

WATER RESOURCES RESEARCH CENTER  
COLLEGE OF AGRICULTURE AND LIFE SCIENCES  
THE UNIVERSITY OF ARIZONA

WATER ISSUES ON THE  
ARIZONA – MEXICO BORDER

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The Santa Cruz, San Pedro and Colorado Rivers

An Issue Paper  
by  
Terry W. Sprouse  
tsprouse@cals.arizona.edu

A portion of the funding for this research was provided by a grant from  
the Fulbright-García Robles Program.

February 2005

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# TABLE OF CONTENTS

<b>LIST OF FIGURES .....</b>	<b>iii</b>
<b>LIST OF TABLES .....</b>	<b>iii</b>
<b>ACKNOWLEDGEMENT .....</b>	<b>iv</b>
<b>ABBREVIATIONS .....</b>	<b>v</b>
<b>INTRODUCTION.....</b>	<b>1</b>
<b>UPPER SANTA CRUZ RIVER .....</b>	<b>4</b>
<b>Water Quality.....</b>	<b>4</b>
<b>Water Quantity .....</b>	<b>7</b>
<b>Environmental Implications .....</b>	<b>7</b>
<b>Recent Actions.....</b>	<b>8</b>
<b>UPPER SAN PEDRO RIVER .....</b>	<b>11</b>
<b>Water Quality.....</b>	<b>12</b>
<b>Water Quantity .....</b>	<b>12</b>
<b>Environmental Implications .....</b>	<b>15</b>
<b>Recent Actions.....</b>	<b>16</b>
<b>LOWER COLORADO RIVER.....</b>	<b>19</b>
<b>Water Quality.....</b>	<b>19</b>
<b>Water Quantity .....</b>	<b>22</b>
<b>Environmental Implications .....</b>	<b>22</b>
<b>Recent Actions.....</b>	<b>23</b>
<b>CONCLUSION .....</b>	<b>27</b>
<b>REFERENCES.....</b>	<b>28</b>

## LIST OF FIGURES

<b>Figure 1. Arizona-Sonora Major Transboundary Rivers .....</b>	<b>3</b>
<b>Figure 2. Upper Santa Cruz River .....</b>	<b>5</b>
<b>Figure 3. Upper San Pedro River .....</b>	<b>12</b>
<b>Figure 4. Streamflow and Trendline: San Pedro River at Charleston Bridge, 1913-2001 .....</b>	<b>14</b>
<b>Figure 5. Lower Colorado River.....</b>	<b>20</b>
<b>Figure 6. Colorado River Flows to Mexico at Morelos Dam, 1914-2001 .....</b>	<b>21</b>
<b>Figure 7. Total Dissolved at Imperial Dam, 1944-1999 .....</b>	<b>22</b>

## LIST OF TABLES

<b>Table 1. Agencies Involved in Arizona-Mexico Border Water.....</b>	<b>2</b>
<b>Table 2. Number of Inhabitants Nogales, Arizona and Nogales, Sonora .....</b>	<b>6</b>
<b>Table 3. Treatment Capacity and Average Sewage Influent Nogales International Wastewater Treatment Plant.....</b>	<b>6</b>
<b>Table 4. Annual Sewage Influent at the NIWTP: 1996-2004.....</b>	<b>8</b>
<b>Table 5. Population Profile: Cochise County and Sierra Vista .....</b>	<b>13</b>
<b>Table 6. Population Profile: Municipality of Cananea.....</b>	<b>13</b>

## **ACKNOWLEDGEMENT**

I would like to express my gratitude to the many people who provided assistance in the preparation of this document. In particular, I am grateful to Tom Carr, Alejandro Barcenas, Linda Stitzer and Stephen Mumme for reviewing the final draft of this paper. I thank Joe Gelt, not only reviewing the final draft version of this paper, but also for his valuable assistance in improving the style of the paper. I want to express my appreciation to Sharon Megdal for her numerous reviews of draft and final versions of this report, and for her many perceptive and insightful comments. I would also like to thank Peter Wierenga for steady guidance and keen insights provided throughout the writing of this document. I extend my thanks to Gabriel Leake and Chris James for maps and technical support.

The ideas and opinions expressed in this paper do not necessarily reflect the views of any of the above people.

## ABBREVIATIONS

ADEQ	Arizona Department of Environmental Quality
ADWR	Arizona Department of Water Resources
AMA	Active Management Area
BA	Biological Assessment
BECC	Border Environment Cooperation Commission
BOR	United States Bureau of Reclamation
CAP	Central Arizona Project
CEC	North American Commission for Environmental Cooperation
CILA	Comisión Internacional de Límites y Aguas
CNA	Comisión Nacional de Agua
COAPAES	Comisión de Agua Potable y Alcantarillado del Estado de Sonora
EPA	United States Environmental Protection Agency
ESA	United States Endangered Species Act
IBWC	International Boundary and Water Commission
LCR MSCP	Lower Colorado River Multi-Species Conservation Program
NADBank	North American Development Bank
NIWTP	Nogales International Wastewater Treatment Plant
PCE	Tetrachloroethylene
PPM	Parts Per Million
SPRNCA	San Pedro Riparian National Conservation Area
TDS	Total Dissolved Solids
USGS	United States Geological Survey
WMID	Wellton-Mohawk Irrigation and Drainage District

## INTRODUCTION

The U.S.-Mexican border not only represents a meeting of two cultures and two countries, but it is also a melting pot mixture where power and responsibilities are shared among local, state and federal agencies from both countries. This meeting of countries and agencies with overlapping power are reasons why change occurs slowly on border water issues. These complexities make the resolution of border water problems more complicated than it would be to resolve the same issues on a river located exclusively within the State of Arizona, or within the United States. Some specific border complexities and differences are outlined below.

Along the border, funding sources are different. Many water-related projects are funded by bi-national organizations. A number of funding and development agencies operate along the United States – Mexican border and some are comprised of representatives from both the United States and Mexico (Table 1). Because of the transboundary nature of water, problems along the border often surpass the ability of one local city or town to successfully address the issues. These problems often require the financial and technical resources of a national or a bi-national agency to create the needed infrastructure (e.g., wastewater treatment plants, dams or potable water systems).

Coordination is difficult between the two countries because an institutional mismatch exists between governmental agencies in Mexico and the United States that deal with water (Varady, Ingram and Milich 1995). In the United States, management of water resources resides primarily in the states. In Arizona, this responsibility is shared by the Arizona Department of Water Resources and the Arizona Department of Environmental Quality. In Mexico, federal water is managed by the Comisión Nacional de Agua (National Water Commission), a federal agency. The mismatch creates difficulties because in order to discuss border water issues, a Mexican federal agency must sometimes negotiate with an Arizona state agency.

Both countries have environmental laws, but they are not the same laws and enforcement procedures differ. While similar in some cases, concentration standards for contaminants in Mexico and the United States differ, and enforcement of regulations is not as strict or consistent in Mexico, as it is in the United States. The United States is more likely to apply strict fines and penalties to polluting industries. Mexico is more likely to take a softer approach with industry, because of less funding for enforcement and because of an emphasis on encouraging economic growth.

Different economic priorities of the two countries result in different perceptions of water. When border residents were asked if they were substantially at risk from pollution in drinking water, 52 percent of border Sonoran residents responded affirmatively, while 24 percent of border Arizonan residents responded that they were at substantial risk (Behavioral Research Center 1996). While “illegal immigration” and “border security” may be high priorities for American border residents, Mexican border residents identify “access to drinking water” as a higher priority.

