irrigation in the United States. The agreement with oil-rich Mexico was reached during the 1970s energy crisis in the United States. (Mumme, 2000).

Implementing the reduction in salinity proved very costly. It involved lining the Coachella Canal, protective pumping, interception of salt seeps, and other measures. The largest source of salts was a single, large irrigation project in southwest Arizona at the mouth of the Gila River. The Wellton-Mohawk Irrigation Project facilities had been built by the federal government. Taking water from the Colorado River through these facilities, the district applied them to lands with saline soils. The irrigated area became increasingly saturated and drainage was needed. Wells then pumped the salty water to a tributary of the Colorado, causing noticeable increases in the river's salinity and sparking the outcry from Mexico. Taking the area out of irrigation to solve the salinity problem was not seriously considered. (Bureau of Reclamation, 2005).

One of the most ambitious plans for enabling the U.S. to produce water of a sufficient quality to satisfy the agreement with Mexico was construction of the Yuma desalination plant,

which would remove salts from the Wellton-Mohawk irrigation return flows so that this water could be mixed into the river water being delivered to Mexico. While the plant was under construction, the briny waste would go through a canal built to deliver it to the plant and continue through an extension of the canal to an area near the delta of the Colorado River until the plant became operational, and could process the salty water. The expensive desalination plant was completed in 1992, but not operated for the next eighteen years, and so the brine continued passing to this delta area known as the Santa Clara Slough. (National Research Council, 2007, pp. 46-47).

The most recent environmental issue that has engaged the United States and Mexico involves the delta area where the river terminates in the Sea of Cortez. Many thousands of acres of rich wetlands in Mexico for centuries sustained vast populations of birds and fish. A vibrant fishing industry thrived there and indigenous people lived comfortably off local resources. When the flows to Mexico dwindled to the minimum required under the treaty, and nearly all of it was taken for use on Mexican farms, the delta area dried up. A vestige of these wetlands was revived and sustained by the highly saline water that was being disposed in the Santa Clara Slough – a supposedly temporary measure until the desalination plant was built.

In the 1990s, during a few high-flow years, the reservoirs on the Colorado in the U.S. exceeded their capacity and "surplus" water flowed to Mexico. The delta area was revitalized, and scientists and environmentalists began an effort to secure sufficient flows to make permanent this accidental restoration. That ten-year effort continues with multi-party collaboration in trying to secure the relatively small annual flows plus occasional large surges that are needed to make the restoration of the delta sustainable. (Pitt, 2001). The interest of U.S. water interests and state and federal governments, Mexican farmers and governmental entities has been aroused by the

prospect for linking environmental restoration with projects for water and sewage treatment and activating the long-moribund desalination plant. The border cities are especially in need of support for such facilities and this has kindled their interest.

Of all the environmental impacts of the dams on the Colorado the greatest attention has been given to another issue. It concerns a few, nearly extinct species of fish indigenous to the river. The problem became more apparent with scientific and public consciousness of the near-extinction of several species of fish indigenous to the river although scientists had been aware of it for a long time. This neglected issue received attention because of a powerful federal law. In the 1980s, the United States Fish and Wildlife Service announced that no more water development could take place on the Colorado or its tributaries without assurance that it would not cause harm to the continued existence of the several threatened and endangered fish species. The Endangered Species Act was to become the primary barrier to water development in the basin as scientists agreed that a primary cause of the demise of the fish was damming and depletion of the river. A process initiated in 1984 among the upper basin states engaged state and federal officials, water developers, and environmentalists to find a way to comply with the ESA without thwarting all water development. After four years a recovery program was agreed upon, and since then more that $120 million in public money has been spent to implement it. The money has been spent mostly on trying to restore the habitat destroyed by water project development. Unfortunately, it appears that fewer fish survive today than when the program began. (Rosner, 2010). A similar program was initiated in the San Juan River basin, a tributary to the Colorado. And in the lower basin there is a large, Lower Basin Multi-Species Conservation Program. Tens of millions of dollars have been spent on these programs as well.

