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Meeting the Water Needs of the Border Region: A Growing Challenge for the United States and Mexico

William A. Nitze

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Abstract

How to share and use the water resources of the border region (defined as extending 100 kilometers on either side of the border) has been an important issue in U.S.-Mexican relations during the 20th century. Increasing demand and declining availability of fresh water in the region will make the issue even more significant during the 21st century. Population growth, urbanization, and industrial development, particularly on the Mexican side of the border, will generate a steadily increasing demand for water services. Aquifer depletion, misuse of surface water resources, pollution, and climate change will all act to reduce available supplies of usable water.

Absent sustained binational efforts to change current water-management agreements, laws, and practices, each country will seek to protect its own citizens against the impact of growing shortages in a manner that harms the interests of its transboundary neighbors and thereby places increasing strains on the binational relationship. This outcome can be avoided if the stakeholders on both sides of the border can agree on a combination of measures that increase the total

amount of water services that can be produced on a long-term basis, then prioritize the allocation of these services among competing claimants through a series of political compromises involving a full range of stakeholders.

The first of these goals will require substantial additional investment in water conservation and recycling in all sectors. Crop irrigation, which accounts for more than 80% of the water consumed in the border area, should receive priority attention, followed by municipal and industrial uses. Incentives for conservation, particularly in the agricultural sector, where irrigators currently pay little or nothing for the water they use, should be strengthened. Crop irrigators, small businesses, homeowners, and other users should be given financing and technical assistance in installing more efficient water-distribution systems, equipment, and appliances.

The second goal will require a fundamentally different approach to allocation of water resources. Historically, water users have acquired rights to the water they used on an ad hoc basis. In the United States, most agricultural and other users have acquired their water rights under the prior appropriation doctrine: "prior in use, prior in right." When conflicts among holders of these rights have arisen, the courts have been required to readjudicate those rights, as in the 10-year-long court case in the 1960s and 1970s with respect to water rights in the lower Rio Grande.[1] In Mexico, water remains part of the national patrimony, but the government has accommodated withdrawals by giving irrigators and other users water rights sufficient to meet their needs at minimal cost.

Municipal and industrial users have subsequently acquired water rights from governmental and other owners through contractual arrangements. Native Americans continue to hold historical rights to water that have not been fully quantified. The U.S. Endangered Species Act and other laws in the United States and Mexico restrict withdrawals by competing users to the extent that those withdrawals threaten the survival of endangered species and ecosystems. Finally the flows of the Colorado and the rivers feeding into the Rio Grande/Río Bravo have been allocated under a set of domestic compacts and binational treaties often referred to as "the law of the river."

One thing missing from this historical accumulation of legal

rights is any systematic attempt to prioritize competing needs for water services according to any calculus of social welfare. Mexican law does provide that drinking water should have the highest priority, a provision that has been used by the National Water Commission to cut off supplies to irrigators in times of drought, but it does not provide for a more specific allocation among competing uses.[2] Texas also has a law defining six descending priorities for water use with drinking water being the highest,[3] but this law has never been used. As a result of the court case referred to above, Texas has a "Rio Grande water master," who allocates rights to lower Rio Grande Valley water among competing users on the Texas side of the river in accordance with a priority system established by the court. The water master does not, however, have authority to establish priorities on his own.

A more systematic attempt to allocate water resources has not yet been made because there has not been a crisis great enough to generate the political will required. This situation may be changing. Over the last several years, Mexico has failed to meet its treaty obligation to deliver 350,000 acre-feet of water per year from the Río Conchos to the United States. The cumulative deficit is estimated to exceed 1.2 million acre-feet. This shortfall has become a contentious issue between the two governments and has put Mexican authorities in the position of reducing water deliveries to Mexican farmers to make up part of the water expected by Texas farmers.

Although the problem is not as immediate, a similar situation is developing in the lower basin of the Colorado. Estimated total consumptive use of water in the upper and lower basins (including evaporation and transpiration), plus deliveries to Mexico, is approaching the estimated average flow of 15 million acre-feet to 16 million acre-feet per year. Any remaining cushion is rapidly disappearing as evidenced by the virtual elimination of the historical flow of water, silt, and nutrients into the Sea of Cortes. Given the projected growth of population in the lower Colorado River subregion by 50% or more from 1990 to 2020, actual shortfalls can be expected to appear soon. If unfulfilled Native-American claims and minimum unmet requirements of ecosystems in the basin are added in, the combined flows of the Colorado and its tributaries are already substantially overcommitted.

