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Integrating Science and Policy for Water Management: A Case Study of the Upper San Pedro River Basin

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1.1 INTRODUCTION

This chapter presents empirical evidence of the positive impacts, on watershed management, of scientists and policy researchers working closely with water managers and basin stakeholders in a functioning HELP basin for the Upper San Pedro River of northern Sonora and south-eastern Arizona. We argue that transboundary cooperation in policymaking and water management is most effective when hydrologists help watershed groups understand the processes controlling water quality and quantity, and when water managers and stakeholders connect these processes to social, economic and legal issues. In this chapter, we assess the distinctive nature of the Upper San Pedro River Basin, in terms of its physical and socioeconomic characteristics as well as the issues of water law and policy in Arizona and Sonora, especially the differences in institutional regulations, water law issues, and local implementation. We assess the accomplishments and challenges of the basin's two most influential watershed groups, the U.S.-based Upper San Pedro Partnership (known simply as, the Partnership) and the Mexico-based Sonora-Arizona Regional Environmental Association (Asociación Regional Ambiental Sonora-Arizona, or, ARASA). We demonstrate how stakeholders and scientific researchers in both portions of a binational basin strive to balance ecosystem needs with human demands to create new, integrated basin management. Finally, we offer to the HELP agenda the major accomplishments of this collaboration and the lessons learned from the San Pedro HELP Basin experience.

1.2 PHYSICAL CHARACTERISTICS

The Upper San Pedro River Basin, located in the semi-arid border region of south-eastern Arizona and north-eastern Sonora (Figure 1.1), lies entirely within the "Basin and Range" physiographic province, a region of steep, elongated, north-south running mountain ranges separated by wide, flat, arid or semi-arid

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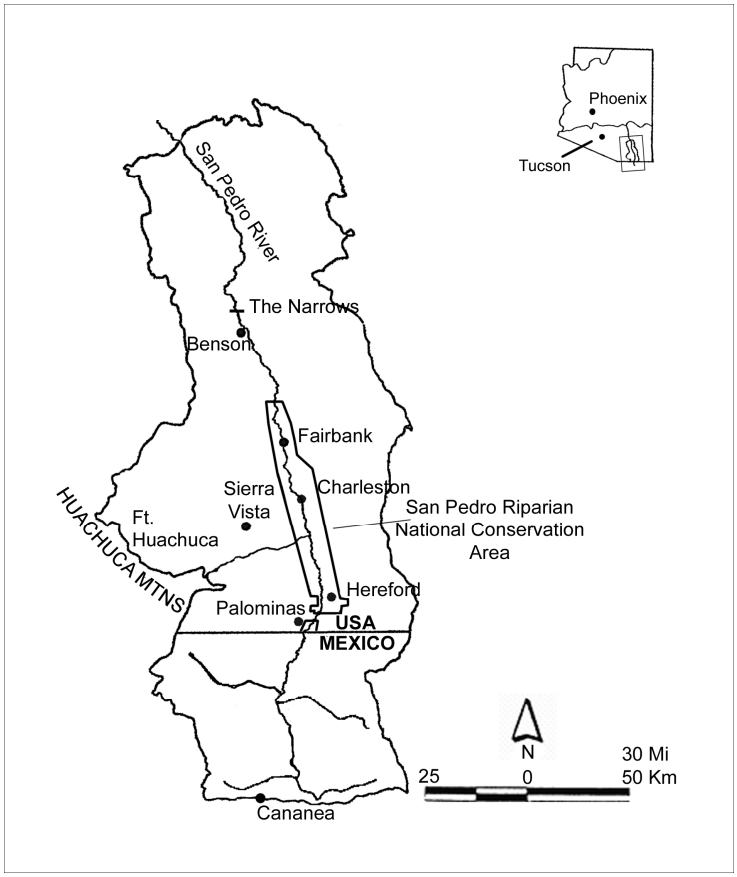

valleys, extending from eastern California to central Utah, and from southern Idaho into the state of Sonora in Mexico. The Upper San Pedro River Basin comprises a broad, high-desert valley bordered by mountain ranges and bisected

Figure 1.1 Upper San Pedro River Basin, Arizona (U.S.) and Sonora (Mexico) (Source: Sprouse 2005:12)

by a narrow riparian corridor sustained by groundwater discharge. The basin has a variety of characteristics that makes it an exceptional outdoor laboratory to

address a large number of scientific and socioeconomic challenges germane to the aim of HELP. The area features significant topographic and vegetative variation, and has a highly variable climate. It is an international basin whose headwaters originate in Mexico. Vastly different historical and contemporary land use practices have occurred on either side of the international border, including fire suppression policies, livestock-grazing management practices, and urban and rural development patterns. The upper watershed encompasses an area of approximately 7600 km^2 with approximately 1800 km^2 of that area in Mexico. Elevations within the basin range from roughly 900 m to 2900 m (Kepner *et al*., 2002: 181).

Annual precipitation in the Upper San Pedro River Basin ranges from around 300 mm in the lower and northern portions of the basin to over 750 mm in the Huachuca and Catalina mountains. Approximately 65 percent of this typically occurs during the July through September monsoon season from high intensity air-mass convective thunderstorms. Roughly 30 percent comes from less intense winter frontal systems. Potential evapotranspiration is estimated at more than ten times annual rainfall at lower elevations in the basin (Renard *et al*., 1993). Interannual climate variability is also high with a demonstrated linkage to the El Niño-Southern Oscillation (Woolhiser *et al*., 1993). Major vegetation types include desert shrub-steppe, riparian, grasslands, oak savannah, Madrean oak woodland, ponderosa pine and mixed coniferous forests. In portions of the basin all of these vegetation types are encountered within a span of 20 km. Landcover in the basin changed dramatically in the period between 1973 and 1986, with mesquite woodlands increasing from 2.75 percent to 14.05 percent, largely replacing desert grasslands (Arias, 2001: 6-7; Kepner *et al*., 2002: 187). These changes are largely attributable to climatic fluctuations, livestock grazing, and more recently, rapid urbanization affecting fire regimes and other factors.

1.2.1 Population and Socioeconomic Characteristics

Approximately 114,000 people live and work in seven incorporated towns and several unincorporated communities in the two countries within the Upper San Pedro River Basin. Principal economic drivers in the valley include the U.S. Army's Fort Huachuca on the Arizona side of the border and the copper mines near Cananea on the Sonora side (CEC, 1999). Population in the Mexican portion of the Upper San Pedro River Basin is mainly concentrated in Cananea and Naco. Most of Cananea's 36,000 residents (INEGI, 2003) depend economically on the copper-mining operation that has been there for over 100 years. This mine represents the largest single source of water consumption in the watershed. However, groundwater availability is essential to sustain the

ranching and agriculture in the Mexican portion of the basin as well. Approximately nine *ejidos*, or communal agricultural settlements, are dispersed across the Mexican subwatershed. Closer to the border, the municipality of Naco has approximately 5,300 residents, which can swell to 7,000 with transient workers waiting to cross into the United States. North of the border, population is concentrated near the city of Sierra Vista, with 40,000 residents, drawn largely from the military base and retirees (Varady *et al*., 2000).

1.2.2 Why Is This Basin So Distinctive?

The San Pedro Basin sits at the ecotone between the Sierra Madre Mountains to the south, the Rocky Mountains to the north, the Sonoran Desert to the west, and the Chihuahuan Desert to the east. As the only remaining perennial stream in the region, the San Pedro River serves as an international flyway for over 400 species of birds. One of the most ecologically diverse areas in the western hemisphere, the basin contains as many as 20 different biotic communities, supports a number of endangered plant and animal species, and "possesses one of the richest assemblages of land mammal species in the world" (CEC, 1999: 3). The basin has been designated a globally important bird habitat by the National Audubon Society and named "One of the World's Last Great Places" by The Nature Conservancy (www.lastgreatplaces.org/sanpedro). In 1988, the United States Congress established the San Pedro Riparian National Conservation Area (SPRNCA) (U.S. Congress, 1988), the first reserve of its kind in the nation, to protect riparian resources along 60 km of riverine territory north of the U.S.-Mexico border. SPRNCA is administered by the U.S. Bureau of Land Management (BLM, 1989).

