ARROYO
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Border Water Source of Conflict and Cooperation

What Makes Management of Border Water Resources a Challenge?

The U.S-Mexico border is not only where two countries meet, but where different cultures face a common need for effective and sustainable use of the available resources. The management of resources and environmental hazards in this region is challenging. Agencies from both countries are addressing the challenge by participating in binational efforts to resolve the issues of water and air contamination, water resource allocation, and solid and hazardous waste disposal in the region. Each side of the border has a unique set of economic, social, and political conditions and institutions, making coordinated action complicated. Yet binational cooperation is essential in the form of planning, monitoring, prevention, mitigation and regulatory oversight. Neither country alone is capable of sustaining the shared environment by attending only to its own jurisdiction. The United States and Mexico have both realized this and have made a commitment to address the region's environmental resource problems, including those affecting the region's most important shared resource: water.

The U.S.-Mexico border runs nearly 2,000 miles from the Pacific Ocean to the Gulf of Mexico. The border region may be designated differently for various purposes by various institutions. For example, the 1983 La Paz Agreement defined the border region as the area of land 100 kilometers (62.5 miles) north and south of the international boundary, while the U.S. Geological Survey Border Environmental Health Initiative defines their program area by watershed boundaries. There is general agreement, however, that four U.S. states and six states in Mexico, with a total of 44 counties and as many as 80 municipalities, are located along the border. While there is much in common between these two countries, there are also differences in resources, regulatory frameworks, development, politics, culture, and language.

Mexico's National Water Commission, known as the Comisión Nacional del Agua (CONAGUA), regulates water use at the federal level, provides substantial funding for infrastructure projects, and is responsible for both the quantity and quality of water. In accordance with the Mexican Constitution, all of the country's waters belong to the nation and are subject to federal regulation and management. The state and municipal water agencies are generally responsible for delivering drinking water, wastewater collection and treatment services, but they have somewhat limited regulatory authority. In contrast, in the United States, quality standards,

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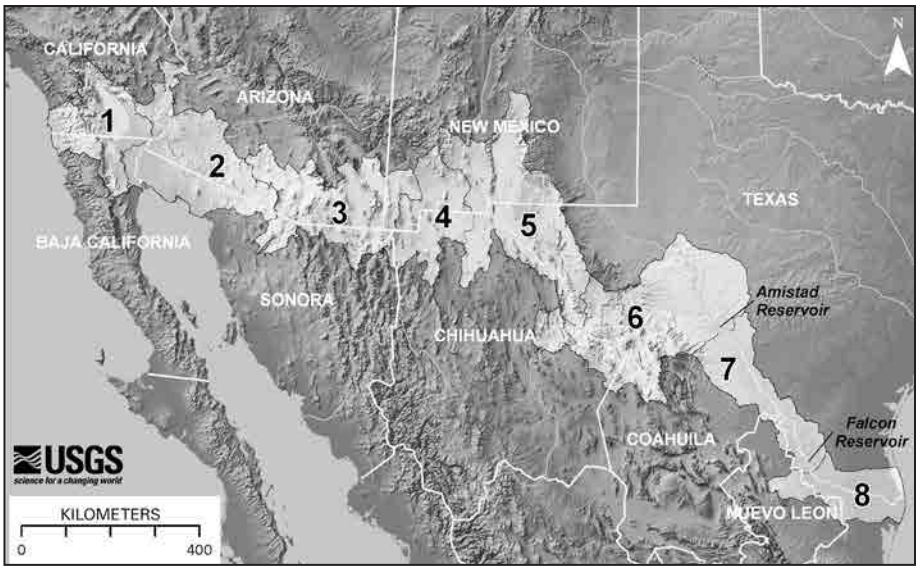


Map of the USGS Border Environmental Health Innitiative regions. Source: U.S. Geological Survey

allocation determinations, and water resource management are largely the responsibility of state-level agencies. Specifically in Arizona, water management tasks are shared by the Arizona Department of Water Resources and the Arizona Department of Environmental Quality. The authorities of U.S. federal agencies may overlap with state counterparts, especially in water quality regulations established by the U.S. Environmental Protection Agency and surface water allocations from water projects built by the U.S. Bureau of Reclamation (Reclamation). County and municipal agencies in the United States also have jurisdiction over water-related issues such as flood control and plumbing ordinances. Also, U.S. water and wastewater utilities are primarily responsible for designing and financing their own infrastructure projects, although national and state level assistance programs exist. In contrast, CONAGUA provides substantial funding and design support for Mexico's water projects. The fact that both countries have a variety of agencies involved makes coordination difficult and policy making is often a slow process.

Water allocation policies in the United States and Mexico are remarkably different. In Mexico, water belongs to the nation and is assigned to the user. This limits disputes over water allocation and can prevent them from proceeding to the court system in most cases. The federal government manages surface water and groundwater water in accordance with a priority-ranked system, with drinking water use as the highest priority. In contrast, Arizona has two fundamentally different systems for water management, one for surface water and one for groundwater. Surface water is allocated according to temporal priority, with the earliest users possessing the highest priority. Groundwater in most of Arizona is managed under the "beneficial use" doctrine, which does not include a temporal priority. Under both systems, all "beneficial uses" of water generally have equal priority. Arizona also has specified Active Management Areas where groundwater is managed within a regulatory and planning framework.

The cover map shows communities in the border region from California to Texas. Shaded area indicates the 100-km (62.5-mile) border area. Source: Central Arizona Project.

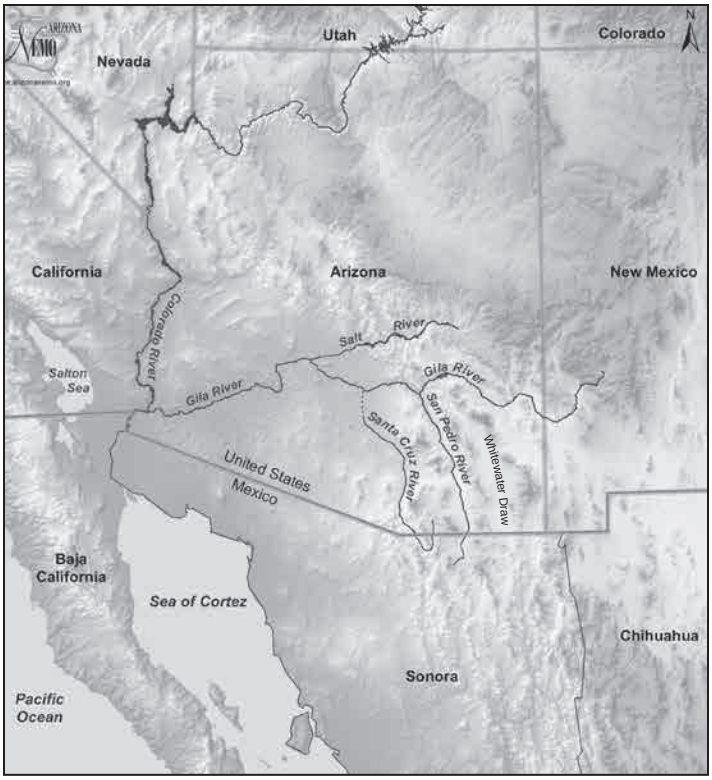
Growing population coupled with increasing water demand is a major issue for many U.S. and Mexican cities. During the past 20 years, urban populations along the border have significantly increased. In 2010, 14 million people lived in the border region, and projections show continuing population growth. By the year 2020, an additional estimated 4.6 million people will live in the border region, increasing by an additional 9.3 million by 2030. This growth largely began in 1965 with the initiation of the maquiladora program, which created incentives for foreign assembly plants to locate in the border region. After the North American Free Trade Agreement was put into effect in 1994, industrial development, especially in Mexico, rapidly grew. Large-scale mining and agriculture also prospered in the area: industries that require large volumes of water. Economic growth and job creation were positive results of these new developments, but infrastructure in the region was not consistently updated to keep pace with the population boom. This strained resources and created hazards for the environment and public health on both sides of the border.