**Table 1**  
**Agencies Involved in Arizona-Mexico Border Water**

<p><b>Federal Level</b></p> <p><u>United States</u> International Boundary and Water Commission (IBWC) United States Environmental Protection Agency (EPA) United States Bureau of Reclamation (BOR)</p> <p><u>Mexico</u> Comisión Nacional de Agua (CNA) Comisión Internacional de Limites y Aguas (CILA)</p> <p><u>Bi-national</u> Border Environment Cooperation Commission (BECC) North American Development Bank (NADBank)</p> <p>The IBWC is the agency responsible for implementing bi-national water treaties on the United States-Mexico border. The IBWC has constructed dams on the Rio Grande and wastewater treatment plants in Nogales and San Diego. The EPA is involved in border water issues through the Border 2012 Program: United States-Mexico environmental program (formerly, the Border XXI Program). The mission of the Border 2012 Program is to protect public health and the environment in the United States-Mexico border region. The BOR operates the Colorado River in the United States. The BECC assists border communities to implement environmental infrastructure projects by offering technical assistance and certifying projects for funding through the NADBank. On the Mexican side, CNA is the federal agency in charge of overall national water management. The CILA is the Mexican Section of the IBWC and is responsible for its country's border waters.</p> <p><b>State Level</b></p> <p><u>United States</u> Arizona Department of Water Resources (ADWR) Arizona Department of Environmental Quality (ADEQ) Border Communities and Water Companies</p> <p><u>Mexico</u> Comisión de Agua Potable y Alcantarillado del Estado de Sonora (COAPAES) Comisión Estatal del Agua</p> <p>ADWR works to secure long-term dependable water supplies, while ADEQ is in charge of protecting water quality. At the local level, border towns and cities and small water companies provide water to their customers and do water testing to assure that quality standards are met. Drinking water for cities in the state of Sonora is provided by the COAPAES, a state agency with headquarters in Hermosillo, Sonora. COAPAES operates strictly as a water delivery and wastewater service provider. The Comisión Estatal del Agua was created in 2003 as part of the delegation of water regulation authority from CNA to the Mexican states.</p> <p><b>Tri-national Level</b></p> <p>Commission for Environmental Cooperation (CEC)</p> <p>The tri-national CEC, established under the environmental provisions of the North American Free Trade Agreement (NAFTA), also operates on the U.S.-Mexico border, and in 1999 produced a report on the Upper San Pedro River. The three representatives that make up the Council are from U.S., Mexican and Canadian federal environmental agencies. The CEC was established to address regional environmental concerns, help prevent potential trade and environmental conflicts, and to promote the effective enforcement of environmental law.</p>
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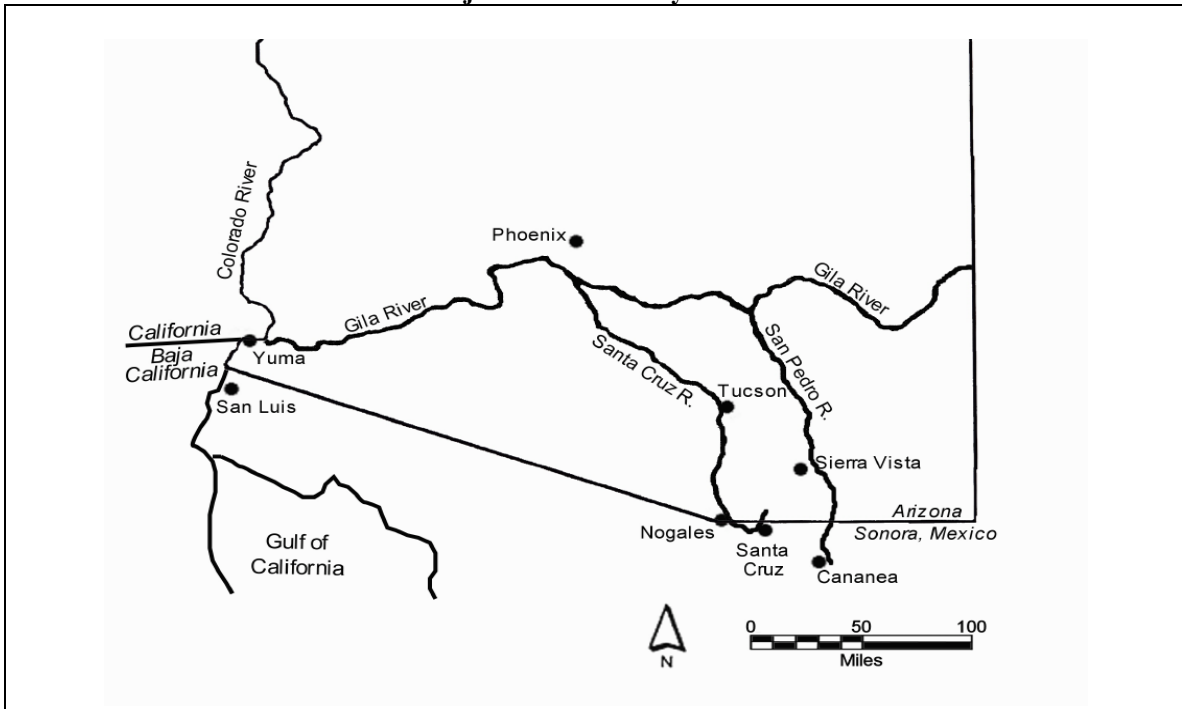
The ability of Arizona and Sonora, Mexico to share border water resources is constrained by ever increasing populations in need of ever greater quantities of water. This trend shows no sign of letting up. From 2000 to 2020, population along the entire U.S.-Mexican border is projected to increase by 64 percent (USEPA 2003). For the same time

frame, population in Santa Cruz County, Arizona is projected to grow by 67 percent, while population in Nogales, Sonora is expected to increase by 86 percent (Peach and Williams 2000).

The human consequences of changes to water quality and quantity may not be readily evident. These changes may first be manifested among fish and wildlife. Birds, in particular, are key indicators of the overall health of an eco-system because birds respond quickly to the changes and stresses of the areas they inhabit. Once fish and wildlife exhibit the stresses to their environment, humans too may soon experience the same stresses.

This paper examines the issues of water quality, water quantity and environmental impacts in the Upper Santa Cruz River, the Upper San Pedro River and the Lower Colorado River. These are the main rivers crossing the border between Arizona and Mexico (see Figure 1). The Santa Cruz and San Pedro rivers run mostly south to north, and the

**Figure 1**  
**Arizona-Sonora**  
**Major Transboundary Rivers**



Colorado River runs north to south. As described above, a unique, multifaceted situation exists on the border and it calls for a special kind of effort to address water issues. This effort involves a slower process, because of the additional coordination requirements, and consequently, an inability to respond quickly. This can leave the impression that some issues never change and some problems are never corrected, or even addressed. That can be a false impression as many of the actions to address border water issues take place, but may not be readily perceived by the public.



## UPPER SANTA CRUZ RIVER

The twin cities of Nogales, Arizona and Nogales, Sonora (Ambos Nogales), share a landscape of steep hills, semi-arid vegetation and limited surface water flow. Perennial flows in the Santa Cruz River depend mostly upon treated wastewater flows downstream of the Nogales International Wastewater Treatment Plant (NIWTP), located nine miles north of the border in Arizona. The river originates in Arizona's San Rafael Valley, northeast of Nogales, Arizona, then loops 25 miles (characterized by both intermittent and perennial reaches) through Sonora and flows back across the border into Arizona (Figure 2). The Nogales Wash, a major tributary of the Santa Cruz River, flows directly through both cities before converging with the river near the NIWTP. The river and the wash historically have been the primary sources of water supply for residents of the watershed. Growing populations have placed added demand on the shared water resources (Table 2).

Roughly 50 percent of each city's potable water is supplied by the Santa Cruz River aquifer. Well fields that supply water to Nogales, Sonora are upstream of Nogales, Arizona well fields. Water management policies of Nogales, Sonora have a direct impact on the volume of water entering Arizona, as pumping along the Santa Cruz River in Sonora reduces both surface and sub-surface flows into Arizona. The remaining 50 percent of water that supplies Nogales, Sonora comes from Los Alisos Basin, 11 miles south of the city, and from wells within the city of Nogales, Sonora. Nogales, Arizona receives the remainder of its water from an aquifer located northeast of the city.

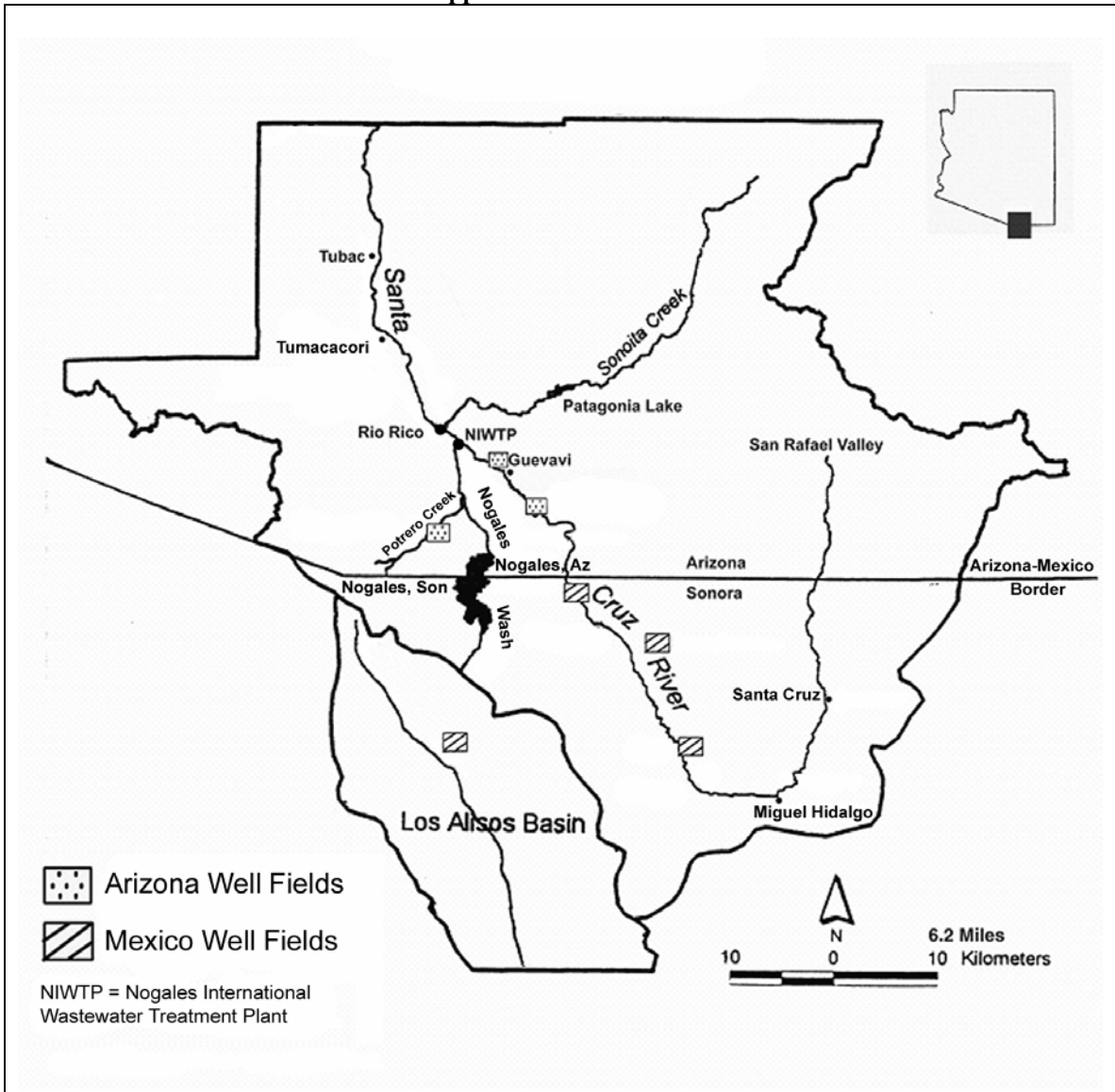
Despite an occasional conflict over water, the two cities have a history of collaboration when hard times hit. During periods of drought, the Sonoran section of the Santa Cruz River aquifer often dries up, leaving Nogales, Sonora with a shortage of available drinking water. During emergencies, drinking water supplies are augmented by water from Nogales, Arizona. In the summers of 2002 and 2003, Nogales, Arizona provided water to Nogales, Sonora to help replace water it normally receives from the Santa Cruz River (Bodenchuk 2004). Temporary pipes are often strung across the border to allow Mexican tanker trucks destined for non-water-serviced *colonias*, to fill up with water from Nogales, Arizona (Steller 2002).