In the face of continued population growth, there is great concern over the long-term viability of the San Pedro riparian system. Groundwater sustains the system throughout its length during dry seasons. A predicted decline in northern Mexico's water availability not only might threaten the viability of the San Pedro River but also might exacerbate the increasing competition for water resources between productive sectors such as agriculture and industry and domestic consumption (Magaña and Conde, 2001: 1).

The threat of excessive groundwater pumping within this riparian system prompted the first application of international environmental law within the United States via the environmental side accord of the North American Free Trade Agreement. In the resulting fact-finding report, *Ribbon of Life: An Agenda for Preserving Transboundary Migratory Bird Habitat*, the CEC-appointed technical-expert team recommended the creation of a Coordinated

Resource Management Program to develop a basin water-planning and management plan (CEC, 1999).

A fifty-year record of scientific investigations within the U.S. portion of the basin provides a unique resource for researchers: an essential foundation upon which to base water management and policy decisions. Much of this research has been centered on the U.S. Department of Agriculture–Agricultural Research Service's (USDA-ARS) Walnut Gulch Experimental Watershed, a sub-watershed within the USPRB (Renard *et al*., 1993; Goodrich and Simanton, 1995). In the early 1990s the core of interdisciplinary researchers from Walnut Gulch formulated the SALSA (Semi-Arid Land-Surface-Atmosphere) Program to expand research into the USPRB in both countries (Wallace, 1995; Goodrich *et al.*, 2000a; Chehbouni *et al*., 2000). The SALSA Program (1995-2000), which will be discussed in depth later in this chapter, expanded the range of disciplines contributing to investigations and initiated much more direct interaction with watershed managers, decision-makers and the public to focus current research onto pressing basin needs. Much of the research initiated in SALSA has been continued and expanded via the SAHRA (Sustainability of semi-Arid Hydrology and Riparian Areas) NSF Science and Technology Center (www.sahra.arizona.edu) starting in 2000.

Perhaps one of the most distinctive aspects of the basin is the difference in the laws governing water management and allocation in the two portions of the basin. Mexican water management traditionally has been carried out in a centralized manner from Mexico City, with large regional watershed districts linked both to state governments and to Mexico City. Devolution of responsibility for watershed management from state and regional levels to watershed and municipal levels has been slow and somewhat problematic because the task is large and budget, small to support its implementation. Water laws in the United States that deal with management, especially in the West, also have shifted the focus to the watershed level with multiple stakeholder and agency involvement. But the concept of water rights in the West, including Arizona is based on prior appropriation tempered by federal reserved water rights, Section 321, and the Endangered Species Act (ESA, 1973). Western water law also has changed water from a common pool resource into private property (Glennon, 2004), while Mexican water is a common pool resource with water use rights determined by the government through the Mexico National Water Commission (CNA).

One other distinct aspect of the Upper San Pedro River Basin is the growth and mobilization of the two key stakeholder organizations, the Partnership in Arizona and ARASA in Sonora. Although many aspects of their internal organizational structure and composition differ significantly, both organizations have gained or are garnering the support of numerous municipal,

state, and national agencies, as well as environmental nongovernmental organizations, in their efforts to address complex challenges associated with water quantity and quality. However, the Partnership is the only one that has research scientists as active members.

1.2.3 Stakeholder Organizations

1.2.3.1 The Upper San Pedro Partnership

In 1998, the Upper San Pedro Partnership was formed under an interagency Memorandum of Understanding in 1998, to facilitate and implement sound water management and conservation strategies in the Sierra Vista subwatershed of the Upper San Pedro River Basin. The consortium's mission is "to coordinate and cooperate in the identification, prioritization and implementation of comprehensive policies and projects to assist in meeting water needs… to protect the people and natural resources of the Sierra Vista Sub-watershed… [and] to ensure an adequate long-term groundwater supply is available to meet the reasonable needs of both the area's residents and property owners (current and future) and the San Pedro Riparian National Conservation Area (SPRNCA)" (Upper San Pedro Partnership 2000: 2). The Upper San Pedro Partnership defined operational objectives in 2001 to support this goal:

- Develop a working conservation plan for the Sierra Vista Subwatershed by 2003, which will be updated annually to incorporate the most recent strategies and scientific findings. The plan will identify strategies that can be implemented and verified, as well as possibilities to be explored in the future.
- Define the acceptable range of hydrologic conditions necessary to meet the Partnership's goal, including depth to groundwater, groundwater deficit, groundwater gradients and natural variability of river surface flows. Then recommend strategies to maintain favorable conditions and monitor to assess performance and to guide future actions.
- Provide the necessary leadership to:

(1) Leverage private, local, state and federal funding to implement projects in support of the Partnership's goal.
(2) Develop the political support necessary for effective water policy formation and project implementation.
(3) Support member agencies in their efforts to conserve water resource.
(4) Develop and implement a public education and participation plan that encourages citizens and businesses to conserve and use water wisely.

(5) Promote collaboration with Mexican counterparts regarding water resources.

The Partnership's organizational structure, membership composition and method of operation have demonstrated an effective approach in breaking the previously discussed "paradigm lock." The Partnership is a consortium of 20 federal, state and local agencies, nongovernmental organizations, and a private water company. Their approach is an adaptive management process wherein annual plans are refined based on the best science currently available to policymakers. As a result, ongoing monitoring and research information is integrated continuously into the planning and decision making process. Tools such as groundwater models and decision-support systems play an important role in this process. Through collaboration with other entities such as HELP, the National Oceanic and Atmospheric Administration (NOAA), and the Netherlands-based Dialogue on Water and Climate, the Partnership's efforts are being shared with the Mexican portion of the basin, with an emphasis on collaborative sharing of information and management strategies.

Within the U.S. portion of the basin the Partnership provides opportunities for public involvement in the research and management process, while Mexican local stakeholder involvement has been sporadic and not encouraged so strongly. The presence of such different legal perspectives challenges the efforts of scientists and policy makers to collaborate on transboundary water issues. Binational treaties and agreements between Mexico and the U.S. are also limited in providing guidance for dealing with groundwater issues, as this chapter will indicate.

Scientists remain focused on research and monitoring issues that are critical to the information needs of decision-makers, to the extent that both parties design research projects jointly from initiation. In turn, decision-makers are in a position to assist with securing the financial and political resources required to support pivotal projects. The Partnership operated under a $33.9 million five-year financial plan during their first five years. The potential for breaking the paradigm lock and planning successful binational management efforts increases with informal communication and cooperation among local borderlands agencies and nongovernmental organizations. The research coordination, binational forums, and evolution of the Partnership and ARASA working together, all suggest a growing momentum toward coordinated water-resources management. However, this process requires continued collaboration between policymakers and physical scientists to integrate science and practice. Scientists working along the San Pedro face not only disparities in transboundary data collection, analysis, archiving and dissemination, but also planning and decision-making processes sensitive to sovereignty and

jurisdictional autonomy, as well as water policies that fail to address stakeholder values other than market commitments.