Contamination of surface and groundwater is a major environmental and public health concern in the border region. Heavy metals, arsenic, lead, pesticides, uranium and organic chemicals have all been found in the soil and water along the border. Both countries have established environmental quality laws. The record of the Mexican government on border environmental regulation is mixed. Water quality standards are sometimes more strict in Mexico, but, regulatory oversight and enforcement are generally much more consistent in the United States. However, a growing focus on the border environment is evident in recent actions of the Mexican government.

The provision of a reliable 24-hour potable water supply for 100 percent of residences in a service area is generally accepted as the norm for water utilities and is usually a regulatory requirement all across the United States. Given a reliable and well-regulated water supply, the U.S. public commonly perceives water quality as the preeminent water issue. In contrast, Mexican communities must deal with regular water shortages, planned rolling outages called *tandeos*, or the complete absence of piped water supplies to individual homes or entire neighborhoods. Consequently, potable water supply issues are often considered preeminent for the public south of the border. During the past 15-20 years, there have been significant improvements in the public's access to water and sanitation services in Mexico, but the level of service is still far from what is taken for granted in the United States. With this context, it is easy to understand why there is a serious effort currently underway to establish a human right to water and sanitation through an amendment of the Mexican Constitution.

Arizona's Shared Rivers

Along the Arizona-Sonora region of the border, there are three major rivers that supply water and sustain the environment. The Colorado River runs from the Rocky Mountains, passing through Arizona and across the binational Colorado River Delta region. Because of upstream diversions, the river is usually dry from its final point of diversion at Morelos Dam to its mouth in the Sea of Cortez. Farther east, the Santa Cruz River flows south from Arizona into Sonora, Mexico then loops northward and crosses



Map of Arizona-Sonora shared rivers. Source: Arizona NEMO

the international border for a second time near the sister cities of Nogales, Arizona and Nogales, Sonora. A third significant transboundary river is the San Pedro. This river's headwaters are in northern Sonora near the city of Cananea, and it flows northward passing near the city of Sierra Vista.

A fourth transboundary watercourse flows by the sister cities of Douglas, Arizona and Agua Prieta, Sonora. Unlike the previous three rivers described here, the name of this watercourse changes as it crosses the border. Known as Whitewater Draw in Arizona, this transboundary stream flows south past Agua Prieta in Mexico as the Rio Agua Prieta, eventually connecting with the larger Rio Bavispe-Yaqui.

The Colorado River and Western Borderland Regions

The Colorado River is one of the most important sources of water for the western United States. More than 25 million people get their water from this river.

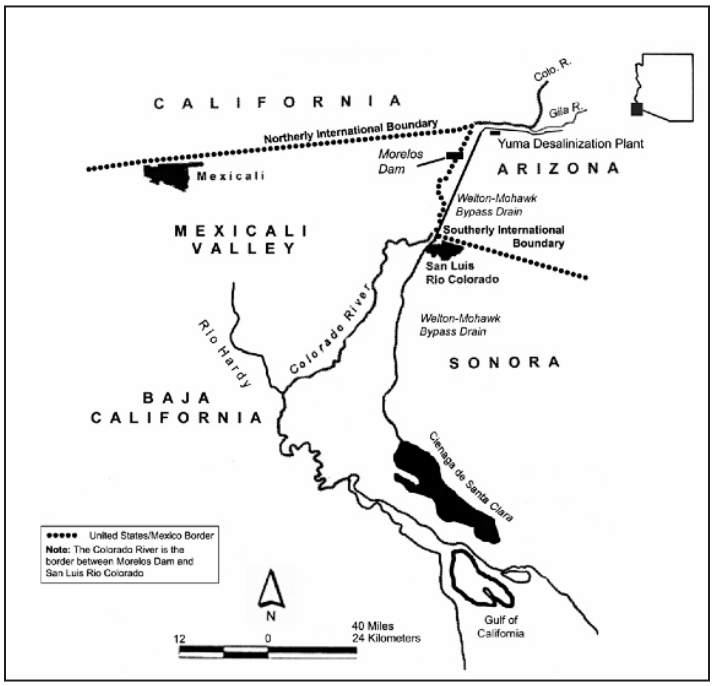
The U.S. portion of the Colorado River Basin encompasses seven states: Arizona, California, Colorado, Nevada, New Mexico, Utah, and Wyoming. For years these states negotiated and litigated how to share Colorado River water. In 1922, representatives from the seven states and the United States government created the Colorado River Compact. This divided the states into the lower and upper basins and gave each basin 7.5 million acre-feet (MAF) per year of water to apportion. Arizona, California, and Nevada make up the lower basin. The Boulder Canyon Project Act of 1968 allocated the 7.5 MAF, giving Arizona rights to 2.8 MAF; California is entitled to 4.4 MAF and Nevada has an annual allocation of 300,000 acre feet. In 1944, the U.S. and Mexico signed a treaty for the Utilization of Waters of the Colorado and Tijuana Rivers and the Rio Grande that allotted 1.5 MAF of Colorado River water to Mexico. Once in Mexican territory, Mexico's allotment is managed by CONAGUA, with most of the water being delivered to the state of Baja California Norte and a smaller portion delivered to the state of Sonora.

Over time, increased demands for water in both the U.S. and Mexico have led to some differences of opinion over Colorado River water and its quality. This has been true for water users within the United States as well as in the international context. Over the years, pressures on the river have led to increased cooperation to resolve issues among the U.S. parties and with Mexico.

The 1944 treaty engaged the International Boundary and Water Commission (IBWC) to administer provisions of the treaty and to address water and boundary issues that might arise between the U.S. and Mexico. The IBWC is a binational organization with a headquarters office and staff in each country. Based in El Paso, Texas and Ciudad Juarez, Chihuahua, each nation's "Section" is led by an Engineer-Commissioner appointed by the President of each country. The agency's foreign affairs budgets and functions are integrated with the U.S. Department of State and its Mexican counterpart, the Secretaría de Relaciones Exteriores (SRE). The IBWC is authorized to develop "Minute agreements" to clarify and facilitate administration of the 1944 treaty. A total of 318 such Minutes currently exist addressing a wide range of topics such as wastewater sanitation issues in Ambos Nogales (Minute 205, dated 21May1956) and water management consequences of earthquake damage in the Mexicali Valley (Minute 318, dated 17Dec2010).

The Yuma Desalting Plant

Increasing use of Colorado River water and the consequential increase of agricultural return flows have led to higher levels of salinity over several decades. In the early 1960's, water from the Colorado River that reached Mexico was so sufficiently degraded that crops in the Mexicali Valley suffered. Mexico protested that the quality of the water was unacceptable. Binational negotiations in 1973 led to IBWC's Minute 242, where the two countries established water quality standards for U.S. deliveries to Mexico. Then in 1974, with the Colorado River Basin Salinity Control Act,



Map of the Colorado River system below the Yuma Desalting Plant. Source: Sprouse, Terry. Water Issues on the Arizona-Mexico Border: The Santa Cruz, San Pedro and Colorado Rivers. Issue Paper. Feb 2005

the United States authorized construction of a desalinization plant near the international border in Yuma, Arizona.