A relatively recent, transboundary issue with Mexico involves groundwater. Early in the twentieth century, in addressing the interstate issues discussed above, the U.S. Congress agreed to spend public money to build water facilities. One of the projects undertaken after the passage of the 1928 Boulder Canyon Project Act was the construction of the All-American Canal. At the time, a rich agricultural industry had grown up in the hot and fertile, but otherwise dry Imperial Valley based on Colorado River Water. The water was taken through the Alamo Canal that was built through Mexico in 1901 to fields north of the border in California. The canal broke during flood years causing damage and interrupting irrigation. To forestall further disasters and to allay concerns that Mexico would lay claim to the water passing through the canal and disrupt the valley's lucrative enterprise, California and local interests championed a canal entirely within the United States. The All-American Canal was completed in 1940, diverting 3 million acre-feet of water per year at Imperial Dam and delivering it to irrigation districts just north of the border.

This huge canal not only delivers vast amounts of water to U.S. farmers, but it leaks large quantities of water – about 67,000 acre-feet per year. At first, this caused flooding, but farmers and communities began pumping and using the water. Local farmers and other users in Mexico became dependent on the availability of this water. The seepage also had environmental benefits, feeding wetlands and terrestrial habitat. In 1988, the United States Congress authorized a canal lining project to capture the seepage so the water could be used in the United States. This was seen partly as a means of providing water to satisfy the commitment made to San Luis Rey Indian tribes in Southern California settling their water rights on a river having no connection to the Colorado, but primarily it would provide even larger quantities of water from the Colorado to growing urban areas of Southern California. (Public Law 100-675, 1988). Federal funds were not

provided because Congress assumed that the cities benefiting from the canal lining would pay for the project. (Bureau of Reclamation, 2006, p. 1.1-1.2).

The failure to consult with Mexico or local water users before the United States unilaterally assumed the seepage water belonged to it created international tensions and Mexico protested. Few discussions were held between the two countries. Canal lining remained a threat to Mexico, but was not moving ahead because of a lack of funding. California eventually said it would pay for the project as part of the Quantification Settlement Agreement discussed above. Thus, it became an element in the complicated arrangement for resolving interstate differences and helping California reduce its overuse of Colorado River water.

Opposition to the canal lining project was not confined to Mexico, but included interests in the United States. This led to a federal lawsuit focusing on the environmental impacts by varied interests, which ranged from community groups in Mexico, to a U.S. city, to environmental organizations in both countries. The action was eventually dismissed with the United States Court of Appeals for the Ninth Circuit holding that the environmental claims were moot because, while the appeal of a lower court dismissal was being considered in 2006, Congress passed legislation saying that the only law governing construction of the canal was the 1944 Treaty with Mexico. This effectively left the court nothing to decide under the National Environmental Policy Act, the Endangered Species Act, the Migratory Bird Treaty Act, and other laws cited by the plaintiffs. (*Consejo de Desarrollo Economico de Mexicali v. United States*, 2007). The canal construction could – and did – commence. (Cortez-Lara et al., 2008).

The issue of tribal rights to water is another critical issue on the Colorado. Thirty-four Indian reservations are located within the Colorado River Basin and an additional twenty-three

reservations located outside the basin have traditional or aboriginal interests in the basin. (Pontius, 1997 p. 69). No reliable estimates exist for the potential water rights claims of these tribes but one extreme estimate was as high as 2 million acre-feet per year for the Navajo Nation alone. (Back & Taylor, 1980, p. 74).