### Water Quality

Treated wastewater, or effluent, from the NIWTP is discharged into the channel of the Santa Cruz River at Rio Rico, Arizona. In addition to sustaining a rich riparian area north of the NIWTP, Mexican effluent is important to Arizona because it recharges the Santa Cruz River aquifer, which is used for irrigation and drinking water by communities along the river. In particular, the communities of Rio Rico, Tumacacori and Tubac benefit from this recharge. Mexican effluent constitutes about two-thirds of the effluent released into

the Santa Cruz River downstream of the NIWTP, the other one-third originating in Nogales and Rio Rico in Arizona.

**Figure 2**  
**Upper Santa Cruz River**



Mexican effluent cannot be used toward an assured water supply designation in Arizona because Mexico maintains the right to recapture the effluent and use it within its own country (IBWC 1967). Under assured water supply rules established by the Arizona Department of Water Resources (ADWR), persons proposing to offer subdivided lands for sale or lease in an Active Management Area (one of five areas established by ADWR where competition for groundwater is most severe), must demonstrate that sufficient water is continuously available to meet the water needs of the proposed use for at least 100 years.

**Table 2**  
**Number of Inhabitants**  
**Nogales, Arizona and Nogales, Sonora**

Year	1950	1970	1990	2000	2010
Nogales, Arizona	6,153	8,946	19,489	20,878	24,282
Nogales, Sonora	26,016	53,494	107,936	206,554	275,704

(IBWC 1999; U.S. Census Bureau 2000)

Not all of Mexico's wastewater is treated at the NIWTP. Fugitive wastewater (not captured by the sewer system) from Sonora represent a threat to public health in Nogales, Arizona. Human and industrial waste materials flow downhill from Nogales, Sonora to Nogales, Arizona and are conveyed into Arizona primarily by the Nogales Wash. The IBWC responds to this threat by treating the Mexican drainage water in the Nogales Wash with chlorine, as it crosses into Arizona. In 1998, the IBWC reported that portions of the Nogales Wash aquifer in Sonora were contaminated with tetrachloroethylene (PCE), a suspected carcinogen (IBWC 2001). The PCE has been detected in border monitoring wells in Arizona as well. The Nogales, Arizona public water system does not pump from the Nogales Wash aquifer.

In 2000, the Border Environment Cooperation Commission (BECC) certified a plan to address wastewater problems in Ambos Nogales (BECC 2000). The plan called for enhanced treatment capacity at the NIWTP, from 17.2 mgd (million gallons per day) to 22.2 mgd, and replacement of the present pipe which conveys Mexican wastewater from the border to the plant (called the International Outfall Interceptor, or IOI), with a larger pipe. Presently, 9.9 mgd of the 17.2 mgd treatment capacity at the plant is allocated to Mexico (Table 3). The remaining 7.3 mgd belongs to Nogales, Arizona. Under the new plan, ammonia and nitrogen levels in the effluent would have been significantly reduced. Turbidity would also have been better controlled to comply with federal standards. Heavy metals, which have exceeded standards in the past, would not have been treated. According to the plan, metals would have been addressed by a pre-treatment process in Mexico.

**Table 3**  
**Treatment Capacity and Average Sewage Influent**  
**Nogales International Wastewater Treatment Plant**  
(million gallons per day)

City	Treatment Capacity	Average Flows (2000-2004)
Nogales, Arizona	7.3 mgd	4.8 mgd
Nogales, Sonora	9.9 mgd	10.2 mgd
Total	17.2 mgd	15.0 mgd

(IBWC 1995; IBWC 2005)

For Mexico, the plan involved construction of a new wastewater treatment plant in Sonora to be located about 11 miles south of the border, in Los Alisos basin. Existing wastewater flows from Mexico to the NIWTP were expected to continue, while flows above 9.9 mgd would have been pumped to the Los Alisos basin. A conveyance system would have transported a portion of the wastewater to the Los Alisos basin, located nine miles to the south of Nogales, Sonora, a basin which is not hydrologically connected to the Santa Cruz River watershed. The plan also called for wastewater collection systems to be upgraded in both Nogales, Arizona and Nogales, Sonora.

### **Water Quantity**

While less threatened by reduced flows of water than either the San Pedro or the Colorado rivers, flows to the Santa Cruz River in Arizona would be reduced if Mexico decided to retain its wastewater or return its portion that is now treated at the NIWTP back to Mexico. This would reduce the water budget by 9.9 mgd, or 26 percent of the total inflows into the Santa Cruz Santa Cruz Active Management Area (AMA) (Morehouse et. al 2000). Due to the technological difficulties and the huge cost involved in retaining or returning its wastewater, Mexico would not likely engage in such an undertaking in the near future. Mexico is more likely to try to get Arizona to pay for the wastewater that it sends across the border (Basaldua 2003).

Drought is a more immediate and regular threat to water supplies in Nogales, Arizona and Nogales, Sonora. During dry summer months under drought conditions the cities of Nogales, Arizona and Nogales, Sonora are both forced to shut down supply wells on the Santa Cruz River. This action is taken because the river aquifer is shallow and can go dry without regular replenishment from rainwater.

### **Environmental Implications**

One impact of the effluent dominated stream, downstream of the treatment plant, is potential contamination of the underlying aquifer. While there have been no measurable effects on groundwater quality by contaminants from the effluent, it is uncertain what the long-term consequences might be. As more contaminants are absorbed, the soil may reach a saturation point and its ability to filter out contaminants may be reduced.

Reduction of the flow of Mexican effluent would greatly reduce the amount of riparian vegetation along the river. Wildlife on the Upper Santa Cruz River is comprised of approximately 100 species of birds, and several species of reptiles and small mammals (burrowing rock squirrels, pocket gophers, skunks, bats, woodrats, kangaroo rats, and various small mice and snakes. Three candidate species for Endangered Species Act (ESA) listing have habitat found around the Santa Cruz River riparian area. These include: the Gila topminnow, the Lesser-long nosed bat, and the Sonoran pronghorn. The Gila topminnow is also a state-listed threatened species, as is the Northern gray hawk. The Arctic peregrine falcon, a federally listed threatened species, may be found in the Upper Santa Cruz. (National Park Service 1993).

Surface water quality in the Santa Cruz River does affect wildlife. A United States Fish and Wildlife Service (USFWS) study discovered that levels of ammonia in NIWTP effluent were toxic to invertebrates and fish (King et al. 1999). A high proportion of one species of fish (*longfin dace*) was found to have skin and skeletal anomalies at sites immediately downstream from the NIWTP.

**Recent Actions**

Since the 2000 grant application to BECC for improvements on the U.S. side of the border, progress to implement the proposed upgrades and construction came to a halt when costs for the new plant design greatly exceeded original estimates (dos Santos 2004). While Nogales, Arizona is still not presently utilizing its total capacity in the plant, Mexico is now regularly exceeding its 9.9 mgd capacity (Table 4). Talks to implement the plant upgrades resumed in October 2003, with ADEQ coordinating discussions involving EPA, BECC, NADBANK, the City of Nogales and the IBWC (Tinney 2004).

The parties involved in the plant upgrade talks were brought back to the table by two impending issues that put pressure on the group to get the process back on its feet. First, penalties could be assessed by ADEQ on the owners of the NIWTP, the City of Nogales and the IBWC. The NIWTP must comply with a deadline established by federal court order, and it must meet ADEQ’s Aquifer Protection Permit program requirements. Fines could be as high as \$25,000 per day. Secondly, the \$60 million set aside for plant upgrades in 2000 by EPA, could soon be reallocated if not used.

Committees have been formed to sort out the complex issues. The four committees address the following issues: finance, legal, political and technical (Tencza 2004). One of the critical technical issues is to look for the most cost effective way to upgrade the plant. With limited money available for the plant, and additional money needed for a complete upgrade, committees must select which upgrade components are needed the most. The goal of the committees is to reach some conclusions by spring 2005 (Tencza 2004).