The Yuma Desalting Plant (YDP) was intended to treat saline drainage waters from the Wellton-Mohawk Irrigation and Drainage District (WMIDD) before this discharge entered the Colorado River near Yuma. By removing the salt from the District's return flows, the U.S. government sought to ensure compliance with the Minute 242 salinity standards. In addition to eliminating the WMIDD's salt load to the Colorado River, the YDP's product water would be re-introduced to the river upstream of the Mexican delivery point at Morelos Dam, thereby allowing the plant's treated water, totaling about 90,000 AF/year if operated at full capacity, to count toward the treaty obligation of 1.5 MAF for Mexico. In a sense, the YDP was built to have a two-fold effect, enhance water quality deliveries to Mexico and ensure that upstream users on the Colorado River would not suffer adverse consequences associated with potential loss of 100,000 AF/year from the federal government's treaty obligation.

Banks of reverse osmosis membranes at the Yuma Desalting Plant. Source: Placido Dos Santos

The YDP was designed and built by the U.S. Bureau of Reclamation during 1975-1992 at a cost of $157.4 million. To immediately improve the quality of deliveries to Mexico, the WMIDD's saline drainage water was kept from entering the Colorado River throughout this period of design and construction. This was accomplished by directing the drainage water away from the river and delivering it through the Main Outlet Drain Extension (MODE) across the international border to intertidal mudflats called the Santa Clara Slough. After many years, the saline flows enabled what is known today as the Ciénega de Santa Clara to become established in Sonora. (The MODE also was intended to accept YDP's concentrate discharges.) In response to this annual introduction of approximately 100,000 acre-feet of water, the wetlands grew from 450 acres to approximately 10,000 acres while the plant was being built. Today, the Ciénega consists of approximately 14,000 vegetated acres and up to 26,000 acres with a water surface area. The water is salty, but the habitat is a widely recognized as an important environmental resource that supports threatened and endangered species.

In 1992 the drainage water was sent to the newly completed desalination plant. However, the plant was only operational for a few months. Operations ceased due to canal damage caused by flooding on the Gila River. Intercepting WMIDD's return flows and a series of wet years that further improved the quality of Colorado River water allowed the United States to achieve the required water quality without resuming operation of the plant. Because of the costs associated with operating the YDP, directing saline drainage away from the river through the MODE was recognized by the U.S. federal government as a much less-expensive solution to the salinity problem. However the 100,000 acre-feet of flow to the Ciénega did not count toward the 1.5 MAF allotment of Colorado River water to Mexico.

In 2001, nearly 10 years after the YDP was taken out of operation, the state of Arizona raised the issue of operating the YDP. Facing prolonged drought, diminishing reservoir supplies, and increasing pressures to meet demands; the Central Arizona Project, the U.S. junior right holder on the Colorado River, joined with other water users in the United States in calling for operation of the YDP. Water users saw YDP operation as a way to restore the 100,000 acre-feet that was being lost annually by U.S. water users as a result of the plant's inactive status.

Consequently, Reclamation performed a 90-day trial of the YDP in 2007 to demonstrate the plant's operability, evaluate the cost of operation, and monitor environmental conditions at the Ciénega. After 14 years of being inactive, the plant ran successfully at 10 percent capacity. This success reinforced interest in operating the plant and led to a one-year pilot scale demonstration that started in 2010 with the plant operating at 30 percent of capacity.

The Central Arizona Project (CAP), Metropolitan Water District of Southern California (MWD), and Southern Nevada Water Authority (SNWA) provided funds for the pilot operation, which would conserve about 30,000 AF of Colorado River water. The conserved water was shared as credits in Lake Mead. Each funder received credits proportional to its share of funding. CAP provided 10 percent of the funding and received approximately 3,000 AF of water credits. All together the funders provided almost $9.5 million, including $8.0 million for plant operations, $1.4 million to prepare the plant for operation, and $352,000 for environmental monitoring at the Ciénega de Santa Clara. CAP's contribution totaled nearly $1.0 million. The contributions included funds to pay for an Environmental Assessment consistent with National Environmental Policy Act and supporting Arizona water quality permits. Reclamation provided almost $6.5 million, primarily in labor and one-time construction costs to prepare infrastructure for operation.

Recognizing potential impacts to the Ciénega, environmental interests on both sides of the border had been quick to express opposition to the idea of operating the YDP. This led to engagement and novel cooperation between environmental interests and water management interests in the United States and Mexico. A historic agreement was reached on supplementing flows to the Ciénega and environmental monitoring before and during the pilot run. Minute 316 included 9 cooperative actions, one of which was added water for the Ciénega.

The plant operated for 10 months and the pilot project was completed in early March 2011, 7 weeks ahead of schedule and under budget. Originally budgeted for $23 million, the total actual cost of the run when completed was $16 million. The YDP recycled 30,496 AF of irrigation return flow water. Preliminary analysis of the environmental monitoring data showed little or no negative effects to the environmental resources of the Ciénega. However,

Border Agriculture Depends on Colorado River and Binational Cooperation

Approximately two-thirds of the water in the Colorado River is used for agricultural irrigation. The primary crops grown in Arizona are lettuce, cotton and hay. In 2010 Arizona ranked 2nd nationally in its production of cantaloupe and honeydew melons, spinach, broccoli, cauliflower and lemons.

Southern California's Imperial Irrigation District (IID) is the largest irrigation district in the United States. The IID serves almost 500,000 irrigation acres and annually delivers up to 3 million acre-feet of Colorado River water. Mexico's Irrigation District #14, located in the Mexicali Valley just south of the IID, is one of Mexico's most fertile and productive agricultural regions. Its almost 500,000 irrigable acres receive the largest proportion of Mexico's Colorado River allotment.

In Mexicali, agricultural production takes place throughout the year on a rotation basis. Wheat and green onions are cultivated in the fall-winter cycle and wheat is normally rotated with cotton. In 2008, asparagus and alfalfa joined wheat, cotton and green onions as the region's highest market value crops, with a combined value of 3.3 billion pesos (about $300 million dollars).

Both of these important agricultural areas share a large north-flowing valley that is seismically active. On Easter Sunday, April 4, 2010, a 7.2 magnitude earthquake shook the Mexicali area, causing significant damage in Mexico. Irrigation infrastructure in Imperial and Mexicali Valleys was damaged, including pumps, pipelines and irrigation channels. This prevented Mexico from using all of its annual allotment of water from the Colorado River. In response, Mexico and the United States, working through the International Boundary and Water Commission (IBWC) negotiated Minute 318 to address the issue through U.S.-Mexico cooperation.

Under Minute 318, Mexico is able to temporarily defer delivery of a portion of its annual Colorado River water allotment while repairs are made to the irrigation system in the Mexicali Valley of Baja California. In a precedent-setting agreement, Mexico will be able to store a portion of its allocation, up to 260,000 acre-feet of water, in the United States while the earthquake damage is being repaired. With historically low water levels in Lake Mead, this accommodation is clearly of benefit to both countries. A similar concept was already being explored by the two countries under binational collaboration framed by Minute 317, largely negotiated before the earthquake occurred.

some very modest changes in vegetation were noted. These changes appear to be consistent with seasonal variations in water supply due to increased evaporation losses during the summer season. Coincidentally, a wildfire spread across 80 percent of the Ciénega de Santa Clara shortly after the pilot run was completed. Monitoring after this accidental event has demonstrated the Ciénega's resilience and showed that periodic burns should be part of the habitat's management.