The case of *Arizona v. California* decided by the Supreme Court in 1963 included the reserved water rights claims of five Indian reservations along the mainstream of the Colorado. The practicably irrigable acreage formula adopted by the Court for quantifying such rights resulted in findings that the tribes are entitled to use annually more than 1.3 million acre-feet per year. At this point, only a small fraction of these rights is being used. On a river where others now use more than the total average annual flow, the assertion of these rights would be profoundly disruptive. Meanwhile, many other tribes in the basin are seeking adjudication of the quantities of water to which they are entitled. For the last thirty years, the Navajo Nation has engaged in a series of negotiations with the various Colorado River Basin states to claim its outstanding water rights. These efforts have resulted in enactment of the Navajo Indian Irrigation Project and securing a share of the Gila River Indian Community Settlement. Notably, the Navajo Nation's long-standing water rights claims with the state of New Mexico were recently resolved and embodied in federal legislation, the Omnibus Public Lands Management Act of 2009. The Act secured the use of 600,000 acre-feet per year to the Navajo Nation as well as allocating $870 million for water delivery infrastructure. The Navajo Nation has significant outstanding water rights in both Utah and Arizona as well, which could amount to an additional 450,000 acre-feet per year. (Jenkins, 2008).

Some tribes in the basin states that are not located along the river itself have pressed their rights and achieved settlements including quantified rights. Several Arizona tribes have had their

rights quantified and – given the other pressures on scarce water supplies – Congress has declared that the water for those tribes is to come from the CAP and from reclaimed sewage. As discussed earlier, CAP water has proven uneconomical for many users in Arizona, so this arrangement provides not only a way to furnish water to the tribes but puts the federal government itself in the position of assuming the cost – which is otherwise payable to the federal government. Moreover, the tribes may sell the water on a limited basis. They need not pay for the water because it is part of their entitlement so they can effectively sell CAP water at less than the usual cost to irrigators and cities. Negotiations are underway for the settlement of water claims of as many as 13 tribes in the Colorado River basin states. (Weldon & McKnight, 2007).

All of the issues discussed – transboundary competition, growth in urban demand, environmental pressures, tribal rights, groundwater availability – are compounded in times of water shortage. And for the states whose water uses depend on the Colorado shortages are an unavoidable reality. First, the transboundary allocation arrangements beginning with the 1922 Compact were erroneously predicated on average flows being 16.5 million acre-feet, which then seemed reasonable based on the short period of record available. The idea was to build enough reservoirs at the right places to distribute that quantity of water, on average, each year. But the Colorado River, like many other western streams, has highly variable flows and droughts are part of the natural scheme. Flows in the Colorado have varied from a high of 22.2 million acre feet per year in 1984 to a low of 3.8 maf/yr in 2002. (USGS, 2004). And new data based on studies of tree rings going back several centuries reveal a troubling reality: the average flow appears to be only about 13.5 million acre-feet. (Woodhouse et al., 2006).

The cyclical variations in stream flows exacerbated by multi-year droughts, and the over-allocation of the water produced by the river, are now further complicated by climate change

impacts, some of which are being felt already and other, graver impacts, are being projected by modeling that increasingly has gained consensus among scientists. A study based on the Intergovernmental Panel on Climate Change data, predicts that in the Colorado River basin runoff may decrease 30% during the 21st century and that the requirements of the Compact may be only met 60-75% of the time by 2025. (Bates et al., 2008). A recent study that has combined multiple climate models makes more modest findings, still projecting supply being reduced below current demand. (Christensen & Lettenmaier, 2007). Projecting growth in demand, including allowing the upper basin states, which are not using their full apportionment, creates an even more troubling scenario.

IV. Conclusion

The multiple and intersecting water policy challenges facing the Colorado River illustrate the confounding complexity of modern water problems. Although not all regions experience as elaborately the six challenges discussed in that case study, several of those scarcity-inducing challenges exist in some measure throughout the Americas. Coping with these challenges by forming policies that take account of the forces inherent in each of the challenges, rather than assuming that "water problems" are simply about finding and delivering a water supply, is the work of water experts and water managers, as well as the work of community and national leaders.

References

Amos, A. (2006). The Use of State Instream Flow Laws for Federal Lands: Respecting State Control while Meeting Federal Purposes, 36 *Envtl. L.* 1237.