**Table 4**  
**Annual Sewage Influent at the NIWTP: 1996-2004**  
(million gallons per day)

Source of Effluent	1996	1997	1998	1999	2000	2001	2002	2003	2004
Arizona.	4.0	4.2	5.0	5.5	5.1	4.5	5.5	4.4	4.3
Mexico	8.8	8.5	9.5	9.0	10.4	11.1	9.2	9.9	10.2
Total	12.8	12.7	14.5	14.5	15.5	15.5	14.7	14.3	14.5

(IBWC 2005)

At the Arizona-Mexico Commission Meeting in November 2003, Mexican authorities stated they are exploring ways to receive payment for the Mexican effluent being utilized in the United States (Basaldua 2003). At minimum, they want to explore the possibility of trading the value of the effluent for payment of the treatment bill. The problem with

that idea is that there is presently no group in Arizona which could pay for the water, although two emerging entities could change that in the future.

### **Nogales Electrical Generating Plant**

First, a proposal is under development to build an electrical generating plant in Nogales, Arizona, utilizing Mexican effluent for cooling (Maestros Group 2004). A consortium of interested individuals is planning to submit a bid to the Mexican Electricity Commission to construct a 411 million watt (MW) gas-powered electrical generation plant in Nogales, Arizona to provide electricity to Nogales, Sonora. The benefits to Mexico would be a needed supply of electricity and relief from the yearly payments to treat their wastewater in Arizona. The cost of treating the Mexican wastewater at the NIWTP would presumably be paid for by the power plant. The benefits to Nogales, Arizona would be additional jobs, a back-up supply of electricity for Santa Cruz County, and higher air quality standards for plant emissions than if the plant were built in Mexico. The plan could also help to assure that the Mexican effluent from the NIWTP stays in Arizona. The bid process application date, twice postponed, has not been officially announced.

The proposed plant would use an estimated 3 million gallons per day of Mexican effluent. As mentioned, Sonoran effluent flows to the NIWTP are exceeding their treaty limit of 9.9 million gallons per day. This flow in excess of the treaty would be utilized for use as cooling water.

The proposed electrical plant is a private-initiative solution to address both energy and water issues. Private-initiative solutions to transboundary problems, in general, have drawn the support of new IBWC Commissioner Arturo Duran. Commissioner Duran stated in February 2004, "We need to focus on how we go about building capacity at the local level and how local communities go about addressing their own issues and start looking for local problems, local solutions, and how we can all facilitate a process and empower that" (Duran 2004).

### **Water Authority**

A second development that could provide a way to pay for the Mexican effluent is the emergence of the Santa Cruz Water Management and Importation Authority. This is an entity being organized by water users along the Santa Cruz River within the Santa Cruz AMA. The Authority would be designed with a package of management tools that would go beyond the present authority of the Santa Cruz AMA (State of Arizona 2002). Some of the Authority's possible tools would be the ability to purchase water rights, the means to store and recharge water, the ability to provide short-term option agreements during times of shortage and the capability to loan money. The Authority would need authorization from the state legislature before it could begin operations.

The Authority could also possibly address one main issue in the basin, which is the inflow of wastewater from Mexico to the NIWTP. The Authority could serve as an organized entity to represent the voice of all water users within the AMA. Ideally, such

an entity could work out an arrangement with Mexico to keep the wastewater flows coming into Arizona.<sup>1</sup>

At a September 2004 meeting of the Santa Cruz AMA Groundwater Users Advisory Committee, a representative of the settlement group reported that the draft settlement is almost ready to present to the public, but added that there are still a few more details to work out (GUAC 2004). It was reported that an outstanding issue was that the National Park Service (NPS) recently purchased land that the Santa Cruz River runs through and the settlement group is waiting for comments from the NPS on the draft settlement. It was stated that the next major hurdle will be all the members of the settlement group to agree to on the terms of the settlement. The settlement group was optimistic about getting an agreement soon.

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<sup>1</sup> A payment option would involve an international agreement specifying the nature of each county's obligation as well as the obligations of private parties. The IBWC and CILA would be involved in such an agreement.

## UPPER SAN PEDRO RIVER

The San Pedro River originates in Sonora, Mexico, near the mining town of Cananea, located about 25 miles south of the Naco border crossing (Figure 3) (Gray 2004). The river, perennial only where the streambed passes through hardrock or flowing springs, flows northward to its confluence with the Gila River. In 1988, a 40-mile portion of the San Pedro riparian system in the U.S. became the first congressionally-designated Riparian National Conservation Area. The San Pedro Riparian National Conservation Area (SPRNCA), managed by the Bureau of Land Management, was established to help protect this important reach of the river. The San Pedro River is nationally recognized as a significant and unique riparian area because of the diversity of its flora and fauna. The San Pedro River is one of the region's last free-flowing rivers, and supports the most extensive cottonwood-willow riparian forest in the Southwest.

The San Pedro River enters Arizona from Mexico near the town of Palominas, Arizona. The river flows northwest between the Huachuca and Mule mountain ranges for about 62 river miles before leaving the upper basin north of Benson. The Sierra Vista Sub-watershed, covering approximately 950 square miles, extends from the international boundary to about 27 miles north near the abandoned mining town of Fairbank, Arizona. The river has a perennial reach of about 18 miles between Hereford and just south of Fairbank. Apart from the perennial reach, the river is mostly ephemeral and only flows when there is rainfall.

Large military and industrial installations on both sides of the border play big roles in the use of San Pedro River water. On the U.S. side, Fort Huachuca, a 73,000-acre Army Intelligence Center located near Sierra Vista, dominates the water scene. The Fort is the largest single employer in Cochise County, providing 40 percent of the jobs. Fort Huachuca adds \$1.5 billion to the Arizona economy, with one-third of that amount spent in Cochise County for salaries and purchases (Kent 2004). In Mexico, the area's most important economic force is the Cananea Copper Mine. The mine employs approximately 70 percent of the population of Cananea and controls water use at the San Pedro River headwaters (Varady et al. 2000).

Like many areas in Arizona, the Upper San Pedro Basin has experienced rapid population growth (Table 5). The municipality of Cananea, Mexico has also experienced population growth (Table 6). In the United States portion of the watershed, rapid urbanization and expansion of Fort Huachuca could affect San Pedro river surface water (CEC 1999). Copper mining near the headwaters of the San Pedro in Cananea, Sonora represents the potential for water quality problems on both sides of the border.

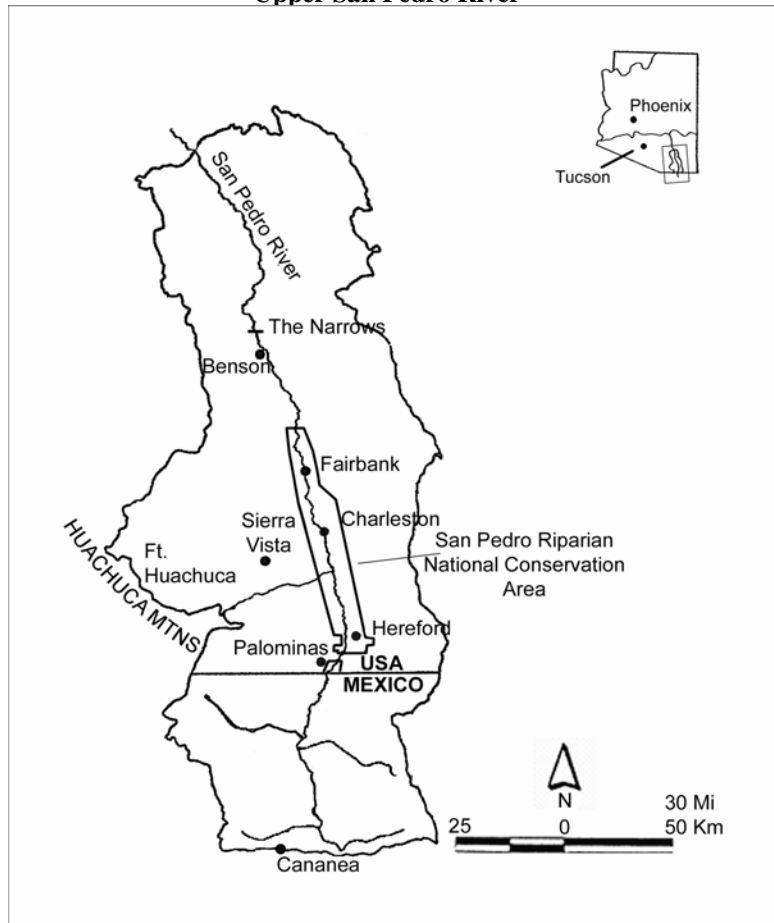


## Water Quality

The Cananea Mine, located 40 miles south of the border, has experienced periodic operational problems particularly during periods of heavy rainfall. Several spills occurred between December 1977 and April 1985 that resulted in fish kills in the San Pedro River, both in Mexico and in Arizona, due to heavy metal and sulfate contamination and extremely acidic pH (King et al. 1992). The mine waters are now being discharged into the Rio Sonora basin to the south to avoid any future mishaps. However, water quality measurements of the San Pedro River in Mexico show that concentrations of acidity

and heavy metals increase as the water is tested closer to the mine site (Maest et al. 2003).