Binational Cooperation on the Colorado River

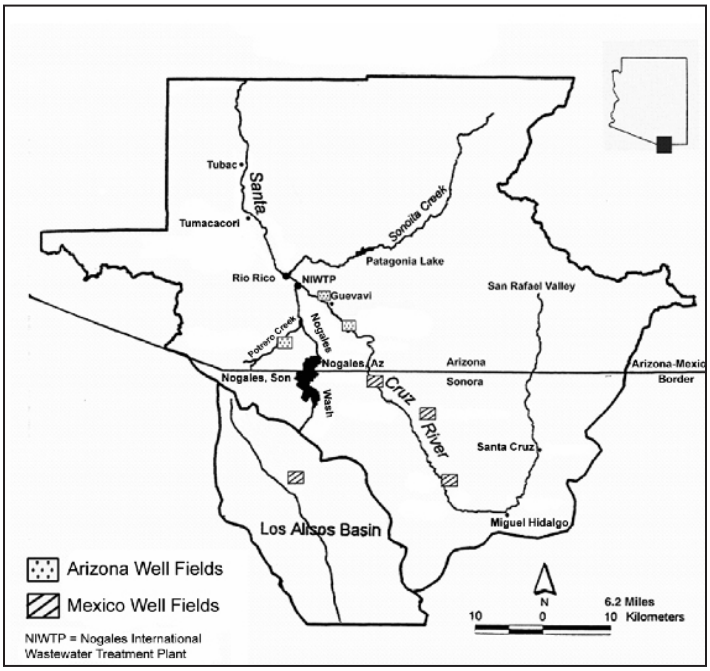
Since entering into the 1944 treaty, the U.S. has always fulfilled its Colorado River treaty obligations to Mexico. However issues such as growth, drought, water quality, environmental protection, over-allocation of the river and the uncertainties of climate change have led to increasing efforts for improved, binationally-coordinated management of the river. IBWC's Minute 317 dated June 17, 2010 authorized a broad set of bilateral discussions to explore concepts that might lead to improved binational management of the Colorado River to address such issues. In a novel approach, these IBWC-led discussions have included federal agencies, state governments, major water utilities and non-governmental organizations.

Santa Cruz River

Wastewater: Bane and Boon

The Santa Cruz River originates in Arizona's San Rafael Valley then loops 25 miles into Sonora before returning to Arizona near the city of Nogales. Today, Nogales, Sonora and Nogales, Arizona get roughly 50 percent of their water from the Santa Cruz River. For Nogales, Sonora the additional water supply is imported from the Los Alisos River, which is 11 miles south of the city. The remaining water for Nogales, Arizona comes from an aquifer in Potrero Canyon, located northwest of the city

Because the Santa Cruz River is a major water supply source for residents in the area, its water quality is always a concern. Nogales, Sonora's fugitive wastewater, the term for sewage that is not collected for treatment, can threaten public health in Nogales, Sonora and Arizona. Fugitive flows can originate from wildcat



Map of the Los Alisos and Santa Cruz River basins including Nogales Wash. Source: Sprouse, Terry. Water Issues on the Arizona- Mexico Border: The Santa Cruz, San Pedro and Colorado Rivers. Issue Paper. Feb 2005

developments, called *colonias* that lack basic infrastructure, or they may be generated by a host of issues that confront the municipal water and wastewater utility systems in Nogales, Sonora. The sewage collection system sometimes becomes clogged with oil, grease and garbage, leading to localized overflows and system failures. Solid and liquid waste flows through Sonora and downhill into Arizona--mostly through the Nogales Wash, a major tributary of the Santa Cruz River. Although not by design, the wastewater system in Nogales, Sonora is operated as a combined sanitary-stormwater system. Floods can overwhelm the capacity of the sewage collection system and contribute substantial

Nogales flooding. Source: Arizona Department of Environmental Quality

amounts of sediment, which leads to clogging and pipe erosion. In addition, portions of the system are antiquated, with leaks that can be challenging from an engineering perspective or stretch the utility's financial capacity. Infrastructure repairs and maintenance may also lead to direct discharges of sewage to the Nogales Wash. For these and other operation and maintenance reasons, fugitive flows have been a chronic problem for the two sister cities. The Nogales, Sonora utility undertook a major project to replace most of the city's large wastewater subcollectors. Preliminary evidence suggests that the project, completed in March 2010, has resulted in a significant reduction of transboundary fugitive flows.

The water and wastewater utility for Nogales, Sonora has been treating Nogales Wash surface flows with chlorine for years with assistance and support from the IBWC. Although needed to protect human health from disease causing microbes, such disinfection may create undesirable by-products. Groundwater in the vicinity of Nogales Wash has historically been found to contain various contaminants of concern including perchlorethylene (PCE) suspected to be from industrial sources. In 1998 the IBWC documented this pollution upstream of Nogales, Arizona, thereby prompting the Arizona Department of Environmental Quality to monitor the aquifer on the north side of the border. Monitoring in 2011 and 2012 found no PCE above the regulatory limit (MCL).

Nogales International Wastewater Treatment Plant (NIWTP)

The Nogales International Wastewater Treatment Plant (NIWTP), which is located about ten miles north of Nogales, at the confluence of the Santa Cruz River and Nogales Wash, processes wastewater collected from both Nogales, Sonora and Nogales, Arizona. The raw sewage from Mexico is delivered to the plant via a pipeline called the International Outfall Interceptor (IOI). The NIWTP and the portion of the IOI located within Arizona are both jointly owned by the U.S. Section of the IBWC and the City of Nogales, Arizona. Mexico shares a portion of the treatment costs and is responsible for the Mexican portion of the IOI.

The daily average dry weather flow is approximately 15 million gallons, but deliveries sometimes exceed this amount and exceed the carrying capacity of the IOI. The plant has a maximum treatment capacity of 17.2 million gallons per day (mgd). Minute 276 allocated 9.9 mgd of this treatment capacity to Mexico. On average, of the 15.4 mgd that is processed, 12.5 mgd originate from Mexico.

In 2009, a $64 million technology upgrade was completed at the NIWTP primarily with grant funds from the U.S. EPA's Border Environment Infrastructure Fund (BEIF). The improvements consisted of equipment for a system to remove nitrogen from the effluent. NIWTP effluent now meets regulatory standards for total suspended solids and total nitrogen and the plant provides improved disinfection and sludge management.

A major benefit to Arizona of the NIWTP upgrade is the improved water quality of the plant discharges into the Santa Cruz River. The treated wastewater is discharged near Rio Rico, Arizona, where it sustains a rich riparian area. With the improvements to the NIWTP, the Santa Cruz is already showing signs of a healthier river. The number of native fish is rapidly growing, with ammonia, phosphorous, and other pollutants now removed by the treatment plant. Also, algae blooms that disrupt a tree's water supply are dissipating, so trees along the river may be repopulated. The effluent also recharges the aquifer along the river.

At the same time, the NIWTP is challenged by metals in the wastewater that it treats from Sonora. Wastewater treatment plants generally are not designed to treat for metals, and the NIWTP upgrade did not include such treatment. Since 2009, water quality limits for cadmium have been exceeded multiple times for both the

The Other Side of Wastewater Flow: Douglas and Agua Prieta

The City of Douglas, Arizona, with Agua Prieta, Sonora as its sister city, has a wastewater treatment plant located precisely at the international border. The plant discharges its treated wastewater into the Whitewater Draw at the border with Mexico, where most of the effluent is reused for agricultural irrigation. The discharges from most municipal wastewater treatment facilities in the U.S. are subject to permits issued under the Clean Water Act's National Pollution Discharge Elimination System (NPDES). However a key provision establishing whether a facility is subject to an NPDES permit specifies discharges "to waters of the United States." Because the Douglas wastewater treatment plant discharges directly to Mexico and not to any waters of the United States, Douglas maintained that NPDES regulatory requirements do not apply to the plant. Complaints about the quality of the effluent were communicated by Mexico for many years. The Arizona Department of Environmental Quality creatively addressed the problem by imposing stricter discharge requirements through its Aquifer Protection Program (APP). Although this was purportedly done to protect the quality of the aquifer in Arizona's territory, it also had the consequential effect of protecting surface and groundwater quality in Mexico. The permit requirements accommodate the Mexican farmers' request for elimination of chorine so their crops can continue to reuse the effluent. Bearing a parallel similarity to the transboundary wastewater deliveries at Ambos Nogales, there are no transboundary payments made for the delivery of these waters and there is no treaty or binational agreement to require future deliveries of this water across the border. Nevertheless at both Ambos Nogales and Douglas-Agua Prieta, the existing transboundary delivery arrangements are currently of mutual benefit.

discharge of treated wastewater and for land application of the plant's sludge. Cadmium has also been detected in Santa Cruz River surface water samples collected by volunteer monitoring downstream of the plant.