Arizona Department of Water Resources (ADWR), (1999), Third Management Plan for Phoenix Active Management Area 2000-2010. Phoenix, Arizona.

Arizona v. California, 373 U.S. 546 (1963).

Back, W. & Taylor, J. (1980). Navajo Water Rights: Pulling the Plug on the Colorado River, 20 *Nat. Resources J*. 71.

Bates, B.C., Z.W. Kundzewicz, S. Wu, & J.P. Palutikof, (Eds.), (2008). *Climate Change and Water. Technical Paper of the Intergovernmental Panel on Climate Change*. Geneva: IPCC Secretariat.

Bean v. Morris, 221 U.S. 485 (1911).

California Department of Water Resources (CDWR). (2008) *Managing an Uncertain Future, Climate Change Adaptation Strategies for California's Water.*

Available at www.water.ca.gov/climatechange/docs/ClimateChangeWhitePaper.pdf.

Council for Agricultural Science and Technology (CAST). 2009. *Water, People, and the Future: Water Availability for Agriculture in the United States.* Issue Paper 44. CAST, Ames, Iowa.

Christensen, N. S., & D. P. Lettenmaier (2007), A multimodel ensemble approach to assessment of climate change impacts on the hydrology and water resources of the Colorado River Basin, *Hydrology and Earth System Sciences*, 11, 1417-1434.

Consejo de Desarrollo Economico de Mexicali v. United States, 482 F.3d 1157 (9th Cir. 2007).

Cortez-Lara, A., Donovan, M. K., & Whiteford, S. (2009) The All-American Canal Lining Dispute: An American Resolution over Mexican Groundwater Rights? *Frontera Norte,* Vol. 21, No. 41: 127-150.

DeCoteau, J. (2006). Effects of Non-Indian Development on Indian Water Rights. In John E. Thorson, J.E., Briton, S. & Colby, B.G. (Eds.), *Tribal Water Rights: Essays in Contemporary Law, Policy, and Economics* (pp. 115-28). Tucson: University of Arizona Press.

Doremus, H. (2001). Water, Population Growth, and Endangered Species in the West, *72 U. Colo. L. Rev.* 361.

Erie, S. P. (2006). *Beyond Chinatown: the Metropolitan Water District, Growth, and the environment in Southern California*. Stanford, CA: Stanford University Press.

Field, C.B., L.D. Mortsch,, M. Brklacich, D.L. Forbes, P. Kovacs, J.A. Patz, S.W. Running & M.J. Scott. (2007). North America. *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson. (Eds.). Cambridge, UK: Cambridge University Press. 617-652.

Getches, D. H. (1985) Competing Demands for the Colorado River, *56 U. Colo. L. Rev*. 413.

Getches, D. H. (2000) Metamorphosis of Western Water Policy, 20 *Stanf. Envtl L. Rev.* 1.

Getches, D. H. (2009) *Water Law in a Nutshell*, (4th ed.) St. Paul, MN: Thomson/West.

Hirt, P., Gustafson, A. & Larson. K.L. (2008). The Mirage in the Valley of the Sun. *Environmental History*. 13: 482-514.

Jenkins, M. (2008, March 17) Seeking the Water Jackpot. High Country News, 10-16.

Kenny, J.F., Barber, N.L., Hutson, S.S., Linsey, K.S., Lovelace, J.K., & Maupin, M.A. (2009). *Estimated Use of Water in the United States in 2005* (U.S. Geological Survey Circular 1344), available at http://pubs.usgs.gov/circ/1344/pdf/c1344.pdf

Larson, E.K., Grimm, N.B., Gober, P. & Redman, C.L. (2005). The paradoxical ecology and management of water in the Phoenix, USA metropolitan area. *Journal of Ecohydology and Hydrobiology* 5(4): 287-296.

Leshy, J.D. (2008). The Federal Role in Managing the Nation's Groundwater. *14 Hastings W. N.W. J. Envtl. L. & Pol'y* 1323.