In addition, the gap between withdrawals from and recharge to underground aquifers throughout the border region is steadily growing. Unless this trend is reversed soon, irrigators and other water users dependent on these aquifers will permanently lose their existing sources of supply. The situation is particularly acute in the Paso del Norte area, including El Paso and Ciudad Juárez, where Juárez is projected to exhaust its existing water sources by 2020 or shortly thereafter. When asked where they will find the water Juárez needs thereafter, Juárez municipal officials point to the groundwater north of the border under El Paso. Juárez is already withdrawing water from the portion of the aquifers on the Mexican side of the border and is considering extending its withdrawals not only to drain aquifers to the south and west of the city, but also to drain the aquifers on the U.S. side. Pursuing this option will not be well-received in El Paso absent binational agreement on a joint long-term water-management plan.

The above trends will lead to a binational water-supply crisis characterized by shortages and conflict, absent a comprehensive effort to: increase the amount and quality of water services from available supplies through conservation, protect subsurface reservoirs by bringing withdrawals into balance with recharge, reach stakeholder consensus on how to allocate available water services to those uses with the greatest economic and social utility, and respect Native-American claims and the minimum needs of water-dependent ecosystems. Necessary components of this effort include:

- Better data and analysis of where the water comes from and where it goes, particularly in Mexico
- Creation of new economic incentives, financing vehicles, and technical assistance programs for conservation in all sectors
- Joint planning among Mexico's National Water Commission, U.S. federal agencies, state and local water authorities in both countries, the International Boundary and Water Commission (IBWC), the Border Environment Cooperation Commission (BECC), and the North American Development Bank (NADBank) to assist irrigation districts and other agricultural water users in conserving water by upgrading water-distribution and irrigation systems, shifting to crops that generate greater economic value per unit of water consumed, and reducing the amount of land being irrigated in return for appropriate economic incentives
- A political process involving all stakeholders that will produce agreement on a more realistic long-term allocation of available surface and subsurface water among competing uses, including honoring legitimate Native American claims and protecting critical ecosystems

Such agreement will only be possible if stakeholders make creative use of technology, markets, and policy reform along the lines discussed here.

Enfrentando las Necesidades de Agua de la Región Fronteriza: Un Reto Creciente para los Estados Unidos y México

William A. Nitze

Resumen

Cómo compartir y usar los recursos acuáticos de la región fronteriza (definida como la que se extiende 100 kilómetros en ambos lados de la frontera) ha sido un tema importante en las relaciones E.U.-México durante el siglo veinte. El incremento en la demanda y la reducción en la disponibilidad de agua dulce en la región harán el tema aún más significativo durante el siglo XXI. El crecimiento poblacional, la urbanización y el desarrollo industrial, particularmente en el lado mexicano de la frontera, generarán un incremento continuo en la demanda de servicios relacionados con el agua. El agotamiento de acuíferos, el mal uso de los recursos de agua superficial, la contaminación, y el cambio climático actuarán en conjunto para reducir las fuentes disponibles de agua potable.

En la ausencia de esfuerzos binacionales sostenidos para cambiar los tratados de administración del agua, leyes, y prácticas, cada país

buscará proteger a sus ciudadanos contra el impacto de la creciente escasez en una manera que daña los intereses de su vecino transfronterizo y por lo tanto coloca presiones crecientes en la relación binacional. Este resultado puede ser evitado si los actores clave en ambos lados de la frontera pueden acordar una combinación de medidas que incrementen el monto total de servicios de agua que pueden ser producidos sobre una base de largo-plazo, después priorizar la asignación de esos servicios entre los competidores demandantes a través de una serie de compromisos políticos que involucran a una gran parte de los actores clave.

La primera de estas metas requerirá una inversión adicional sustancial en la conservación del agua y reciclamiento en todos los sectores. La irrigación de cultivos, que constituye más del 80% del agua consumida en la región de la frontera, deberá recibir atención prioritaria, seguida por el uso municipal e industrial. Los incentivos para la conservación, particularmente en el sector agrícola, en donde los usuarios pagan actualmente poco o nada por el agua que utilizan, deben ser fortalecidos. Irrigadores de cultivos, pequeñas empresas, propietarios de inmuebles, y otros usuarios deberán recibir financiamiento y asistencia técnica para la instalación de sistemas de distribución de agua más eficientes, equipos, y aparatos.

La segunda meta requerirá de un enfoque fundamentalmente diferente para la asignación de los recursos del agua. Históricamente, los usuarios de agua han adquirido derechos del agua que usaron para un momento específico en particular. En los Estados Unidos, la mayoría de los agricultores y otros usuarios han adquirido sus derechos de agua bajo el derecho de apropiación por antigüedad: "primero en uso, primero en derecho." Cuando han surgido conflictos entre los poseedores [propietarios] de estos derechos, las cortes han sido requeridas para readjudicar esos derechos, como en el caso jurídico con duración de 10 años en las décadas de los 60 y 70 con respecto a los derechos del agua en la parte baja del Río Grande.[1] En México, el agua permanece como parte del patrimonio nacional, pero el gobierno ha distribuido volúmenes al otorgar a los irrigadores y a otros usuarios derechos de agua suficientes para satisfacer sus necesidades a un costo mínimo.