A major challenge in addressing the mission of the Partnership was to attempt to quantify water needs for the SPRNCA. Decision-makers needed sound science to provide guidance as to what "success" might look like for the San Pedro River in hydrologic terms; how else could they know whether their objectives in terms of the river had been met? To address this information need, members of the Partnership, including scientists and decision-makers, crafted a three-year interdisciplinary research project that would:

- determine temporal and spatial water needs of riparian vegetation within the SPRNCA to ensure its long-term ecological integrity;
- quantify total consumptive water use of riparian vegetation within the SPRNCA for water budgets and groundwater modeling efforts; and
- determine the source of water (groundwater versus precipitation or runoff) consumed by key riparian plant species within the SPRNCA (also important for water budgets and groundwater modeling applications).

This study involved three agencies: the U.S. Geological Survey, which took the lead on hydrologic variables; the Agricultural Research Service, which quantified consumptive uses by vegetation; and Arizona State University, which addressed riparian-ecology issues. The large scope of this $1.5-million research project never could have been addressed, nor would funding have been obtained, by any single agency. But through collaborative efforts of the Partnership it was feasible. More importantly, the engagement of diverse stakeholders within the Partnership from the inception of the project will help ensure acceptance of the eventual results.

1.2.3.2 ARASA

In 2001 a diverse group of stakeholders created ARASA, the Sonora-Arizona Regional Environmental Association, in Sonora, Mexico. The founders included teachers, doctors, mining engineers, attorneys, farmers, ranchers, other citizens from Cananea and Naco, Sonora, as well as a small number of participants from Arizona. Their goal was to address regional environmental issues in Sonora. ARASA's mission is "to carry out actions that benefit the environment and at the same time improve the quality of life, through projects and actions oriented towards the protection, preservation, education and scientific investigation of ecosystems and populations in the north-eastern region of Sonora and southern

region of Arizona" (ARASA, 2001). The group's priorities have been to obtain funding for capacity-building and project development, collect scientific research about the basin's water resources, carry out environmental education in the schools, develop a collaborative relationship with the Upper San Pedro Partnership and, more recently, re-establish an environmental committee with the newly elected mayor of Cananea.

Comparing both of these sub-basin groups, we can easily see that the Partnership has had three years more to evolve and to acquire funding for projects. Because of this, the Partnership has an established organizational structure with subcommittees working on specific tasks. The organization has accomplished this in an environment that favors decentralization and offers ample sources of financial support.

Across the border, in a strongly federalized setting with far scarcer resources and a nearly nonexistent tradition of bottom-up mobilization, the Mexican group ARASA has just begun its work. Each group benefits from strong leadership by dedicated local people knowledgeable in policy issues and community concerns. Fortunately, both ARASA and the Partnership have as part of their goals strengthening collaboration with each other, especially in regard to the sharing of scientific information, water-conservation strategies and capacity-building strategies.[6]

1.3 ISSUES AND CHALLENGES: WATER LAW AND POLICY

Water and environmental policies in both the United States and Mexico are crafted to be environmentally proactive and to promote water conservation. However, the U.S. legal system is derived from British common law, and the Mexican system from Napoleonic codes (Bennett and Herzog, 2000: 979). Differences in water policy between the two countries challenge binational collaboration on resource management, especially since Mexico has been adopting a neoliberal perspective that advocates privatized management and

[6] During the writing of this chapter, ARASA disintegrated and is reorganizing. In addition, the Mexican National Water Commission (CNA) has stated publicly that a technical (basin) groundwater committee (COTA) will be established in the Upper San Pedro River Basin by the end of 2005 (Salmon, 2005). CNA specifies that membership in watershed councils and commissions must include federal and state water officials, but there is also potential for non-agency civil participation.

trade markets as the path to economic solvency. This policy, along with the limited ability of the Mexican National Water Commission (CNA) to enforce water and environmental policies, contradicts the conservationist impulse to some extent. However, the role of the Mexican federal government remains supportive in that it establishes national standards or mandates with which states and municipalities must conform (Peña, 2002: 10).

1.3.1 Mexico's Water Management Framework

Article 27 of the Mexican Constitution recognizes that water within Mexico's boundaries belongs to the nation. But since the 1990s, the government, specifically the CNA, has been decentralizing the responsibility for water management to local users such as state and municipal offices and agricultural water-user associations in irrigation districts. The 1992 Mexican *Ley de Aguas Nacionales* (National Water Law) further called for the development of watershed councils and irrigation districts to serve the many users of hydraulic resources, to establish water infrastructure, and to preserve water resources in the borderlands (CNA, 1992). This law "conceptualizes the stakeholder as a consumer acting within a context of economic rationality, rather than as a citizen with a fundamental right to water" (Bennett and Herzog, 2000: 981).However, new environmental principles, such as "the polluter pays," environmental-impact assessment and cost-benefit analysis, were incorporated into the water law, together with water users being assigned responsibility for monitoring and complying with environmental standards.

In reality, Mexican municipalities along the U.S.-Mexico border remain very dependent upon the federal government or upon a mixture of national and international credits (World Bank, Inter-American Development Bank, or Banobras, the Mexican bank for infrastructure projects) for investment in water infrastructure (Romero Lankao, 2001: 4). Private participation in the financing, construction, and administration of water services has been encouraged in Mexico, but Mexican communities themselves do not have fiscal authority to impose new taxes or to issue bonds for financing repairs or new infrastructure (Peña, 2002: 15). Irrigation districts do, however, establish fees for their members, including a limited infrastructure improvement fee.

A further constraint is that the CNA's budget for infrastructure has been reduced dramatically since the Article 27 reforms took effect. At the same time, revenues from water bills are not enough for the water sector to become self-sufficient, let alone to encourage efficient patterns of use, and SEMARNAT (Mexico's environmental ministry) receives very limited resources that must be

allocated among too many programs for it to manage environmental policy effectively (Romero Lankao, 2001: 2-6, 176-178).

Officially within SEMARNAT, but largely autonomous in practice, the CNA has on paper instituted a new "culture of water." This approach, formulated in 2001, with the presidency of Vicente Fox, Mexico's first non-PRI (Institutional Revolutionary Party) president in 70 years, provided guidelines for restructuring the management of aquifers through watershed councils or committees (*comites tecnicos de agua subterraneos*, *consejos, comisiones,* or *comites de cuencas).* These watershed councils are intended to link state and municipal government with local community participation in managing and financing systems for potable water, sanitation and irrigation (CNA, 2002). The formation of *consejos de cuencas* (watershed councils) has been one of the slowest aspects of the reform program. Since very few are operative, the Upper San Pedro River Basin, which established its own such council without government assistance or support, may be in the vanguard of the reform process in Mexico. While a formal *consejo* does not yet exist in the Mexican portion of the Upper San Pedro River Basin, the CNA has indicated it will support the establishment of a formal council to address basin water issues by the end of 2005.

1.3.2 United States Water Management Framework

In the U.S., the federal Environmental Protection Agency (EPA) has a statutory responsibility to regulate water quality in accordance with established national standards. As such, it has partially served as a model for SEMARNAT. But unlike in Mexico, where authority remains highly centralized, the 10th Amendment to the U.S. Constitution empowers states (and, indirectly, local governments) to make decisions on such issues as user fees and taxes.

In terms of water quantity issues, Western U.S. towns and states play a much stronger role in managing water and planning growth in general because of the prior appropriation doctrine, which permits individuals the right to water use based upon their presence "first in time." As Glennon indicates, this doctrine made water a private property issue rather than a shared common resource (Glennon, 2004: 1). Water use based on right rather than need and the heavy dependence upon groundwater (60 percent of Arizona residents use groundwater for drinking) have contributed to the state's aridity and heightened the need to locate new sources of water (Glennon, 2002: 16-17, 31). The state of Arizona, in the Arizona Revised Statutes, defines surface water as "water of all sources, flowing in streams, canyons, ravines or other natural channels, or in definite underground channels, whether perennial or intermittent, floodwater, wastewaters, or surplus water, and of lakes, ponds and springs on the surface

(ARS § 45-101)." Arizona, like most other western U.S. states, follows the century-old "prior appropriation doctrine," which grants landowners the right to divert as much water that crosses their property as they need for a "beneficial purpose" (ARS § 45-141(B)). U.S. water laws, especially those relating to priority rights, honor established rights, even at the expense of downstream users, and ignore *de minimis* (small-scale) pumping in formulating water budgets.