During most of the year, the amount of water in the Santa Cruz River that flows north toward Tucson, Arizona depends almost entirely on the effluent discharged by the NIWTP. However, Minute 276 gives Mexico the right to recapture the effluent attributable to the sewage they send to the plant, such that about 80 percent of the plant's discharges cannot be counted on long term without formal agreements.

While Minute 276 gives Mexico the right to recapture its effluent or keep sewage flows from entering the United States, there are significant practical barriers to both alternatives. In the short run, the capital and energy costs to physically deliver such a large volume of effluent to the south, up gradient, are largely considered prohibitive. Cost and other factors have led decision-makers in Mexico to continue using their 9.9 mgd treatment capacity at the NIWTP for now. Nevertheless, there are options that could be explored to secure the effluent supply for the United States. These may include lowering treatment costs for Sonoran wastewater, paying for the water or trading power for water.

Additional Wastewater Treatment for Nogales

Although much of the growth in and around Nogales, Sonora is unplanned, and many of its new residents lack water and sanitation infrastructure, some development reflects a policy of asking developers to ensure the availability of water and wastewater treatment when planning new communities. For example, in a small community south of Nogales, Sonora called La Mesa, developers have already built a 0.3 mgd treatment plant that serves a community of roughly 2,000 households.

On a much larger scale, a new wastewater treatment plant has been built about 20 miles south of Nogales, Sonora. The Los Alisos Wastewater Treatment Plant (LAWTP) is located along the banks of the Los Alisos River, south of the Santa Cruz River watershed in Mexico. The plant will give Mexico the ability to control a portion of its own wastewater. In the past, Nogales, Sonora regularly exceeded its 9.9 mgd allocation of NIWTP capacity. The new plant will reduce Mexican wastewater flow to the NIWTP, which has been operating almost at full capacity. The LAWTP is scheduled to treat up to 7.5 mgd by 2013.

Currently Nogales, Sonora pays roughly $350,000 for treatment of 9.9 mgd and additional amounts for flows in excess of 9.9 mgd, plus an amount for disposal of contaminated sludge. Once the LAWTP comes on line, the amount OOMAPAS pays for NIWTP treatment will decrease. Reducing payments to the NIWTP will partially offset the cost of operation for the new plant, but Mexico will be taking on more of the cost of accommodating the large population increases and new developments near Nogales, Sonora.

San Pedro River

Protecting Riparian Values While Respecting Other Uses

The San Pedro Basin and its natural resources are truly binational treasures. The San Pedro's riparian corridor is an important sanctuary, maintaining both local and regional biodiversity and supporting habitat for migratory birds and other wildlife species. Millions of songbirds migrate from southern Mexico to the United States each year, using the San Pedro River as a north-south corridor where there is food, water and shelter. The Upper San Pedro River Basin spans the international border between Arizona and Sonora, Mexico. From its headwaters near the mining town of Cananea, Sonora, the San Pedro River flows north into the United States passing near the towns of Sierra Vista, Tombstone, and Benson, Arizona.

San Pedro Water Use

Communities have developed in the San Pedro Basin largely due to the availability of groundwater. Agriculture, mining, and municipalities have all used groundwater to sustain their activities. One of the basin's largest water users is Mexicana de Cananea, an open-pit copper mine that is among the largest mines in the world. This mine is located near the town of Cananea, on the southwestern edge of the basin. Agriculture is the next major water user in Mexico, especially since large water pumps were installed to extract groundwater. Across the border in Arizona, the Fort Huachuca Army Base is the largest water user. The Fort is located near Sierra Vista, which is considered to be one of the fastest growing areas

IOI in Need of Attention

The International Outfall Interceptor (IOI), an underground concrete pipeline that delivers sewage from Mexico to the NIWTP, is in very poor condition. Although some targeted repairs were made while the treatment plant was being upgraded, its deteriorated condition continues to be one of the most serious environmental problems on the Arizona-Mexico border. Several miles of the IOI are located beneath Nogales Wash, which is also in a seriously deteriorated condition. The Nogales Wash channel has already suffered significant failures during periods of flooding. In 2007 a failure resulted in a significant disruption to international railroad commerce. Subsequent inspections by the Army Corps of Engineers (ACE) in 2007 noted that a section of the concrete bottom in Arizona had lost half of its thickness. ACE inspections in 2008 noted that its structural stability was unpredictable and represented a hazard.

A truly dramatic failure in Nogales, Sonora, on July 12, 2008, led to the catastrophic collapse of the concrete-box underground channel at a main street in downtown. This resulted in the temporary closure of the international port of entry and major damage to streets. A second set of failures have occurred in the United States, where Nogales Wash is lined with a series of large concrete panels. These have required extensive repairs to prevent further erosion, loss of property and environmental damages. Depending on the location or severity of future damage to these concrete panels during floods, destruction of the IOI located beneath the wash could easily follow, releasing copious raw sewage flows into Nogales Wash and the Santa Cruz River.

In 2007, the ACE and the EPA estimated that the cost to repair damaged sections of the Nogales Channel and the IOI would exceed $10 million. More recent estimates suggest that design and rehabilitation of the IOI alone could cost $27 million, and replacement could cost as much as $100 million.

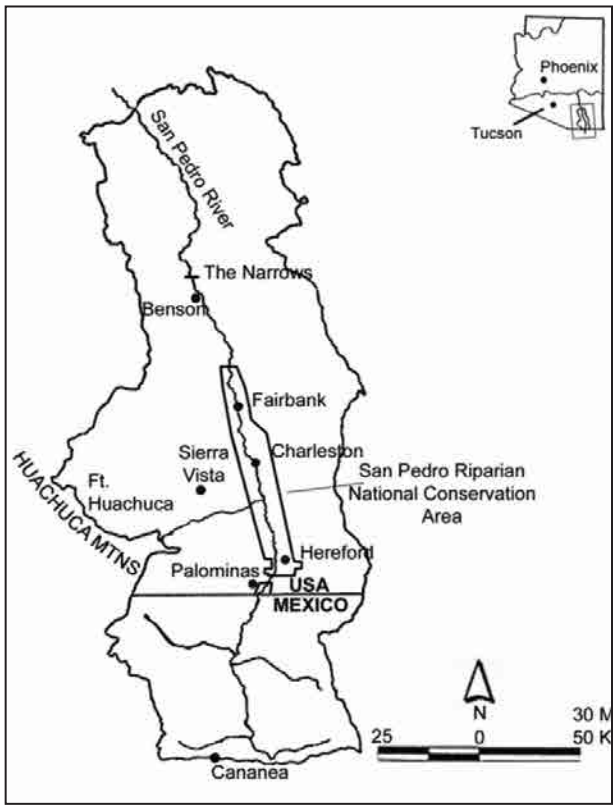
Given the precarious condition of the wash and the underlying IOI, the Arizona Division of Emergency Management has led the development of an emergency response plan to prepare for future failures. The plan is updated annually.

in Arizona. Groundwater in the basin is already being extracted at a rate greater than natural recharge.

With population growth in that area, the groundwater deficit is likely to increase, eventually affecting the river aquifer. Competition for water may have economic consequences; Fort Huachuca and the Cananea copper mine are the primary economic engines in the area as well as being the largest water users on each side of the border. Competition is likely to increase between communities and the natural riparian ecosystem if there are not additional efforts for conservation and mitigation. Sierra Vista has started using wastewater to restore and enhance the environment by protecting a perennial flow. This water recharges the alluvial aquifer near the river and postpones the date when extraction of groundwater from the regional aquifer depletes stream flow.