**Figure 3**  
**Upper San Pedro River**



## Water Quantity

The Upper San Pedro Watershed figures prominently in the rich and diverse history of the area. In 1848, as part of the Gadsden Purchase, the United States acquired what would become Southern Arizona to support what U.S. Minister to Mexico, James Gadsden, and other U.S. officials, considered to be the most direct and practicable route for the southern transcontinental railroad. Fort Huachuca was established in 1877 to secure the recently expanded southern borders of the United States and to protect settlers from Indian attack (City of Sierra Vista 2004). Initially the only settlements in the vicinity of the Fort were small ranches near the San Pedro River and close to the mountains. A small community began to grow to the east of the Fort. This community, originally named Fry (Tellman 1997), was incorporated as Sierra Vista in 1956. By the 1920s agriculture was widespread along the river, and together with mining in Mexico, these activities resulted in large quantities of water diverted from the San Pedro River.

Historical data from the sub-watershed indicates that stream flows have diminished over time. Records of stream flow at the United States Geological Survey (USGS)-operated Charleston gauge show that flows in the year 2000 have dropped to about half of 1913 levels (Figure 4). Between 1990 and 2000, population growth within the City limits of Sierra Vista was 15 percent, while populations in Cochise County as a whole increased at a higher rate of 20 percent (Table 5).

**Table 5**  
**Population Profile: Cochise County and Sierra Vista**

Year	Cochise County	Percent Change (for 10 year period)	Sierra Vista	Percent Change (for 10 year period)
1960	55,039		3,121	
1970	62,800	14%	6,689	114 %
1980	86,300	37%	24,937	273%
1990	97,800	13%	32,983	32%
2000	117,755	20%	37,775	15%

(United States Census Bureau 2004, City of Sierra Vista 2004)

**Table 6**  
**Population Profile: Municipality of Cananea**  
**(the city and surrounding area)**

Year	Cananea	Percent Change (for 10 year period)
1960	21,048	
1970	21,315	1%
1980	25,327	19%
1990	26,931	6%
2000	32,074	19%

(INEGI 2000)

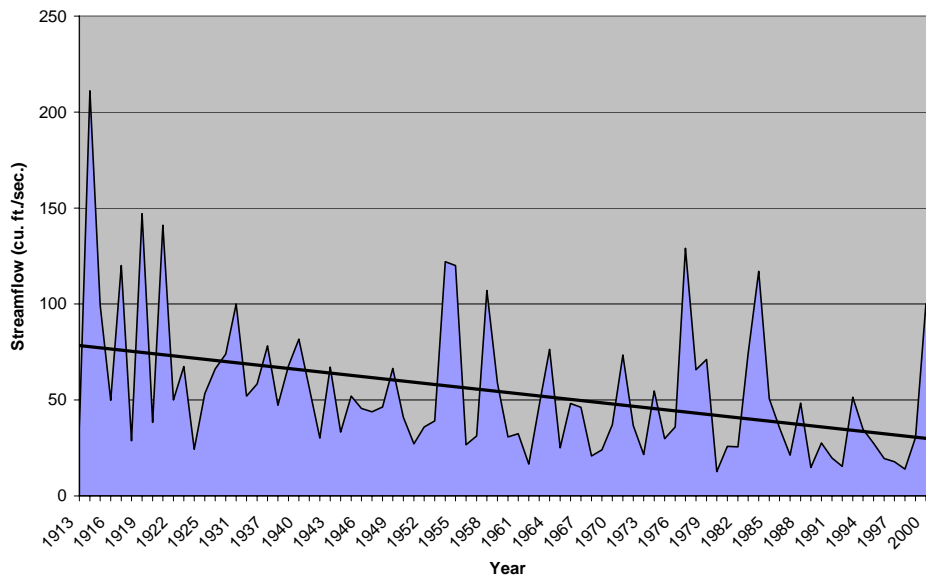
USGS researchers Pool and Coes (1999) state that this decline in base flow, during the period from 1940 to 1985, corresponds with a period of below-average winter precipitation. Other potential causes of the drop in base flow are increased interception of groundwater flow to the river by wells and phreatophytes.<sup>2</sup> However, Pool and Coes assert that their review of 1998 water well levels indicates that groundwater withdrawals in the vicinity of Fort Huachuca and Sierra Vista diverted groundwater flow from the San Pedro River. The groundwater withdrawals created a cone of depression (a cone-shaped lowering of the water table around a pumped well) in the heavily pumped area near Sierra Vista (Pool and Coes 1999).

While recognizing a need for more research on the overall effect of groundwater pumping in Mexico, a 1999 North American Commission for Environmental Cooperation

<sup>2</sup> Groundwater discharge by evapotranspiration from phreatophytes (or water loving plants) in arid and semiarid regions is a principal mechanism for water loss in surface water bodies.

(CEC) Study concluded that Mexico’s contribution to SPRNCA’s baseflows is minimal (CEC 1999). Agricultural pumping may affect streamflow in the United States, but it is not likely to affect groundwater depths in the Sierra Vista sub-basin. Pumping in Mexico does impact river flows near Cananea. The CEC report concluded that the annual groundwater deficit for the Sierra Vista sub-watershed was approximately 7,000 acre-feet per year (CEC 1999). (One acre-foot is 326,000 gallons, approximately enough to meet the needs of a three or four person family for one year.) This means that more water was being removed from the aquifer than was being replaced, or recharged, resulting in a

**Figure 4**  
**Streamflow and Trendline: San Pedro River at Charleston Gauge**  
**1913-2001**  
 (USGS 2004)



reduction to the amount of water stored in the aquifer. The report identified several potential threats to the hydrologic balance necessary to maintain riparian habitat in the SPRNCA. These threats included water demands of riparian vegetation, irrigated agriculture, private water companies serving the municipality of Sierra Vista and Fort Huachuca, and domestic wells in the unincorporated area of Cochise County. A study presently being undertaken by the USGS is examining factor such as drought and riparian habitat evapo-transpiration, in relation to SPRNCA water needs (Strain 2003).

Environmental groups such as the Center for Biological Diversity have had concerns about the long-term viability of the San Pedro riparian system in the face of continued population growth. Groundwater sustains the riparian system during the dry months of the year. Although accessible groundwater reserves in the Upper San Pedro River basin (an area of 1730 square miles) are estimated to be considerable (Cochise County 2002), the river survives at the top of the water table. If the water table is lowered by groundwater pumping near the river, the connection between surface water and groundwater would be broken, and the river could dry up. Although there appears to be

available groundwater in the basin to meet the water needs of the surrounding communities, most of the water may not be readily available to population centers.

The January 1997 listing of several new endangered species triggered a requirement for Fort Huachuca to consult with the Fish and Wildlife Service under Section 7 of the Endangered Species Act. The Fort initiated consultation with a submission of a biological assessment (BA) to the USFWS. The BA outlines the Fort's analysis of the potential impacts of its actions on federally-listed species and designated critical habitat. In October 1999, the USFWS' resulting biological opinion declared that the military's water conservation plan was adequate. (A biological opinion is a USFWS response to the BA, a statement of whether or not a federal action would jeopardize the existence of an endangered or threatened species, or result in destruction or degradation of critical habitat.) However, in April 2002 the 1999 biological opinion was set aside by the United States District Court due to a lack of specific, quantifiable conservation measures (USFWS 2002). The Fort and the USFWS entered a second consultation process to produce a new, non-jeopardy biological opinion.

In the second biological opinion issued in August 2002, the USFWS again concluded that the Army's ongoing and planned operations were not likely to jeopardize the continued survival or recovery of any threatened or endangered species or result in adverse modification of critical habitat, on-post or in the nearby San Pedro River (USFWS 2002). The Army's revised biological assessment of the Fort's activities, upon which the biological opinion was based, estimated the regional groundwater deficit in the Sierra Vista subwatershed at 5,144 acre-feet (down from the 7,000 acre-foot estimate made by the CEC in 1999, possibly the result of conservation measures). The study determined that 54 per cent of the residents in the sub watershed were there because of the fort's presence (USFWS 2002). The fort was deemed responsible for 54 percent of the annual deficit, or 2,874 acre-feet. In the biological assessment, however, the Army committed itself to mitigate 3,077 acre-feet of the deficit, or 200 additional acre-feet above what was required, by the year 2011.

### **Environmental Implications**

The San Pedro River corridor is one of the richest and most biodiverse in North America. The corridor provides habit for 250 species of migratory birds (or 1 to 4 million individual birds) that winter in South America, Central America and Mexico and breed during the summer months in the United States and Canada (Nature Conservancy 2004). One species of bird, the sulphur-bellied flycatcher, travels 4000 miles one way from the mountains near the San Pedro River to wintering grounds in the Amazon Basin of South America.

The internationally renowned birdlife of the San Pedro River attracts thousands of birdwatchers from all over the world each year. Over 100 species of breeding birds, in addition to the migrant and wintering birds, inhabit this area, representing one-half the known breeding species in North America (BLM 2004). In particular, 36 species of raptors, including the gray hawk, Mississippi kite, and crested caracara can be found

within the SPRNCA. Other species include the green kingfisher, northern beardless-tyrannulet and yellow-billed cuckoo. In 1996, the American Bird Conservancy designated the Conservation Area as a Globally Important Bird Area in recognition of the River's importance to migrating birds as well as habitat for many rare species of birds. The Upper San Pedro Valley attracts roughly \$6 million in tourism revenue yearly, much of it directly related to bird watching (CEC 1999).