"Reasonable use" and "beneficial purpose" associated with the prior appropriation doctrine were loosely defined to allow Arizona property owners to pump water freely until the 1980 Arizona Groundwater Act. ARS § 45-151(A) identifies beneficial uses as: domestic, municipal, irrigation, stock watering, water power, recreation, wildlife including fish, nonrecoverable water storage, and mining uses. The quantity of water that may be appropriated for reasonable use, including the location of water use, is determined by the Arizona Department of Water Resources (ADWR) on a case-by-case basis. The loosely defined reasonable use doctrine allows a water user to withdraw groundwater as long as the water is used for a beneficial purpose (Glennon, 2004: 2).

1.3.2.1 Clean Water Act

The Arizona Department of Environmental Quality (ADEQ) concerns itself primarily with monitoring water quality and with assessment, compliance and enforcement at the state level. The EPA, in cooperation with ADEQ, administers the Clean Water Act (33 U.S.C. § 1251 *et seq*.) The goal of the Act is to "restore and maintain the chemical, physical and biological integrity of the nation's waters" (Section 101a, 33 U.S.C. § 1251(a)). To achieve its object, the Act established the following goals: (1) elimination of the discharge of pollutants into surface water, and (2) achievement of a level of water quality which "provides for the protection and propagation of fish, shellfish and wildlife" and "for recreation in and on the water" (Section 101a(1) & 33 U.S.C. § 1251(a)(1) & (2)). The Act's regulatory tools include prohibition of some discharges into surface waters (Section 301) and a permit program to authorize and regulate certain discharges (Section 401).

1.3.2.2 Groundwater Management Code

In 1980 the Arizona legislature authorized the creation of the Arizona Groundwater Management Code to address groundwater depletion in the state's populous areas. The Code had two goals: (1) to control groundwater depletion; and (2) to establish a means to allocate Arizona's limited groundwater resources to meet the state's changing water needs. Active Management Areas (AMAs)

were created where groundwater depletion was most severe, with the primary goal of safe yield by 2025.

Under A.R.S. § 45-412 (C), ADWR must periodically review all areas which are not included within an active management area to determine whether such areas meet any of the criteria for active management area. The three criteria for designation are specific: (1) active management practices are necessary to preserve the existing supply of groundwater for future needs; (2) land subsidence or fissuring is endangering property or potential groundwater storage capacity; and (3) use of groundwater is resulting in actual or threatened water quality degradation (A.R.S. 45-412(A)).

In 2001 ADWR undertook its second AMA review of the Upper San Pedro River Basin to determine if it met the statutory requirements for AMA designation. Similar to the previous 1988 determination, ADWR again found that the basin did not meet these criteria (Putman *et al*., 1988; ADWR 2005). However, even though the basin was not designated an AMA, ADWR did provide a list of specific recommendations in their 2005 AMA report for additional hydrologic monitoring, and research needs, in addition to offering support for future legislative changes to facilitate water management efforts.

1.3.2.3 Gila River Adjudication

Within the context of prior appropriation, and in response to claims by local American Indian tribes, the State of Arizona is conducting a general stream adjudication of water rights for the two major river systems of the state: the Gila River and the Little Colorado River systems. The San Pedro River is a tributary of the Gila River. Adjudications by the State Superior Court will determine the status of all surface water rights based upon state and federal law within the river system. The adjudication process will identify and rank the rights to water for users in the area. However, up to now, the Indian water-rights litigation has addressed issues mostly within the central part of the state rather than closer to the border region.

One ongoing issue in adjudication of Gila River water rights has been the distinction between surface water and groundwater. Arizona operates under a bifurcated system of water rights that differentiates surface water from groundwater. While surface water is subject to the doctrines of appropriation and beneficial use, percolating groundwater is not appropriable and may be pumped by an overlying landowner subject to reasonable use and federal reserved rights doctrine[7]. Under Arizona's system, no criteria have been established to distinguish between surface water and groundwater in areas close

[7] In re the Adjudication of All Rights to Use Water in the Gila River System and Source, 198 Ariz. 330, 334, 9P.3d 1069, 1074 (2000).

to streams. Water located below the surface is not necessarily classified as groundwater, it could be appropriable subflow. In a landmark case, *Maricopa County v. Southwest Cotton*[8], the court recognized that well pumping near streams can have a direct impact on stream flows. Identifying wells that pump appropriable subflow has been a problem for the Gila River Adjudication. A recent Arizona Supreme Court decision concluded: "the subflow zone is defined as the saturated floodplain Holocene alluvium. ADWR, in turn, will determine the specific parameters of that zone in a particular area by evaluating all of the applicable and measurable criteria… In addition, all wells located outside the subflow zone that are pumping water from a stream or from its subflow … are included in this adjudication[9]."

The ADWR was requested through the Adjudication Court, to prepare a report to identify and describe the procedures and process to establish the limits of the subflow zone within the San Pedro River watershed. ADWR completed its report of recommended methodologies, entitled "Subflow Technical Report" on March 29, 2002[10]. The methodologies recommended in ADWR's report have not yet been adopted by the Adjudication Court.

The State of Arizona's legal distinction between groundwater and surface water has proved troublesome to scientists, who recognize a physical connection between these waters within the hydrologic cycle. The Arizona Supreme Court has tried to get around this problem by using the term "subflow" in determining the impacts of wells located within a mile of the San Pedro River. Furthermore, the presiding judge ruled that wells outside the subflow area would be subject to the General Adjudication to the extent that the water piped from either the stream itself or the subflow area (Glennon and Maddock, 1994).

Another complication in the adjudication of water rights in the Upper San Pedro River Basin lies within the federal reserved rights of the SPRNCA.[11] The U.S. Supreme Court is not bound by Arizona's definition of subflow as the connection between surface and groundwater if that definition does not protect the SPRNCA's water rights (Glennon, 2004). Still, Fort Huachuca, under the U.S. Department of Defense, might obtain rights to additional water under the federal reserved rights law (Lacher, 1994). The suggestion here is that a balance

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[8] *Maricopa County Municipal Water Conservation Dist. No. One v. Southwest Cotton Co.* (39 Ariz 65, 4 P.2d 369 (1931).

[9] *In re the Adjudication of All Rights to Use Water in the Gila River System and Source*, 198 Ariz. 334, 9P.3d 1093 (2000).

[10] Available from ADWR at: www.water.az.gov/adwr/Content/Publications/files/subflow_technical_report_San_pedro_watershed_A_032902.pdf

[11] The Bureau of Land Management (BLM) is expected to file a statement of claim in the Gila River Adjudication on behalf of water rights for the SPRNCA.

in water extraction will need to be negotiated by these agencies and with the Upper San Pedro Partnership in response to its obligation to fulfil Section 321.