Megdal, S. B. (2007). Arizona's Recharge and Recovery Programs in Colby, B.G. & Jacobs, K.L. (eds). *Arizona Water Policy: Management Innovations in an Urbanizing, Arid Region (pp. 188-203).* Washington, DC: RFF Press.

Mumme, S.P. (2000) Minute 242 and Beyond: Challenges and Opportunities for Managing Transboundary Groundwater on the Mexico-U.S. Border, *40 Nat. Resources J.* 341.

National Research Council (2007). Committee on the Scientific Basis of Colorado Basin River Water Management, *Colorado River Basin Management: Evaluating and Adjusting to Hydroclimatic Variability*. Washington, D.C.: National Academies Press.

National Research Council (1992). National Academy of Science, *Water Transfers in the West: Efficiency, Equity, and the Environment*. Washington, D.C.: National Academies Press.

Parry, M.L., Canziani, O.F., & Palutikof, J.P. (2007). Technical Summary. *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* Parry, M.L., Canziani, O.F., Palutikof, J.P., van der Linden, P.J., & Hanson, C.E. (Eds.). Cambridge, UK: Cambridge University Press. p. 23-78.

Pitt, J. (2001). Can we restore the Colorado River Delta? *Journal of Arid Env'ts* 49 (1): 211-220.

Pontius, D. (1997). *Colorado River Basin Study*, Final Report to the Western Water Policy Review Advisory Commission.

Reisner, M., (1993). *Cadillac Desert: The American West and its Disappearing Water* (Rev. ed.). New York: Penguin Books.

Riverside Irrigation Dist. v. Andrews, 758 F.2d 508 (10th Cir. 1985).

Reynolds, K. A., Mena, K. D., & Gerba, C. P., (2008), Risk of Waterborne Illness Via Drinking Water in the United States, *Rev. Environ. Contam. Toxicol*. 192: 117–158.

Rosner, H. (2010, June 7). One Tough Sucker. High Country News, 12-19.

Tarlock, A.D., Corbridge, J.N., Getches, D.H., & Benson, R. (2009) *Water Resource Management: A Casebook in Law and Public Policy* (6th ed.). New York: The Foundation Press.

Travis, W. (2007). *New Geographies of the American West*. Washington DC: Island Press.

United States v. New Mexico, 438 U.S. 696 (1978).

United States v. Winters, 207 U.S. 564 (1908).

U.S. Bureau of Reclamation. (2006). All-American Canal Lining Project Supplemental Information Report.

U.S. Bureau of Reclamation (2005), Quality of Water, Colorado River Basin, Progress Report 22.

Available at http://www.usbr.gov/uc/progact/salinity/pdfs/PR22.pdf

USEPA. (2009). Drinking Water Infrastructure Needs Survey and Assessment: Fourth Report to Congress. EPA 816-R-09-001. Office of Water, U.S. Environmental Protection Agency, Washington, DC.

USGS. (2004). Climatic Fluctuations, Drought, and Flow in the Colorado River Basin. (U.S. Geological Survey Fact Sheet 2004-3062 version 2).

Weldon, J.B. & McKnight L.M. (2007). Future Indian Water Settlements in Arizona: The Race to the Bottom of the Waterhole, *49 Arizona Law Review* 441.

Wilkinson, C. F. (1992). *Crossing the Next Meridian: Land, Water, and the Future of the West*. Washington, DC: Island Press.

Wolf, A. (2005) Transboundary Water Conflicts and Cooperation. In Kenney D. (Ed). *In Search of Sustainable Water Management*. (pp. 131-154). Northampton, Mass: Edward Elgar Publishing.

Woodhouse, C. A., Gray, S. & Meko, D. (2006). Updated streamflow reconstructions for the Upper Colorado River Basin. *Water Resources Research* 42(5), W05415, doi: 10.1029/2005WR004455.