With an estimated 90 percent of Arizona's riparian areas degraded or destroyed, the San Pedro River stands out as an example of a highly productive natural riparian community in the southwestern United States. In addition to bird species, 82 species of mammals, and 43 species of reptiles and amphibians utilize the corridor for nesting, foraging, water, and shelter. Endangered species supported by the river include the jaguar, Mexican spotted owl, cactus ferruginous pygmy owl, southwestern willow flycatcher, loach minnow, spikedace, and Huachuca water umbel (Nature Conservancy 2004).

### **Recent Actions**

The Army has undertaken a number of conservation measures and activities to lessen the potential effects their activities might have on listed plants and animals. These measures include educating Army personnel to possible species location and needs, conducting preconstruction plant and animal surveys, protecting and monitoring species and their habitat. The Army has also implemented fire, erosion and numerous water recharge, reuse and conservation projects, and has cooperated with partners of the Upper San Pedro Partnership to balance the water budget in the Sierra Vista Subwatershed.

The Upper San Pedro Partnership was formed in 1998 with the stated goal of cooperating in the "identification, prioritization and implementation of comprehensive policies and projects" to help meet water needs in the Sierra Vista Subwatershed of the Upper San Pedro River Basin. The first priority of the Partnership was to ensure that an adequate long-term groundwater supply is available to meet the current and future needs of area residents as well as the San Pedro Riparian National Conservation Area. The Partnership is comprised of a diverse group of 20 organizations, including The Nature Conservancy, Fort Huachuca, the City of Sierra Vista and the U.S. Geological Survey.

Members of the Partnership have taken concrete steps to help save the river. These include: construction of a wastewater recharge project near the river; development of retention basins to capture and recharge rainwater runoff; toilet rebate programs; and a water audit program to help individuals identify how to save water around the house. Huachuca City is working with Fort Huachuca to pump sewage from Huachuca City for treatment and recharge at the fort. Effluent is used to irrigate the golf course and parade grounds of the fort.

Three member agencies of the Partnership worked together to establish a voluntary conservation easement on a 909-acre ranch near Palominas (Cramer 2003). The intent of the easement was to conserve groundwater resources in this area and to retain open space adjacent to the San Pedro Riparian National Conservation Area. The ranch easement

permanently retires previous agricultural groundwater pumping on 120 acres of the ranch, and puts limits on future subdivision of the land. The Nature Conservancy, Fort Huachuca and Bureau of Land Management plan to work with additional landowners in the area who might have an interest in similar conservation projects.

One of the goals of the Partnership is to collaborate with entities within the Mexican portion of the watershed. Since 2002, four meetings have taken place between the Partnership and a grassroots group of teachers, government representatives, mining engineers, lawyers and other local citizenry in the Cananea-Naco area to address issues of water quality and delivery problems (Udall Center & ISPE 2003; Browning-Aiken 2004). The United States-Mexico group is now called the San Pedro Binational Partnership. Beyond the meetings of the full body, three sub-committee meetings have been held with more dialogues planned for the future.

A recently published book, *Alternative Futures for Changing Landscapes* (Steinitz et al. 2003) , examined various growth and conservation scenarios and the effect each scenario would have on the San Pedro River. The study concluded that even the most optimal scenario of restricted population growth and reduced water use would result in a loss of groundwater storage and increased drying of the San Pedro River. The most important factors identified which will affect the river, in order of significance, were agricultural water use, and development. Population growth in Sonora, Mexico and activities at Fort Huachuca were considered to have a small impact when compared to the impacts of agriculture and urbanization in the Arizona portion of the basin. One scenario that showed the potential to dry the river at a faster rate involved closing Fort Huachuca and allowing development of that land.

On November 24, 2003, the President signed the National Defense Authorization Act, H.R. 1588, legislation which included the Fort Huachuca Preservation amendment. The amendment has provisions both to limit Ft. 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 strengthen the Upper San Pedro Partnership and protect the regional aquifer from over pumping. The amendment requires the Secretary of the Interior to produce a report by December 31, 2004 describing water use management and conservation measures necessary to restore and maintain the sustainable yield of the aquifer by September 20, 2011. 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 San Pedro Partnership but, as of February 2005, has not been finalized by the Secretary of the Interior (Richter 2005).

The Partnership, despite its notable successes, may have to look beyond existing conservation measures to reverse the continued reduction of the aquifer (Richter 2003; Steinitz et al. 2003). Growth rates show no signs of slowing in this region, which will place additional demands on the aquifer. While growth cannot legally be stopped, in order to preserve surface water flows in the river, it will probably have to be managed.

To address this regional issue no one entity can solve the problem alone and the collaborative work begun by the Partnership will be essential in the future.

## LOWER COLORADO RIVER

The Colorado River, with headwaters in the snow-packed mountains of Wyoming and Colorado, provides irrigation and drinking water to over 25 million people in the southwestern United States. The Colorado River drainage basin covers about 243,000 square miles, almost 10 percent of the continental United States. Annual river flows into Arizona average 11.4 million acre-feet. In normal years, the Colorado River travels 1450 miles from its origin to its terminus near the Gulf of California.

### Water Quality

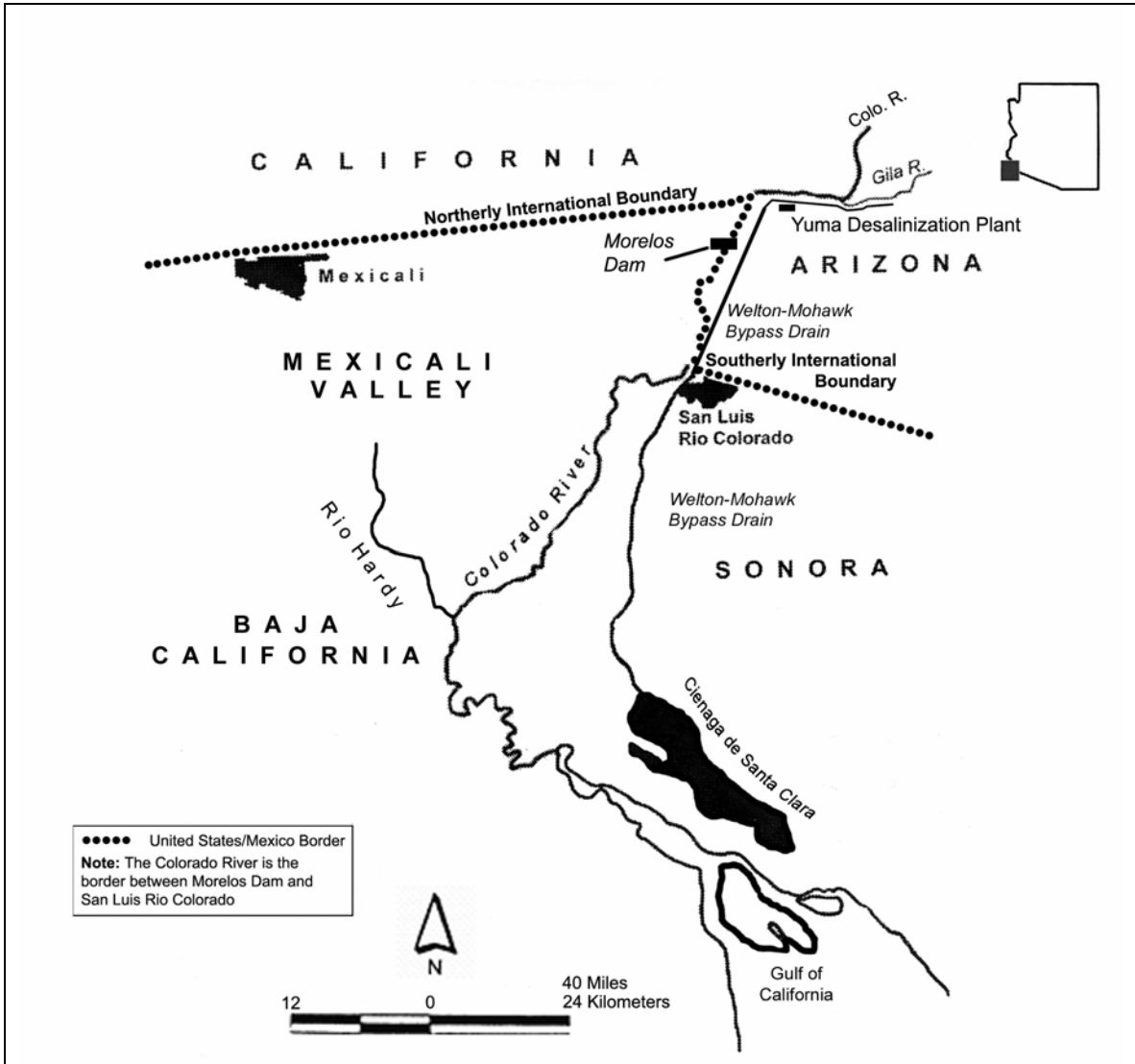
Both the United States and Mexico have long pursued policies to fully develop and utilize the water supplies of the Colorado River for agriculture, municipal and industrial purposes. The pressure for development and the resulting tension between the two countries over the allocation of the Colorado River finally resulted in a treaty to divide the waters (Treaty 1944). The U.S. is obliged, under the 1944 treaty, to deliver 1.5 million acre-feet (maf) of surface water per year to Mexico, approximately 10 percent of the overall yearly flows in the river.