1.3.2.4 National Defense Authorization Act

On November 24, 2003, the President signed the National Defense Authorization Act (H.R. 1588 National Defense Authorization Act, § 321), legislation that included the Fort Huachuca Preservation amendment. The amendment has provisions both to limit Fort Huachuca's responsibility for civilian water use off the base and to preserve the San Pedro River. The measure would help protect Cochise County's largest employer, while at the same time recognize the role of the Upper San Pedro Partnership as a coordinating body, and help to protect the regional aquifer from over pumping. The amendment requires the Secretary of the Interior to produce a report by December 31, 2004, in consultation with the Secretary of Defense and the Secretary of Agriculture, and in coordination with the Partnership, describing water use management and conservation measures necessary to restore and maintain the sustainable yield of the aquifer by September 20, 2011. It is important to note that the term "sustainable yield" is used within this legislation, as opposed to the more widely applied groundwater management concept of safe yield. Sustainable yield suggests that groundwater is managed in a way that it can be maintained for an indefinite period of time without causing unacceptable environmental, social, or economic consequences (Alley *et al.*, 1999). The term "unacceptable consequences" is largely subjective, and may involve a large number of criteria that are established specifically for the basin of concern. Each year from 2005 to 2011, the Secretary must submit reports to Congress to document the progress made in reducing groundwater overdraft for that year. The 2004 report was compiled by the Upper San Pedro Partnership working closely with the U.S. Geological Survey, but, as of March 2005, has not been finalized by the Secretary of the Interior.

1.3.2.5 Federal Reserved Water Rights

In the Upper San Pedro River Basin, two separate federal entities must both be considered by the Department of Justice in terms of their respective federal reserved water rights (Lacher, 1994). The Department of the Interior represents the interests the federal reserved rights for SPRNCA, and the Department of Defense presides over the interests of Fort Huachuca.

Fort Huachuca has the right to pump groundwater under the reasonable use doctrine. Its federal reserved rights to groundwater and surface water have not been quantified but may be addressed by the Gila River Adjudication

Special Master in early 2005[12]. The SPRNCA's federal reserved rights also have not been determined, however, the BLM did file for a state instream flow water right for the SPRNCA of 11,208 acre/feet per year (ADWR, 1992).

Another issue related to SPRNCA's water right is whether ADWR can issue well permits and adequacy statement to new home developments that might affect SPRNCA's federal water right. ADWR recognizes the priority right for the SPRNCA as August 12, 1985, but new wells for housing have been granted since that time. In 1976 the U.S. Supreme Court, in *Cappaert v. United States*[13], stopped groundwater pumping of Nevada farmers that was intercepting and depleting surface water belonging to the Federal government and necessary to the survival of the endangered Devil's Hole Pupfish. This occurred even though local farmers had a well permit from the state engineer. *Cappaert v. United States* established that in questions of reserved water rights, federal interests prevail over state interests (Glennon and Maddock, 1994).

Since well water use remains largely unmetered in rural parts of the basin, the Center for Biological Diversity filed a Notice of Appeal against ADWR and the State of Arizona to stop ADWR from issuing well permits that could affect surface water flows to the SPRNCA. In March 2004, the Arizona Superior Court ruled, in part, that plaintiffs did not have standing to challenge state adequacy determinations. Plaintiffs filed a Notice of Appeal in June 2004. As of March 2005, ADWR has recommended "Metering and consistent annual reporting of water demands by all large water users in the Basin would provide a more accurate source of data for planning and monitoring purposes" (ADWR, 2005:7-6).

1.3.2.6 Other State Water Management Initiatives

The ADWR has promoted the establishment of the Arizona Rural Watershed Initiative, which enables local communities to form watershed groups to address local issues. The Upper San Pedro Partnership is one of the most successful watershed groups to have evolved from this initiative (Browning-Aiken *et al.*, 2004). Finally, as an example of the leeway afforded to state governments in the United States, ADWR is in the process of developing a long-term, comprehensive plan that will provide for drought-planning efforts throughout the state within a coordinated-response framework. This initiative is intended to recognize and build upon existing drought efforts and to reduce the impact of

[12] *In re General Adjudication of all Rights to Use Water in the Gila River System and Source,* Civil No. W1-11-605, Ariz., Sup. Ct. Mar. Cty. (January 27, 2005).
[13] *Cappaert v. United States* (426 U.S. 128 (1976).

drought on economic activities, communities and habitat throughout the state (www.water.az.gov/gdtf).

Another state regulatory agency with the authority to impact water policy and management in the Upper San Pedro River Basin is the Arizona Corporation Commission. This commission regulates the rates charged by privately-owned water distributors. Water companies whose costs are not currently covered by water rates have the right to appeal to the Commission. While these regulated rates do not take into consideration environmental or climatic conditions such as drought (with the exception of small water companies importing water from outside a given basin), the Commission is considering the possibility of adding a conservation surcharge to current rates. The Sierra Vista subwatershed of the San Pedro Basin appears to be a testing ground for this new policy (Gignac, 2003). This revised pricing structure would increase water rates incrementally to end users, based on the quantity of water they consumed. If the ACC decides to structure its water rates in this way, the new pricing could serve as an incentive to water conservation, and perhaps also generate additional funding for new conservation projects.

1.3.2.7 Endangered Species Act

Finally, one other federal regulatory consideration plays an important role in decisions about water use on the United States side of the border. The Endangered Species Act (ESA) of 1973, administered by the U.S. Fish and Wildlife Service (USFWS)[14].

In this regard, some of the ESA-listed species that occur along the Upper San Pedro, including the Southwestern willow flycatcher (*Empidonax trailli extimus*) and the Huachuca water umbel (*Lilaeopsis schaffneriana recurva)* have been the basis of previous lawsuits aimed at the Department of Defense and Fort Huachuca. The U.S. Fish and Wildlife Service issued its most recent Biological Opinion regarding Fort Huachuca's operations and activities in 2002. Within this document, numerous conservation measures were proposed by the Fort for the ensuing ten-year period, including actions to address water use that would conserve 3.8 million cm of groundwater, or 54 percent of the groundwater deficit in the Sierra Vista subwatershed. The communities and agencies within the Sierra Vista Subwatershed are working through the Upper San Pedro Partnership to offset the remaining portion of the deficit that represents the cumulative effects associated with groundwater usage by 2011.

[14] *Endangered Species Act of 1973*. 16 U.S.C. 1531-1544, 87 Stat. 884.

1.4 BINATIONAL POLICY EFFORTS

Local communities and states in the United States and Mexico cannot legally enter into formal binational agreements as defined by treaty between the two nations in 1944[15]. The resulting treaty placed transnational water authority in the hands of a binational commission: the International Boundary and Water Commission (IBWC) in the United States, and the Comisión de Limites y Aguas (CILA) in Mexico. The treaty placed ecological uses of water on the low rung of priorities, a position that reflected public feelings of that time period, but does not reflect more recent increased concern for the environment and endangered species (Mumme, 2002).

The priority of uses listed under Article 3 of the 1944 Treaty are:

1. Domestic and municipal uses
2. Agriculture and stock-raising
3. Electric power
4. Other industrial uses
5. Navigation
6. Fishing and hunting
7. Any other beneficial uses which may be determined by the Commission

It is possible for the authority of the IBWC to be extended to include an Environmental Minute[16]. The 1944 Water Treaty allows for treaty interpretation, and possible ecological application, through the IBWC Minute facility (Mumme, 2002). Under Articles 2, 24 and 25 of the treaty, and subject to the approval of both governments, the IBWC can interpret the treaty and apply its provisions to address specific issues that fall within the treaty's scope. For example, Minute 242 (IBWC, 1973) acknowledged the need to develop a comprehensive groundwater agreement for the border region and Minute 306 (IBWC, 2000) created a framework to consider Colorado River Delta ecology and formulate recommendations for cooperative projects. Building upon Minutes 242 and 306, a new IBWC Environmental Minute could support the protection of groundwater quality and sustainable use in the Upper San Pedro River Basin, and in other regions of the border (Mumme, 2000).