San Pedro River Water Quality

Because the San Pedro River flows downstream of the Cananea Mine, activities at the mine can have an impact on river water quality. Between December 1977 and April 1985, several spills at the mine caused acidification, heavy metal and sulfate contamination. This resulted in the death of many fish in Mexico and the United States. Now the mine tailings are discharged south into the Rio Sonora to avoid similar contamination of the San Pedro River in the future. However, a study completed in 2005 showed total concentrations above the maximum permissible levels of cadmium, copper, iron, manganese, lead, and zinc in surface waters near the mine. Some attenuation of the heavy metal content in surface water does occur downstream of the mine when pH increases and contaminants are diluted by discharge of wastewater into the river. Monitoring of the water surrounding this mine is needed to ensure that water quality is not unacceptably compromised.



Map of the San Pedro River Basin. Source: Sprouse, Terry. Water Issues on the Arizona- Mexico Border: The Santa Cruz, San Pedro and Colorado Rivers. Issue Paper. Feb 2005.

In Arizona, the ADEQ monitors the San Pedro River. At times there have been health concerns along the river due to E. coli from sources like septic tanks near the river, cattle grazing, and trash or debris left by people walking along the river. In August of 2010, state health officials warned people to stay out of a section of the San Pedro River to avoid exposure to contamination.

Recognition of the River's Environmental Significance on Both Sides of the Border

In 1988, the U.S. Congress established the San Pedro Riparian National Conservation Area (SPRNCA), administered by the Bureau of Land Management (BLM), recognizing the social and ecological values of the river and the need to protect it. The SPRNCA's goal is "to protect the riparian area and aquatic, wildlife, archaeological, paleontological, scientific, cultural, educational and recreational resources of the public lands surrounding the San Pedro River." The conservation area consists of 55,000 acres (22,260 hectares). Irrigated lands formerly used for agriculture were retired to preserve water in the river and maintain this natural riparian area.

South of the border, Mexico allotted a corner of the basin on the southeastern headwaters in the Sierra Madre Mountains as the Ajos Bavispe Reserve, also known as the Reserva Forestal Nacional y Refugio de Fauna Silvestre. This acts as a counterpart to the SPRNCA and is managed by the Mexican Secretariat of the Environment and Natural Resources (SEMARNAT). Originally established in 1936, the Ajos Bavispe Reserve now consists of 184,000 hectares (454,670 acres). The preservation of this area is important to both Mexico and the United States because three important rivers originate in the "sky islands" or mountain tops in the reserve. These are the San Pedro River, Bavispe-Yaqui River and the Sonora River. Water from these rivers provides drinking water for growing populations, including large communities such as the capitol city of Sonora, Hermosillo.

In 1999, following the release of a report by the Commission for Environmental Cooperation, *Ribbon of Life: An Agenda for Preserving Transboundary Migratory Bird Habitat on the Upper San Pedro River*, the U.S. Secretary of the Interior Bruce Babbitt and Mexico's Secretary of the Environment and Natural Resources Julia Carabias launched the San Pedro Binational Initiative. By signing a Joint Declaration, Babbitt and Carabias formalized the sharing of funds, information, and conservation expertise across the border. The most significant and unusual aspect of the Initiative was a program to designate a protected area in the Mexican part of the basin with $1.5 million of funding from private U.S. sources. Partners for this project included the World Wildlife Fund, the National Fish and Wildlife Foundation, and the U.S. Department of Interior. The funds from private benefactors were put into a Mexican Fund for Nature Conservation to establish a large protected area encompassing the San Pedro River in Mexico. This area, the Mavavi Biosphere Reserve, is an expansion to the Ajos Bavispe Reserve.

Protection Efforts in the US

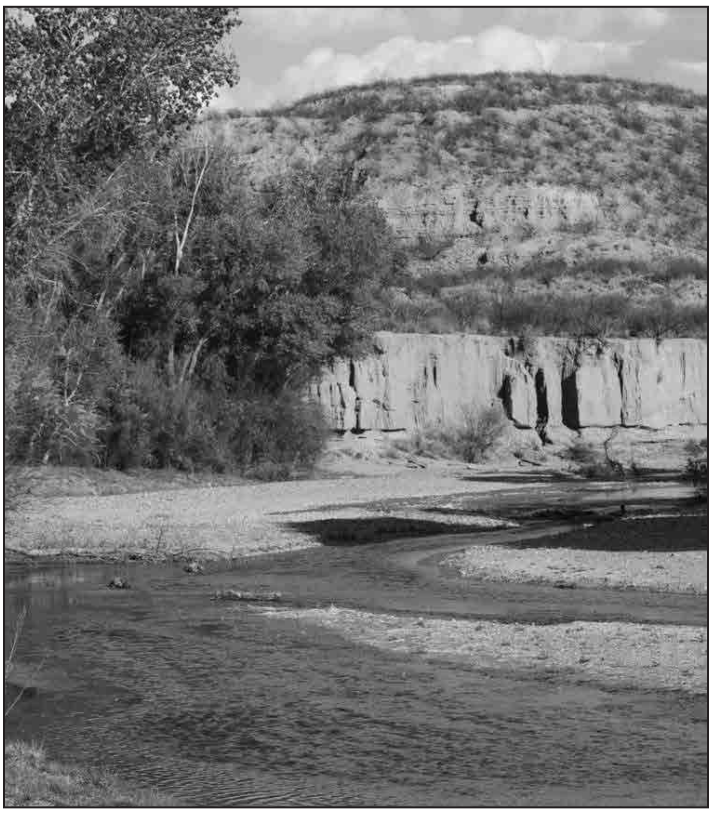
After the development of the SPRNCA, the importance of the San Pedro River has significantly increased. Evidence of the growing significance can be found in the many organizations and initiatives that have emerged in recent years. These include the Upper San Pedro River Basin Issue Team, the Commission for Environmental Cooperation Upper San Pedro Initiative, the San Pedro Binational Initiative, and other transboundary activities.

In 1998 the Upper San Pedro Partnership brought together U.S. federal, state and local agencies and organizations to work

towards meeting long term water needs in the San Pedro basin. The U.S. Congress passed legislation in 2003 that employed the Partnership to prepare an annual report on the water management and conservation measures implemented. The Partnership also has a goal of reaching and maintaining "sustainable yield" of the regional aquifer, which has been interpreted as recharging an amount of water equal to the amount pumped from groundwater sources. Today, 21 agencies and organizations are part of the Partnership working to balance the needs for water and protecting the river.

University researchers are part of this effort. The Semi-Arid Land-Surface-Atmosphere (SALSA) program in the late 1990s also encouraged binational cooperation. Researchers from this program focused on studying the hydrology and ecological diversity in the region to provide information for natural resource decision making. The SALSA program also sponsored a binational conference, *Divided Waters-Common Ground*, in 1999. During the conference participants traveled to Cananea, Sonora, the San Pedro River, and Bisbee, Arizona for a first-hand experience of the basin.

The Sustainability of Semi-Arid Hydrology and Riparian Areas (SAHRA) program, which originated in 2000 with funding from the National Science Foundation, conducted basin-focused multidisciplinary research to improve water management and policy. Since 2000, the research conducted through SAHRA has ranged from evaluating ephemeral streams, riparian corridors, urban runoff and vegetation change, to soil moisture observations. Currently, the University of Arizona's Institute of the Environment (IE) is focused on resolving environmental challenges and seizing solution-driven opportunities, which include challenges on the San Pedro River. Research conducted under the IE umbrella is related to analysis of pollution potential of the San Pedro aquifer, vegetation as a function of climate and river flows, land cover change, water use and ecosystem services in riparian corridors, and ecohydrology and decision making in the Sonora and San Pedro Watersheds.