Colorado River water quality became an issue in 1961. Prior to 1961, Mexico received Colorado River flows that exceeded treaty requirements, and the quality of the water delivered to Mexico was roughly the same as that in the lower Colorado River Basin of the United States. (Figure 5). During the 1950s, several factors contributed to a decline in water quality. Intense growth was taking place in the southwestern United States, construction of Glen Canyon Dam was nearing completion, and increased agricultural production resulted in rapidly growing demands for use of Colorado River waters. The United States began diverting significant amounts of water from the Colorado River in order to bring new areas under cultivation (Figure 6). Return flows from agricultural districts back to the river increased. The largest increases were from the Yuma Mesa Division Irrigation Districts and the Wellton-Mohawk Irrigation and Drainage District (WMID) of Arizona. At the same time, fresh water supplies were reduced due to increased storage on Lake Powell. Arizona also began pumping highly saline drainage from the Yuma Districts and the WMID back into the Colorado River. The United States continued to fulfill the Treaty's water quantity requirement by returning the diverted water to the river before it reached Mexico. However, the water returned to the river from the irrigated areas was of a significantly lower quality.

The result of the decreased flows and increased salinity was to increase the average annual salinity of waters made available to Mexico from an annual average of 650 parts of salt per million to 800 parts per million. Crop yields in Mexico went into sharp decline. In November, 1961 Mexico formally protested that the quality of the waters it received was not good enough for agricultural uses, and that the high saline water caused



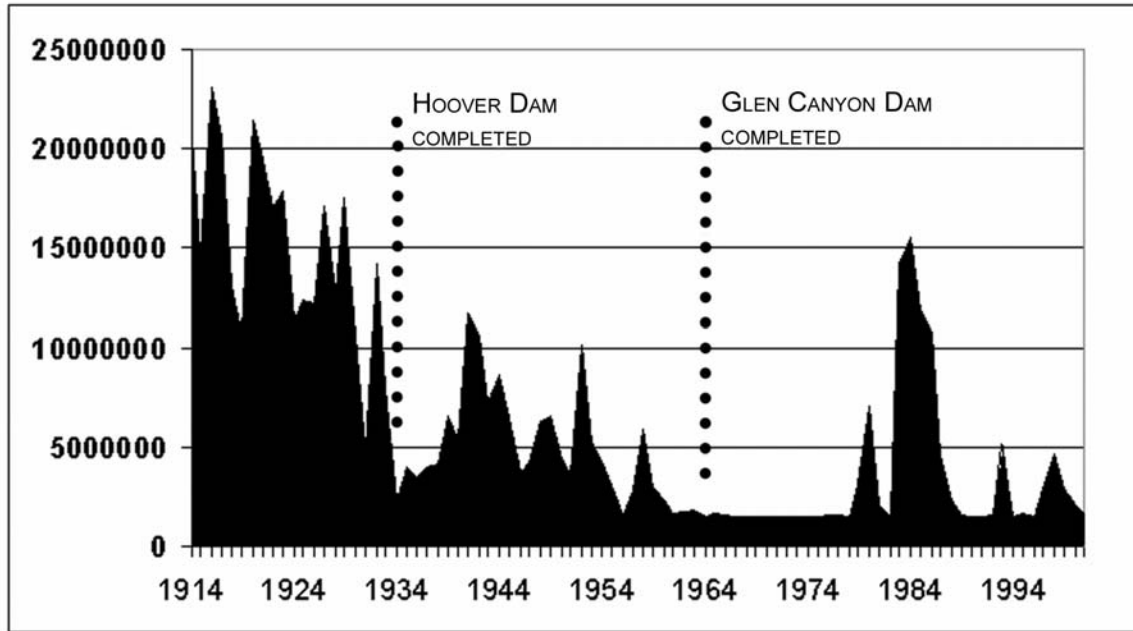
Figure 5  
Lower Colorado River



agricultural production in the Mexicali Valley to suffer. Mexico also claimed that the United States was violating the 1944 Treaty and international law.

In 1973, the United States and Mexico agreed to a "permanent and definitive solution" to the salinity problem (IBWC 1973). In addition to providing Mexico with the quantity of water mandated by the 1944 Treaty, the United States consented to take measures to improve the water quality. In order to comply with the 1973 agreement, the United States built a desalinization plant in Arizona to process Wellton-Mohawk diversion water. This plant was intended to reduce the mineral content of the water before it was sent to Mexico by way of the Colorado River. Under the agreement, Colorado River water delivered

**Figure 6**  
**Colorado River Flows to Mexico at Morelos Dam, 1914-2001**



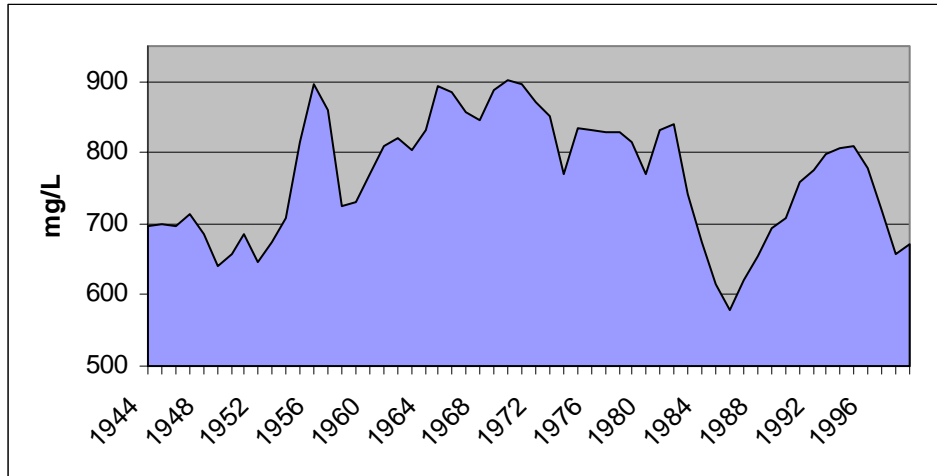
(Tellman, Yarde and Wallace 1997)

to Mexico was mandated to have a salt content of no more than 115 part per million (ppm) over the annual average salinity of the Colorado River at Imperial Dam. Because the plant would take time to build, the United States agreed to temporarily reroute the high saline WMID drain water through a canal (the Wellton-Mohawk Bypass Drain), paid for by the Bureau of Reclamation, that would carry it to the Cienega de Santa Clara (Santa Clara Slough). These canal flows constitute about 115,000 acre-feet per year and are not counted as part of the 1.5 million acre-feet delivered to Mexico as part of the Treaty.

The Colorado River Basin Salinity Control Act was passed by Congress in 1974 to fund salt control projects along the river at a total cost approaching a billion dollars (de Kok 2004). In 1971, the EPA calculated that one-half of the salt in the Colorado River was the result of natural causes, such as marine sediments and saline springs along the river (McClurg 2003). The other one-half of salt in the river was the result of human activities such as agriculture (37 percent), reservoir evaporation (12 percent) and municipal and industrial use (1 percent). Salinity control measures included lining canals with concrete, promoting less water intensive irrigation practices, and reducing runoff into the river from soil that are naturally saline (McClurg 2003). The measures taken were effective in reducing salt in the Colorado River. The average total dissolved solids (TDS) at Imperial Dam in 1999 was 672 mg/L, more than 200 mg/L less than in 1973 (Figure 7).

The construction of the Yuma desalinization plant, which was built at a cost of \$256 million, was completed in 1992. The plant operated at one-third capacity from May 1992 to January 1993. In 1993 plant operation was halted when flood flows in the Gila River destroyed a drainage canal. After the canal was repaired, the Colorado River experienced a series of wet years that made the restarting of the plant unnecessary.

**Figure 7**  
**Total Dissolved at Imperial Dam, 1944-1999**



(U.S. Bureau of Reclamation 2004)

## Water Quantity

Prior to the major dam projects along the Colorado River, the river enriched a great delta of wetlands that covered 475 square miles and sustained a variety of plant, bird and marine life (Pitt et al. 2000). During these earlier “wet” times, most of the river’s flow reached the Delta. The freshwater, silt and nutrients from the river helped create an expansive wetland system that provided feeding and nesting areas for birds and spawning habitat for marine life.

In 1905, flood waters left the main channel of the river near Yuma and flowed into the Imperial Valley for 18 months, forming the Salton Sea. The river was re-diverted back to the main channel only after extensive and costly efforts. However, as author Marc Reisner observed, “the Colorado River was a rampant horse in a balsa corral” (Reisner 1993). After this, and subsequent floods in 1906 and 1907, water users in the United States lobbied heavily for flood control on the river. The result was the authorization of the Hoover Dam, which was intended to give farmers insurance against drought and reduce the frequency of devastating floods. Because of decades of dam construction and water diversions in both the United States and Mexico, the Delta is a remnant of the system it once was.

## Environmental Implications

The delta’s marshes once provided habitat for millions of birds migrating on the Pacific Flyway. Although reduced in size, the delta still supports a large number of migratory and non-migratory waterfowl and shorebirds as well as fish, reptiles and mammals. Species found in the Mexican Delta that are listed as endangered under the United States Endangered Species Act (ESA) are the desert pupfish (*Cyprinodon macularius*), the totoaba (*Totoaba macdonaldi*) and the vaquita porpoise (*Phocaena sinus*) (USBOR 2000). ESA listed bird species found in the Mexican Delta include the Southwestern

willow flycatcher (*Emidonax traillii extimus*) and the Yuma clapper rail (*Rallus longirostris yumanensis*). The Yellow-billed cuckoo (*coccyzus americanus*), which is proposed for listing, also inhabits the Mexican Delta.