While most planning in the past specialized in purely technological solutions to transboundary water and sanitation problems, the IBWC has begun to incorporate sustainable development and public participation as part of its

[15] Treaty Regarding Utilization of Waters of the Colorado and Tijuana Rivers and of the Rio Grande, February 3, 1944, United States-Mexico, Stat. 1219, T.S. No. 994.

[16] A Minute is a written decision of the Commission.

mission (Peña, 2002: 10). In addition, the Mexican National Water Commission (CNA) has a Border Urban Water Infrastructure Issues office (Gerente de Asuntos Fronterizos, Subdireción General de Infraestructura Hídraulica Urbana) which handles questions and concerns related to border water infrastructure (Martinez Austria, 2004). How this office interacts with CILA, IBWC, and institutions such as Border 2012 is not clear. In general, transboundary water basins remain largely unregulated with the exception of regional efforts such as the Tijuana Watershed.

More recently, as a result of the North American Free Trade Agreement (NAFTA, 1993) and the North American Agreement on Environmental Cooperation (NAAEC, 1993), the Commission for Environmental Cooperation (CEC), was created with the U.S., Mexico and Canada as partners,. Under Articles 14 and 15 of the NAAEC, the CEC has the responsibility to "consider and develop recommendations regarding … transboundary and border environmental issues" (NAAEC, 1993: Arts. 14-15). Operating with a relatively small budget and under the political constraints of its member governments, the CEC's role may be described as "an indirect and facilitative role, rather than direct and managerial" (Mumme and Brown, 2002: 245). In the case of the Upper San Pedro River Basin, the CEC, with its authority to investigate and report on border environmental conditions, commissioned and completed an Advisory Panel Report (CEC, 1998) on the Upper San Pedro River Initiative. This report solicited and included public participation that recommended "a broad and robust dialogue to explore opportunities for conservation, preservation and economic betterment" (CEC, 1999: 3). Pursuant to the spirit of this mandate, basin stakeholders established the Upper San Pedro Partnership and ARASA.

The third side of this institutional triangle includes a pair of sibling organizations, the Border Environment Cooperation Commission (BECC) and the North American Development Bank (NADB). These institutions were designed to improve environmental infrastructure along the border. Together they have certified and helped to fund a number of joint water and wastewater projects in the border region, costing a total of more than U.S. $600 million. BECC's technical assistance program has allocated an additional U.S. $16.3 million to develop proposals (Mumme and Brown, 2002: 237). Cananea has applied for a water-treatment system, but the project has stalled for lack of financial support from the state of Sonora (Macias, 2003).

The U.S. Environmental Protection Agency and SEMARNAT offered a water-management plan in the 1996 Border XXI Framework Document (U.S. EPA 1997) with a water resources agenda that included collection and sharing of basic data on groundwater dynamics along the border. The governmental participants included the EPA, CNA, IBWC, the U.S. Geological Survey

(USGS), and state water agencies (Mumme, 2000: 354-355). Border XXI undeniably broadened and intensified interagency ties, principally at the federal level, helped develop environmental indicators, sponsored new initiatives for binational information and data sharing, and promoted greater coordination of domestic programs in the border region—even if the program remains a process dominated by federal agencies on both sides of the border (Mumme and Brown, 2002: 239-241). Its successor program, Border 2012, has adopted a more decentralized approach, forming regional working groups that include agency stakeholders. But Border 2012 has been restricted to funding small water quality projects in its first year. Thus, in the Upper San Pedro River Basin, despite efforts of stakeholders to draw attention to local water issues, Border 2012 has been unable to support efforts to address binational water issues.

1.4.1 Issues and Challenges: Land Use Impacts on Water

In Arizona, the Bureau of Land Management (BLM) has been charged with administration of the SPRNCA in a manner that conserves, protects and enhances its riparian values; however, several factors outside the control of that agency make protection of the SPRNCA problematic. These external factors include mine-related pollution, surface diversions and groundwater pumping in Mexico, potential water-rights claims by downstream users, and increased groundwater use by communities near the conservation area (Jackson *et al.*, 1987; Pool and Coes, 1999). In the U.S. portion, irrigated agriculture, dryland cattle grazing, mining and recreation, formerly the predominant land uses, are being supplanted by urbanization and rural development. Fort Huachuca has provided leadership within the local community by lowering its water consumption considerably in recent years, and additional conservation measures are being implemented off post by Department of Defense, including their efforts to retire irrigated agriculture through the establishment of conservation easements with local landowners, The Nature Conservancy, and BLM. The City of Sierra Vista has constructed a wastewater effluent recharge facility that returns over 1600 acre-feet of treated effluent to the regional aquifer each year.

In spite of these and other efforts, the basin's current water supply is considered to be in deficit, with annual withdrawals exceeding recharge by approximately 6.5 to 8.6 million cu m (Corell *et al.*, 1996; CEC, 1999). In northern Mexico the predicted decline in water availability may exacerbate increasing competition for water resources between such productive sectors as agriculture and industry and domestic consumption (Magaña and Conde, 2001: 1). Increased production of copper from extensive ore reserves in Mexico will likely continue to limit groundwater availability for municipal and agricultural

uses in that region and compromise water-conservation efforts. Expansion and modernization of the Cananea mine, particularly of the new concentrator, from 1978 to 1986, and again between 1992 and 1997, increased water extraction from 12.9 million cu m in 1980 to 20.2 million cu m in 1989, and 18 million cu m in 1990. On the U.S. side, total water extraction was 12.2 million cu m (CEC, 1999: 4, 50; SIUE, 1993: 19, 21). The Mexican National Water Commission (CNA) has recommended reducing the mine's use of fresh well water (SIUE, 1993: 19, 76). Meanwhile, population projections for south-eastern Arizona parallel those elsewhere in the rapidly-growing South-west—with roughly a 50 percent increase anticipated from 2000 to 2030—and will result in a major increase in water use to support municipal and domestic needs. Recent research suggests that riparian vegetation also requires a large portion of the basin's annual water budget through evapotranspiration (Goodrich *et al*., 2000b).

In addition to the potential for water scarcity associated with human extraction and climate variability, groundwater and surface-water contamination also affect the quality of potable-water supplies near the headwaters of the San Pedro River. Inadequate or nonexistent wastewater-treatment plants contribute to uncontrolled discharge of residual waters into the river. Unlined landfills introduce a variety of known and unknown substances that infiltrate into the aquifer. Moreover, the copper mines produce industrial waste that contaminates groundwater supplies via unlined and occasionally overflowing tailing dams (Moreno, 1991: 7; Jamail and Ullery, 1979: 37-45; Zavala, 1987: 5). With the approval of the municipalities of Cananea and Naco, Sonora, and the support of the IBWC and CILA, the University of Sonora's Department of Scientific Research and Technology (DICTUS) and the ADEQ conducted water-quality tests of the San Pedro River in 1998. Initial results indicated the presence of raw sewage and mining by-products, including arsenic, near the headwaters of the San Pedro and in wells close to Cananea (Da Viana, 1998: 1; Kamp, 1999; Maest *et al*., 2003).

At the same time, the Upper San Pedro River Basin has recently been recognized by a number of global water and climate organizations as a pilot model for binational coordinated basin management. The basin's manageable scale is a useful characteristic, compared to larger catchments such as those of the Colorado and Rio Grande Rivers. This feature has permitted intensive scientific investigation that has contributed to a clearer understanding of issues and has eased the watershed groups' task of attempting to coordinate water-management strategies.