San Pedro River within the San Pedro River National Conservation Area. Source: Kerry Schwartz

Groundwater: Out of Sight But Kept in Mind

The United States and Mexico share several aquifers that straddle the border. Minute 242 of the 1944 Water Treaty restricts the amount of groundwater pumping that either country can do within five miles of the border at a specific location near the Colorado River. Other than this limited restriction, however, there is no treaty regarding the management of groundwater in the border region. At some locations, such as El Paso and Ciudad Juarez, the absence of coordinated management has led to overdraft and, on occasion, tensions over the use and availability of groundwater in transboundary basins. To develop a binationally-shared scientific understanding about some of the key U.S.-Mexico transboundary aquifers, the U.S. Congress passed the Transboundary Aquifer Assessment Act in 2006. A total of four transboundary aquifers along the U.S.-Mexico border were designated for priority assessment. Included are the Santa Cruz River and San Pedro River Basins in the Arizona-Sonora border region.

The United States Geological Survey (USGS) and the Water Resources Research Institutes in Arizona, New Mexico, and Texas are responsible for completing assessments on the aquifers in collaboration with Mexican colleagues. The USGS and Mexico's CONAGUA are the lead federal agencies for the effort, but the U.S. and Mexico Sections IBWC have been providing important coordination support. The Transboundary Aquifer Assessment Program (TAAP) is authorized for $50 million over 10 years. So far only about $2 million has been appropriated by the United States, but Mexico has provided cost matches with both cash and in-kind services for studies performed south of the border. In 2011 the Mexican government dedicated two million pesos, approximately $150,000, for program activities until 2013. Although less U.S. funding has materialized than was originally anticipated, the program has made significant progress through binational engagement that has science as its focus.

The Arizona aquifers provide essential water for cities, rural communities, industry, and ecosystems. To accommodate all of these interests, representatives from municipal, state, federal, and binational agencies have been working together under the TAAP umbrella. The two primary goals that emerged from these stakeholder consultations were to establish a mechanism for information and data exchange and create physically-based hydrologic models to address a range of resource management questions. Progress has been made on these research priorities. A major product has been a searchable, online, bilingual database. The database includes over 280 sources for information on groundwater resources within the Santa Cruz and San Pedro aquifers. In addition, the scientific team in Arizona and Sonora has agreed to develop binational and bilingual reports focusing on the Santa Cruz and San Pedro aquifers.

In 2008, the United Nations Educational, Scientific and Cultural Organization (UNESCO) designated the TAAP-Arizona/Sonora effort as a case study in the International Shared Aquifer Resource Management (ISARM) program. This transboundary aquifer case is representative of urban zones and will be used by ISARM to analyze socio-economic aspects and joint management.

The hope for all of these transboundary aquifer studies is to gain information that will improve decision-making and encourage coordinated water management in the future.

Overarching Water and Environmental Agreements

Much of the cooperation for the protection and improvement of the environment in the border region has been a result of binational institutions. The IBWC, known as the Comisión Internacional de Límites y Agua (CILA) in Mexico, is charged with administering provisions of the 1944 Water Treaty as well as matters regarding demarcation of the international boundary. Throughout its history, the IBWC/CILA has addressed a wide range of water-related issues including improvements and maintenance of water infrastructure, routine and emergency transboundary water deliveries, and national responsibilities during periods of drought. They also manage and operate binational infrastructure such as wastewater treatment plants in Arizona and San Diego, as well as Morelos Dam on the Colorado River and dams along the Rio Grande River. The agency has resolved numerous issues regarding national ownership of water, sanitation, water quality, and flood control, and it continues to evolve as issues arise over time.

The United States and Mexico also collaborate on environmental issues under auspices of the 1983 La Paz Agreement, which is not a treaty but is an Executive Agreement between President Ronald Reagan and President Miguel de la Madrid. This established a formal foundation and framework for protecting, conserving, and improving the environment in the border region, defined as 100 kilometers (approximately 62 miles) north and south of the border. The U.S. Environmental Protection Agency and Mexico's federal environmental agency, then called the Secretaría de Desarrollo Urbano y Ecología (SEDUE), were charged with pursuing solutions to problems related to air, water, and land pollution along the border. The U.S.-Mexico border environmental program evolved over time in various iterations including the 1992 Integrated Border Environmental Plan (IBEP), the Border 21 Program, the Border 2012 Program and now, the Border 2020 Program. With partners at the federal, state, local and tribal governments, the programs have evolved as environmental and political conditions changed over time. For example, climate change and greenhouse gas emissions are now explicitly included in the Border 2020 program. Water, however, has always figured prominently.

When the North American Free Trade Agreement (NAFTA) was passed in 1994, the United States entered into two environmental side agreements. One of the side agreements was designed to address the environmental infrastructure deficiencies that characterized the U.S.-Mexico border and were expected to worsen with the expected increase in trade between the two countries. This side agreement established the Border Environmental Cooperation Commission (BECC), located in Ciudad Juarez, Chihuahua, and the North American Development Bank (NADB) which is based in San Antonio, Texas. Together, the BECC and the NADB help plan, certify and finance environmental infrastructure projects in the U.S.-Mexico border region.

Thus far, more than 190 projects have been approved by BECC/NADB with a value exceeding $4.3 billion, benefiting 13 million border residents. Many of these projects involve collaboration with national and state agencies such as the U.S. EPA, Arizona's Water Infrastructure Finance Authority, and the Mexican government. A number of the projects have been funded by the U.S. EPA with grants from the Border Environment Infrastructure Fund (BEIF). Arizona has had 16 certified projects with a cost of $168 million and there are five more projects under development. Also, in December of 2011, the Board of Directors of the BECC and the NADB announced four new projects that will benefit approximately one million residents in communities along the U.S. –Mexico border. The work done during all of these projects has improved the infrastructure, sanitation, and environment for numerous border communities. Although not a comprehensive

2011 Summer Intern Looks at Water from Both Sides

Josue Sanchez Esqueda was the 2011 Montgomery & Associates Summer Writing Intern at the WRRC. Sanchez is completing his senior year in the Department of Soil, Water and Environmental Science at UA. As a native of Hermosillo, Sonora Mexico, where water is scarce and has always been one of the major concerns of the community, he has had an enduring interest is water resources. He has also had a consistent interest in writing and came to the WRRC with the intention of honing his writing skills. During the summer he took his research south of the border to learn more about water resources in Nogales and the Santa Cruz River basin.

MONTGOMERY & ASSOCIATES
Water Resource Consultants

Mining Development Plans Raise Water Issues for Binational Consideration

As it flows ephemerally through northern Sonora and southern Arizona, the Santa Cruz River provides groundwater resources that are vital for the sister cities of Ambos Nogales. However, the relatively shallow hydrogeological system that the two cities depend on experiences pronounced changes in response to pumping and natural recharge during wet periods. Shallow wells and an infiltration gallery located in Mexico are vulnerable to seasonal water level declines and drought. Consequently, the state of the shared aquifer system, both in water quality and quantity, has been a matter of concern in both states for decades.

For this reason, there is concern regarding imminent construction of a large-scale copper mine in the area that has applied to the federal water commission (CONAGUA) for 3.0 million cubic meters of water per year (approximately 2450 AF/year). In January 2012, a Canadian company, Mercator Minerals, received all of the necessary permits and agreements to commence construction on the mine located 15 km south of the international border in Sonora. The 17,000 acre property, called El Pilar, is located close to the small community of San Lazaro at the southern loop of the Santa Cruz River. The planned mine will have a production capacity of up to 100 million pounds of copper during its projected 14-year life. The water required for this production is 2.4 million cubic meters per year (approximately 1950 AF/year) which will be supplied by the Santa Cruz Aquifer. Recognizing the shared nature of this important transboundary basin, some say, issues relating water resource impacts should be explored in a bilateral context.

list, the communities of Ambos Nogales, Ambos Nacos, Bisbee, Douglas, Patagonia, San Luís Rio Colorado, and Yuma have all benefitted from the U.S. EPA's BEIF grants and support from the BECC/NADB. It is also worth noting that the U.S. Department of Agriculture's Rural Development Program is active on the U.S. side of the border, funding many infrastructure projects, often in coordination with EPA.