The marine environment of the Gulf of California is also regenerated by freshwater inflows from the Colorado River. With those flows greatly reduced, the estuarine environment is becoming more and more saline, potentially endangering the existence of many of the species that inhabit the Gulf region. However, although the Colorado River Delta has been severely disturbed for a half century, research on this estuarine system has only begun fairly recently.

### **Recent Actions**

On the U.S. side, a partnership of state, federal, tribal and other public and private stakeholders has been organized to conserve habitat, to facilitate recovery of threatened and endangered species, and to reduce the likelihood of additional species listings under the Endangered Species Act (ESA). Implementation of this Lower Colorado River Multi-Species Conservation Program (LCR MSCP) is expected to have beneficial impacts on floodplains and wetlands, especially in maintaining or creating wetlands and reestablishing riparian habitat that is essential to the recovery of species.

Potential conservation measures could include protecting existing habitat by managing access, converting agricultural land to habitat and, manipulating discretionary flows to enhance and restore habitat. One drawback to the plan is that, over objections by environmental groups in Mexico and the United States, the Colorado River Delta in Mexico is not included as part of the Conservation Program, due to legal restrictions of extending the ESA program into another country. In 2000, Environmental groups lost a legal battle in federal court to force the LCR MSCP to include the Colorado River Delta within its scope (Campbell and Bueno 2002). A draft Environment Impact Statement for the program was released in 2004. While the LCR MSCP will not address the need for continued or increased flows to the Delta, the program will not affect the minimum amount or quality of water delivered to Mexico pursuant to treaties between the United States and Mexico.

Lawyers Robert Glennon and Peter Culp point out that the river water flowing into the Sea of Cortes provides the freshwater necessary for reproduction of countless species of sea life, including what some consider to be the most endangered porpoise in the world, the *vaquita* harbor porpoise (Glennon and Culp 2002). The river serves to protect many species from extinction as it preserves biological diversity. Glennon states that the cost of a Delta restoration program is far outweighed by the benefits. Some scientists estimate that only a relatively small amount of water is needed to restore and preserve critical species (32,000 acre-feet per year, with periodic flood flows of around 260,000 acre-feet) (Lueke et al. 1999). By comparison, Arizona's Water Banking Authority recharged Arizona's aquifers with 346,000 acre-feet of Colorado River water in 2003 (AWBA 2003). Also in 2003, California used 800,000 acre-feet in excess of their entitlement of Colorado River water (Martin 2003). Obtaining a significant portion of the

recommended 32,000 acre-feet for the Delta on an annual basis from the WMID would constitute only a fraction of the 270,000 acre-feet consumptive-use entitlement of the irrigation district (Glennon and Culp 2002; Flores 2004).

However, if water use were reduced in the WMID, either through water conservation or land retirement, the Central Arizona Project (CAP) would have the right to request the water through a contract agreement with the Secretary of the Interior (Carr 2005). The CAP has the right to divert any water unused by higher priority water users in the state. In addition, if Arizona did not claim the water, other lower basin states would request the unused water. Both California and Nevada have water demands in excess of their entitlements. Land retirement and water conservation proposals would have to include the additional costs of arranging forbearance by lower priority water users (ADWR 2002). New federal rules and concurrence by the lower basin state legislatures would be required before any “saved” water could reach riparian habitat in Mexico.

In addition, any increase in deliveries of water to Mexico could result in reduced water supplies in United States reservoirs (ADWR 2002). This would remove the cushion of safety that the reservoirs provide for dry years when Colorado River flows are below normal. Reduced reservoir storage could lead to water supply shortages in Arizona. The Central Arizona Project (CAP), as the junior water entitlement holder to all other water users in the Lower Basin, bears the brunt of any water supply shortage impacts (ADWR 2002).

The vast majority of water sent to Mexico is utilized for agricultural production in the Mexicali Valley and its 500,000 acres of farmland. In 2001, 1.3 million acre-feet of Mexico’s 1.5 allotment was used for agriculture (Goff 2004). The agricultural flows return to the Colorado River by way of the Rio Hardy. However, numbers are not readily available for river flows in the Rio Hardy or how much water actually makes it to the Gulf.

Professor Steve Mumme, of Colorado State University, points out that the 1944 treaty establishing the IBWC placed ecological uses of treaty 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). Mumme states that the IBWC has the authority and duty to address ecological issues on the Colorado River Delta. He maintains that there is solid scientific evidence that water is needed to sustain the Colorado River Delta ecosystem, although the quality and quantity needed and where it will come from, will need to be worked out. Mumme asserts that a new ecological IBWC Minute (a written decision of the Commission) would provide additional legal support for obtaining instream flows for ecosystems. In addition, a Minute could offer an established approach for dealing with similar problems in other regions and it would aid in the development of a more integrated and sustainable approach to federal water management in both countries.

An IBWC meeting on December 12, 2000 established a conceptual framework for cooperation on the Colorado River Delta (IBWC 2000). As a result of the meeting, a

binational task force was established by the IBWC to facilitate studies concerning the Colorado River Delta in Mexico to help save the Delta from further decline. The IBWC action is intended to examine existing Colorado River Delta studies by government, scientific, academic and non-governmental organizations in the United States and Mexico, provide support for additional studies through the binational task force, and formulate recommendations for cooperative projects in Mexico.

### **Desalinization Plant Controversy**

The drought along the Colorado River has raised new interest in re-starting the desalinization plant (Megdal 2004). Bennett Raley, then-assistant Interior secretary, told the Arizona Republic that the drought makes it “imperative” that the issues related to the desalinization plant be resolved (Nelson 2004). Raley said the Interior Department wants to pursue “a dual track” to make the plant operational and persuade farmers to fallow land to make available additional water supplies. Bennett stated that the 2006 budget should allow for at least a partial start-up of the desalinization plant. The plant’s start up would allow an extra 100,000 acre-feet of water to be kept in Lake Mead to provide for shortages, and not be released to fulfill the treaty obligation to Mexico.

Environmentalists have opposed starting up the Yuma plant because it would affect the volume of agricultural return flows going into the Cienega de Santa Clara in Mexico. In 2003, the WMID delivered 116,000 ac-ft of brackish wastewater (with a TDS of 2500 ppm) to the Cienega (Adams 2004). The operation of the 100,000 acre-feet capacity plant, at an annual cost of \$25-\$32 million, would generate approximately 20,000 ac-ft of extremely saline brine (9-11,000 ppm TDS) (Adams 2004), which could replace the present 116,000 ac-ft going to the Cienega (Dalton 2003). Because of the increased TDS concentration, the saline brine would need to be diluted to mitigate harm to the Cienega. (Adams 2004).

Operation of the plant and maintaining the Cienega may not be mutually exclusive. A group is being formed, comprised of CAP officials, the Bureau of Reclamation, the Arizona Department of Water Resources, and environmentalists, to see if it can find common ground on both starting the plant and continuing flows to the Cienega. George Renner, president of the CAP board, said, “We now understand the importance to come up with ways to maintain the Cienega and we’re committed to do that” (Nelson 2004).

Utilization of the desalinization plant will generate a higher quality of water to send to Mexico, but at a relatively high price. Robert Johnson, director of the Bureau of Reclamation’s Lower Colorado Region, estimated that the cost per acre-foot to treat water at the plant is \$305 to \$425 (McClurg 2003). In California, Imperial Irrigation District farmers pay \$16.50 per acre-foot of water (University of California 2004), while Arizona farmers pay \$76 per acre-foot for Central Arizona Project water (CAP 2004).

ADWR has long held the view that the desalinization plant should be restarted and put into service (ADWR 2002). ADWR’s argument in favor of operating the desalinization plant is that although the Cienega de Santa Clara provides a significant benefit to the

Mexican economy and environment, the WMID water is not counted as a delivery under the treaty. The loss of the WMID water from the Colorado River System creates an increased possibility of water shortage to Arizona. Since Mexico receives the WMID water and its benefits, ADWR argues that the WMID water should be counted under the treaty (ADWR 2004).

Re-starting the desalinization plant would be beneficial to Arizona by allowing additional Colorado River water to be kept in storage reservoirs located along the river in the United States. Arizona has a right to expect the federal government to meet international obligations without putting state water supplies in jeopardy. However, restarting the desalinization plant might involve environmental mitigation if the quantity of water delivered to the Santa Clara Slough were reduced (Carr 2003). More mitigation would be needed to address consequences of replacing the existing flows to the Slough with highly concentrated brackish water. Such mitigation requires bi-lateral cooperation and funding, something that has not historically been easy to achieve.

## CONCLUSION

While change often occurs slowly on border water problems, it still occurs. Some border observers can look back 10 or 15 years at the problems associated with the San Pedro, Santa Cruz and Colorado Rivers and say “nothing has changed.” The rivers may flow as they always have, and most activities go on as before. From one perspective, that statement is true because the same problems exist now which have existed in the past. Yet a closer look reveals that changes are occurring, although perhaps not immediately seen. There are institutional responses, such as the LCR MSCP and studies by the IBWC. There are grassroot responses such as meetings between local groups from Cananea, Sonora and Cochise County, Arizona, and there now exists the Upper San Pedro Partnership. In addition, there is a management group trying to form in Santa Cruz County. These responses did not exist 10 to 15 years ago and the results from these responses may not be manifested for another 10 to 15 years, but movement is taking place.



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