1.4.2 Science in the San Pedro Basin

A rich history and array of scientific information exists within the San Pedro Basin. The oldest scientific presence there, dating from 1953, is the Walnut Gulch Experimental Watershed, administered by the Southwest Watershed Research Center of the U.S. Department of Agriculture-Agricultural Research Service (Renard *et al.*, 1993). The Walnut Gulch Experimental Watershed is arguably the most intensively instrumented and best-researched semi-arid watershed in the world, and scientists and technical staff there have been able to cultivate a long-term relationship with local ranchers and landowners. The mission of the Southwest Watershed Research Center is to: quantify, understand and model the effects of changing climate, land-use and management practices on the hydrologic cycle, soil-erosion processes and watershed resources; develop remote-sensing technology and apply geospatial analysis techniques; develop decision-support tools for natural-resources management; and to develop new technology to assess and predict the condition and sustainability of rangeland watersheds (www.tucson.ars.ag.gov).

Building on the experience of these previous interdisciplinary experiments, 65 scientists from a broad spectrum of disciplines met in Tucson, Arizona, in July 1995, to discuss plans for a new effort named SALSA (Semi-arid Land Surface Atmosphere Program) (Wallace, 1995). Their objective was "to understand, model and predict the consequences of natural and human-induced change on the basin-wide water balance and ecological complexity of semi-arid basins at event, seasonal, interannual and decadal time scales" (Brady et al., 2000: 17). Secondary objectives were formulated to address the primary objective and served to integrate the research of several disciplines. SALSA thus broadened the range of scientific disciplines involved in prior efforts to include the biotic ecological sciences. SALSA operated on the principle of voluntary collaboration, whereby researchers interacted with one another across disciplinary, institutional and political boundaries. The purpose of SALSA was to facilitate interactions and to serve as a platform for research coordination, data assimilation and synthesis, and information exchange. In this sense, SALSA operated as an "open-market" research consortium into which participants brought financial resources. In this way, SALSA broke new ground in the approach to large-scale interdisciplinary science, for which only limited resources are available.

Planning resulted in the identification of critical and exciting scientific challenges that not only required but also fostered interdisciplinary collaboration. Attention to enhancing interdisciplinary communication built the foundation for trusting collaborations. This enabled unselfish sharing of

numerous small grants and in-kind resources to accomplish a whole that is much greater than the sum of the disciplinary parts. An additional driving force behind the SALSA Program's success is the knowledge that the results of this research will aid land managers and decision-makers directly in the near term.

The SALSA program was viewed as very successful scientifically (primary results summarized in Chehbouni *et al*., 2000) and in terms of beginning to bridge the gap between research scientists and watershed managers and decision-makers. This was exemplified by a binational conference, "Divided Waters-Common Ground" ("*Aguas Divididas–Áreas Comunes*") designed specifically to include basin residents and decision-makers. At this bilingual conference, both U.S. and Mexican scientists and residents listened to one another regarding needs—unlike more typical scientific meetings at which scientists talk to each other or "tell" basin residents what they did (Brady *et al*., 2000).

In 2000 much of the SALSA research was incorporated into SAHRA, the NSF Science and Technology Center for Sustainability of semi-Arid Hydrology and Riparian Areas, based at the University of Arizona. Since then SAHRA has been developing an integrated, multidisciplinary understanding of the hydrology of semiarid regions and building partnerships with a broad spectrum of stakeholders (public agencies and private organizations) so that this understanding is applied to optimal management of water resources and rational implementation of public policy. The key question that SAHRA addresses is, "How can science help communities manage their water resources in a sustainable manner?" This highlights the fact that SAHRA is concerned both with advancing the understanding of fundamental principles in semi-arid hydrology (through stakeholder-driven multidisciplinary research) and with developing strategies for implementing scientific understanding on a practical level through aggressive knowledge transfer and strong educational initiatives (from kindergarten through to the end of schooling).

SAHRA's greatest challenge is to bring about a high level of coordination and integration across a range of scientific disciplines, and among scientists, policy- and decision-makers and the general public. This coordination involves the diverse talents of physical scientists, social scientists (including economists), educators, practising engineers (from both public agencies and private companies), legal experts and decision-makers. This challenge can be considered met if new technologies, analytical tools and modeling approaches are rapidly assimilated into the understanding and management of water resources.

Within this context, the University of Arizona's Udall Center for Studies in Public Policy has been working with the Upper San Pedro Partnership and with SAHRA in the Upper San Pedro River Basin to integrate scientific

research with the needs of regional water-resources management organizations and policy-makers (Browning-Aiken *et al*., 2004). The Udall Center has used stakeholder surveys and background historic and socio-economic research to assess the effectiveness of current water-management organizations in addressing basin issues and to identify potential links between scientific research and stakeholder needs for more effective management tools. Similarly, the Udall Center has worked with CLIMAS (Climate Assessment of the Southwest) at the University of Arizona's Institute for the Study of Planet Earth to characterize and analyze droughts as another means of addressing institutional, management and policy issues of binational concern. Research findings from the basin are then utilized to model systems developed collaboratively with water managers. These system dynamic models act as frameworks for integrating physical and social sciences as decision tools for management of scarce water resources.

An integral part of this research is studying whether watershed councils are effective institutions for integrating scientific research on hydrology and ecosystems with watershed management at a binational level. The hypothesis is that decision-making for sustainable development in terms of water resources is based on a full assessment and analysis of complex ecological and socioeconomic relationships within a watershed, and the availability of effective tools, such as decision-support system models.

The potential for successful binational planning and management efforts increases with informal communication and cooperation among local borderlands agencies and nongovernmental organizations. The research coordination, binational forums and evolution of the Upper San Pedro Partnership and ARASA working together all suggest a growing momentum toward coordinated water resources management. However, this process requires continued collaboration between policy and physical scientists to fully integrate science into decision-making.

The San Pedro Dialogue on Water and Climate (DWC), a UNESCO based network promotes the role of watershed councils in coordinated water-resources management. In an effort to better understand climate variability and change in relation to watershed management, ARASA and the Partnership are participating in binational research exchanges and discussions. The DWC project, managed by the Udall Center and CLIMAS, was designed to assess water users' and managers' use of climate and hydrologic information and to convene public forums to address basin-watershed issues through the exchange of scientific information has evaluated the use of climate and hydrologic information in making decisions about water service and water use through a series of surveys with municipal and rural water-users and managers in the

Mexican portion of the basin. In the U.S. portion of the basin, the ADWR has conducted a similar survey of managers. As these surveys are compiled and analyzed to identify regional vulnerabilities, land use and potential water-conservation strategies, binational forums will be convened to discuss their results and implications. The goal will be to integrate climate- and water-management strategies and to increase binational organizational and institutional cooperation.

1.5 MAJOR ACCOMPLISHMENTS AND IMPLICATIONS

- The efforts of projects, institutions, and organizations such as HELP, Upper San Pedro Partnership, Udall Center for Studies in Public Policy, SALSA, SAHRA, Arizona Department of Water Resources, U.S. Geological Survey, National Oceanic and Atmospheric Administration, and the Dialogue on Water and Climate—to name a few—have all been instrumental in promoting binational collaboration on basin water issues. They have contributed to the ability of policymakers and water managers in the San Pedro Basin to address complex transboundary water and climate issues, with access to the best science available.
- Equally significant, high stakeholder involvement increases the potential for success in any watershed, and has proven important within the Upper San Pedro River Basin (Born and Genskow, 2001; Browning-Aiken *et al*., 2004; Imperial and Henessey, 2000; Kenney and Lord, 1999; Leach, 2000; Schuett *et al*., 2001; Scurlock and Curtis, 2000; Vasquez-Castillo, 2001). Public dialogues within the two San Pedro watershed organizations, the Partnership and ARASA, have "stirred controversy and revealed the importance of accounting for the region's social and political forces" (Varady *et al.,* 2000: 234). Yet water law in Mexico has been slower than in the U.S. in encouraging grassroots stakeholder involvement; this makes sustaining local institutional parity and representation more challenging.
- International law regarding surface waters has addressed some problems with wastewater overflows in Naco, Sonora, but it has not been utilized to address broader water quality problems that potentially affect the health of either Mexican or U.S. communities within the Upper San Pedro River Basin.
- Creating international law regarding transboundary aquifers remains the most difficult challenge for border water management, but specific basin efforts to remedy water quality problems might be the first step needed to branch into groundwater issues.