The second NAFTA environmental side agreement, titled the North American Agreement on Environmental Cooperation (NAAEC), is a trilateral agreement among the United States, Canada and Mexico. It was essentially developed to address issues at the North American continental scale and to ensure that none of the NAFTA parties gained an economic advantage through lax enforcement of their respective environmental laws. The NAAEC established the Commission for Environmental Cooperation (CEC), which is based in Montréal, Québec, Canada and is funded equally by the three countries. The CEC works to promote environmental cooperation throughout North America.

Binational Programs Offer Assistance for the Border Region

A binational assessment was completed in 1999 that determined that 12 percent of the border population did not have access to potable water and 30 percent lacked access to wastewater treatment facilities. Since then, many U.S. - Mexico environmental programs, such as Border 2012, have made great strides to increase these fundamental public services.

In August 2013, the U.S.-Mexico Environmental Program: Border 2012, will transition to Border 2020. As a continuation of Border 2012, Border 2020 is a strategy to provide the technical expertise and infrastructure support necessary to protect and improve the air and water quality of border communities. The Border 2020 program has established six goals to address these growing problems. Among these is a goal to improve water quality and water infrastructure sustainability and reduce exposure to contaminated water.

To achieve its goals, the U.S. EPA and Mexico's SEMARNAT will conduct regional workshops to emphasize regional public health and environmental issues. In addition, they will provide support to local task force efforts and work with the U.S. tribes and Mexican indigenous communities. Local Task Forces will facilitate pilot projects with the local, state, and tribal governments, academia, NGOs, and the public. Every two years during this program, action plans will help to account for resources and priority changes. With this approach, the Border 2020 program hopes to improve the state of children's health, provide environmental education, strengthen tribal, state, federal, and international partnerships, better serve disadvantaged and underserved communities, and build resilience to climate change.

The United States Geological Survey (USGS) is another entity interested in monitoring and protecting the water resources border wide. Since 2004, the USGS has been operating the U.S.-Mexico Border Environmental Health Initiative. This project has the goal of developing and maintaining a border transboundary geographic information system and natural resource database, which will help researchers, government officials, planners, and citizens in decision-making. Currently the USGS provides an

Tribal Border Infrastructure Program

The Environmental Protection Agency (EPA) created the Tribal Border Infrastructure Program (TBIP) to support drinking water and basic sanitation infrastructure projects. Federally-recognized tribes that are within the border zone, (100 km or 62.5-miles of the U.S. – Mexico border) can apply for funds. So far, EPA has invested approximately $32.5 million into TBIP, with 56 drinking water and wastewater projects. The projects have benefitted 10,896 homes or about 46,000 people.

Office of Border Environmental Protection (OBEP)

Office of Border Environmental Protection (OBEP) provides assistance to border communities. As a branch of the Arizona Department of Environmental Quality (ADEQ), OBEP focuses on transboundary issues that affect Arizona's environment and its citizens. This work entails improving air quality, waste management, and water quality in Arizona border communities.

OBEP acts as a liaison between the State of Arizona, the U.S. Environmental Protection Agency (EPA) and the Nogales, Sonora Public Works Department (OOMAPAS-NS) with the goal of improving wastewater quality from Sonora that is treated in the Nogales International Wastewater Treatment Plant and supporting infrastructure needs. For several years, OBEP has coordinated material and technical support from the City of Phoenix Industrial Pretreatment Program to help OOMAPAS-NS with pretreatment issues. This helps Arizona and Sonora protect water resources and infrastructure investments in both countries. On the U.S. side of the border, volunteers from the citizen's organization, Friends of the Santa Cruz River, work with OBEP to monitor water quality in the river and Nogales Wash, with quality assurance and financial assistance provided by OBEP.

OBEP also supports the EPA's U.S.-Mexico Border Environmental Programs, which leveraged development of a water quality laboratory in Nogales, Sonora. That laboratory is now undergoing Mexican certification for metals analyses. The laboratory tests drinking water and wastewater for compliance with Mexico's regulatory standards. In the future, it could serve the analytical needs of many border communities in Sonora.

OBEP has led binational efforts to reduce sanitary-sewer overflows in the Nogales Wash. To address the issue, it coordinates with local, state, and federal stakeholders on both sides of the border for data collection and helped formalize protocols for responding to abnormal flows. OBEP also has provided technical support through hydrologic analyses and mapping of infrastructure to help with planning emergency responses to flooding and infrastructure failures. Finally, OBEP locates and facilitates funding for infrastructure projects along the border and provides technical assistance in reviewing proposals for water and wastewater projects.

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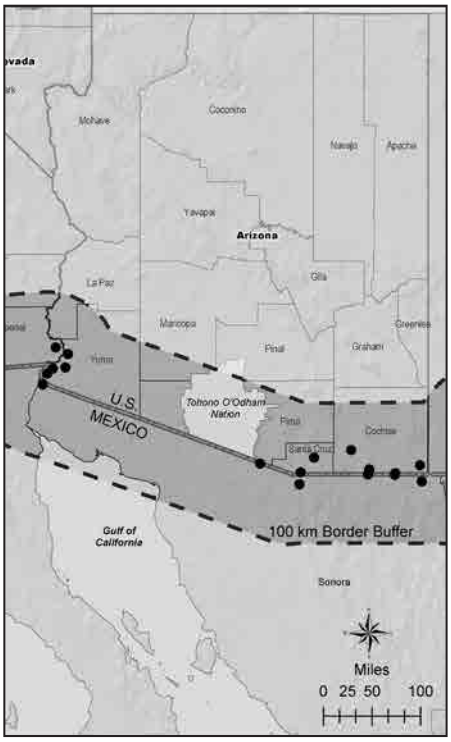
internet map service and data download of the geographic information system. The second goal of the program is to investigate linkages between the conditions of the physical environment and health issues. A study is focusing on relationships between environmental changes, contaminant trends, and human and wildlife health along the Rio Grande. The USGS is also doing research on organic and inorganic contaminants and their effects on sediments, water, plants, and animals in the Upper Santa Cruz Basin. Numerous publications have resulted from this work to inform decision makers and the general public of current conditions, future issues, and possible solutions for the water resources in the border region.

What Does the Future Hold for the Border Region?

Along the border considerable progress in binational collaboration and resulting improvements in transboundary water resource issues have been seen in recent years. Protection of the environment has received binational support in planning and concrete actions.



U.S. EPA Border Environmental Infrastructure Fund projects in Arizona-Sonora. Source: U.S. Environmental Protection Agency Region 9 GIS Center, 4/24/2012

Development of community forums have increased citizen participation in decisions and enhanced binational cooperation. Cooperative explorations of options to solve problems on both sides of the border have led to mutual benefits.

The programs and institutions that have been developing over the past 20 years provide a framework for continued cooperative problem solving. But challenges remain. Among these, persistent socio-economic asymmetries and overarching issues such as illegal immigration that can cascade into counter-productive discourse that ultimately impedes constructive progress. Climate change respects no borders and it will stress already stretched resources, demanding changes in resource management. Population growth will continue to place increasing demands on limited water, infrastructure and regulatory resources, while droughts will require additional conservation at irregular intervals. With these challenges, the critical importance of collaboration cannot be over emphasized.