- The establishment of the CEC, and its intervention into Upper San Pedro River Basin issues, has resulted in a heightened awareness of water issues in the basin and was likely a key component that led to ongoing efforts such as those underway by the Upper San Pedro Partnership.
- The IBWC's gradual movement toward including ecological consideration into its operations is a positive sign for the United States-Mexcian border. If an ecological minute were produced by the IBWC it could give support to states and local groups to protect surface water flows.
- The research scientists who are now working directly with water managers and decision-makers are more cognizant of applied-science needs, and are also being educated about the constraints and political realities under which managers and decision-makers operate.
- A "bottom-up," collaborative, community-based approach between stakeholder organizations and agencies and the scientific community can serve as a more effective management approach than the old top-down, regulatory models (Milich and Varady, 1999).
- National policy considerations influence the potential for coordinated basin management. Local initiatives along the northern Mexican border are linked to national policy demands. Mexican environmental policy frequently runs counter to Mexican economic policy in the critical importance attached to development, especially in mineral resources and *maquiladoras* along the northern border.
- Arizona law's distinction between ground and surface water remains an obstacle in the collaboration between scientists, policy makers and other basin stakeholders in addressing water governance and management.
- The Gila River Adjudication Process is addressing this complicated issue of which wells are pumping river "subflow." If the Adjudication Process can delineate where subflow zones are located, and settle who has legal rights to the subflow, it could help address the issue of over-allocation of surface water in the San Pedro River.
- The Arizona Groundwater Code's failure to include ecological protection as a beneficial use of water is an obstacle to surface water flows in the San Pedro River.
- On a positive note, in a 2001 report from a commission appointed by the Arizona Governor recommended limiting new wells from being drilled within designated riparian area protection zones (Arizona Governor's Water Management Commission, 2001). While the proposals of the commission were yet been adopted, the fact that a commission was

created indicates that a large section of the water community in Arizona now recognizes that there is a problem with the Groundwater Code that needs to be fixed..

- If an Active Management Area (AMA) were created by ADWR in the Upper San Pedro River Basin, it might have provided some water management tools that are not currently available. However, managing for safe yield under an AMA would not provide the level of protection already offered under sustainable yield criteria included in the National Defense Authorization Act.
- Differences in Mexican and U.S. water law make it difficult for binational institutions to treat water as a common pool resource along the border.
- Building consensus and bringing a broad spectrum of groups and interests together to speak with "one voice" and share a common vision of success, as the Upper San Pedro Partnership does, is a very compelling strategy in acquiring financial and political support from many sectors. It allows for a vast array of resources that would not be accessible to its member agencies if they were working to secure them independently.
- Collaborative research based on water-stakeholders' needs is far more effective in addressing complex management of a basin, especially a binational one. Water management and policy, by their natures, face challenges from user demands as well as from ecological requirements so that sound decision-making must be informed by good science that reflects the complexities of water use by humans and the by the ecological systems in which they exist. Regions such as the Upper San Pedro River Basin, with complex physical, political, social and economic issues, provide the ideal context for collaborative, interdisciplinary science. These "place-based" issues force scientists from many disciplines to look at the same piece of ground, the same data, and often, to work together in the same location. It has been our experience that this builds camaraderie and productive interdisciplinary collaboration far faster than when scientists work on the same problem in different places.
- Finally, trust between scientists, managers, decision-makers, environmentalists, developers and the public is essential for integrated watershed management (Browning-Aiken *et al*., 2004). Building and holding this trust requires a major commitment of time and energy by all involved. Prior to the Partnership there were several failed attempts at creating groups with similar goals. They largely failed because personal trust between individuals was undercut, or lost, many times as

an outcome of limited time or resources. For research scientists, this long-term commitment to build trust with stakeholders runs counter to the time of a typical two- or three-year research grant. Many scientists and graduate students have carried out research in the San Pedro with short-term grants (three years or less), but they are not the scientists who sit with and are listened to by the decision-makers, elected officials and managers in the basin. The decision-makers and managers of a basin are typically senior, highly-respected individuals. The commitment of scientists of comparable stature, who can make research-related decisions quickly and with authority, is an important factor in acquiring mutual respect.

1.6 CONCLUSION: CONTRIBUTIONS TO THE HELP AGENDA

As a HELP demonstration basin, the Upper San Pedro River Basin experiences indicate that the potential for successful planning and management efforts greatly increases with improved understanding of the impacts of climate variability, land-use changes, and hydrologic processes. This information appears essential for decision-making, especially in a transboundary setting—which is almost more the norm than the exception, as international basins cover 44 percent of the land surface of the earth (Varady and Morehouse, 2003). In this setting, with disparities between nations in economic development, infrastructure capacity, and political orientation, the greater engagement of communities and stakeholders at the regional level in priority-setting for water-resources issues offers a glimmer of hope to water conflicts elsewhere.

However, the effectiveness of local watershed councils is directly linked to utility and reality of water laws and to the availability of scientific information and cultural attitudes towards water. Access to data and effective decision-making tools have been regularly named as critical to building institutional capacity, but management decisions must reflect the attitudes, meanings, and values attached to water and land use as well (Wolfe, 2002: 3-11). Likewise water laws suggest national or regional cultural values and the nature of stakeholder expectations as well as obligations.

The HELP agenda promotes the integration of climate variability, specifically understanding the region in terms of seasonal to interdecadal time scales and the causes of climate variability, into the management strategies of

water stakeholders and managers. This is especially important because the basin is periodically subject to both drought and monsoonal flooding.

The HELP approach can redirect government agencies at the federal, state and local level in terms of setting the agenda for sustainable use of water resources, so that issues of equitable access to water, the application and use of economics, and incentives for efficient use are addressed through public participation in decision-making. Water users need help from agencies in understanding how water budgets are constructed and in understanding their own role in capturing lower-cost opportunities for water savings.

Finally, the San Pedro Basin provides an example for other HELP basins in the importance of communication and networking within and across a transboundary basin—a situation that vastly complicates issues and amplifies disparities. Legal and institutional differences across international borders are especially stark, and overcoming the obstacles they pose offers a special challenge to planners, scientists, lawyers and policymakers.

In the Upper San Pedro River Basin, contemporary communication over the prospect of basin water management began with the Commission on Environmental Cooperation's report, *Ribbon of Life* (CEC, 1999), with the recommendation for the creation of a Coordinated Resource Management Program. It is noteworthy, however, that the communication process was carried forward not by an exogenous multinational institution, but by a bottom-up federation of local residents, scientists, environmental organizations and educators, working with municipal, state and federal officials. They accomplished this through a series of collaborative projects including SALSA, the San Pedro Dialogue on Water and Climate, Project WET, ECOSTART, and the 1999 binational San Pedro Conference "Divided Waters, Common Ground" ("*Aguas Divididas–Areas Comunes*").

While the process of coordinating binational resource management is a slow one, residents, scientists and water managers have addressed issues in the Upper San Pedro River Basin with intensity if not enthusiasm. Collaborative, interdisciplinary research efforts, the binational forums for information exchange in the basin, and the evolution of the Upper San Pedro Partnership, all suggest a momentum toward integrated, binational water-resources management. There exists a clear interest in learning how to do this effectively and a desire to share information and other resources on both sides of the border.

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