Los usuarios municipales e industriales han adquirido subsecuentemente derechos de agua del gobierno y de otros propietarios a

través de convenios. Las poblaciones indígenas continúan siendo poseedores de derechos históricos sobre el agua que no han sido completamente cuantificados. El Acta de Especies Amenazadas de los E.U. y otras leyes en los Estados Unidos y México restringen la extracción por usuarios competidores si amenazan la supervivencia de especies y ecosistemas amenazados. Finalmente los flujos del Río Colorado y los ríos tributarios del Rio Grande/Río Bravo han sido ubicados bajo una serie de acuerdos y tratados binacionales a menudo referidos como "la ley del río."

Un aspecto ausente en esta acumulación histórica de derechos legales, es algún intento sistemático para priorizar las necesidades que compiten por servicios de agua de acuerdo con alguna estimación del nivel de bienestar social. La ley mexicana ubica al agua potable como asunto de la más alta prioridad, argumento que ha sido usado por la Comisión Nacional del Agua para suspender el abastecimiento a los irrigadores en temporadas de sequía, pero no define alguna ubicación específica entre los usos que compiten.[2] Texas también tiene una ley que define seis prioridades descendentes para el uso del agua siendo la del consumo humano como la más alta,[3] pero esta ley jamás ha sido usada. Como resultado del caso jurídico arriba referido, Texas tiene un "Programa Maestro de Agua del Río Grande," quien asigna derechos de agua al Valle del Bajo Río Grande entre usuarios competidores para el lado de Texas del río, de acuerdo con un sistema de prioridades establecido por la corte. Sin embargo, el Programa Maestro de Agua no tiene autoridad para establecer prioridades por su cuenta.

Un intento más sistemático para asignar dotaciones de agua aún no se ha hecho porque no ha habido una crisis lo suficientemente grave para generar la voluntad política requerida. Esta situación puede estar cambiando. En el transcurso de los últimos años, México no ha cumplido con su obligación del tratado de entregar 350,000 pies-acre de agua por año del Río Conchos hacia los Estados Unidos. Se estima que el déficit acumulativo excede los 1.2 millones de pies-acre. Esta deuda se ha convertido en un tema polémico entre los dos gobiernos y ha puesto a las autoridades mexicanas en la posición de reducir las entregas de agua a agricultores mexicanos para proveer parte del agua esperada por los agricultores tejanos [texanos].

Aunque el problema no es tan inmediato, una situación similar

se está desarrollando en la cuenca baja del Colorado. El consumo de agua estimado en la cuenca alta y baja (incluyendo evaporación y transpiración), más las entregas a México, se acerca al flujo promedio estimado de 15 a 16 millones de pies-acre por año. Cualquier reserva restante está desapareciendo rápidamente como se aprecia en la eliminación virtual del flujo histórico de agua, sedimento, y nutrientes hacia el Mar de Cortés. Dado que el crecimiento poblacional proyectado en la subregión de la parte baja del Río Colorado es de un 50% o más entre 1990 y el 2020, se puede esperar que desabastos aparezcan pronto. Si se añaden los reclamos de Las poblaciones indígenas y los requerimientos mínimos no cumplidos para los ecosistemas de la cuenca, los flujos combinados del Colorado y sus afluentes se encuentran ya sustancialmente rebasados.

Además, la diferencia entre las extracciones y las recargas a los acuíferos subterráneos a lo largo de la región fronteriza, está creciendo constantemente. A menos que esta tendencia sea revertida pronto, los regadores y otros usuarios del agua dependientes de estos acuíferos, perderán permanentemente sus fuentes de abastecimiento existentes. La situación es particularmente crítica en el área Paso del Norte, incluyendo El Paso y Ciudad Juárez, en donde se proyecta que Juárez agotará sus fuentes existentes de agua para el año 2020 o un poco después. Al cuestionar a las autoridades municipales de Juárez sobre donde encontrarán el agua que Juárez necesitará posteriormente, estos apuntan hacia el agua subterránea ubicada al norte de la frontera debajo de El Paso. Juárez ya está bombeando el agua de la porción de acuíferos en el lado mexicano de la frontera pero está considerando extender sus extracciones no solo para drenar acuíferos al Sur y Oeste de la ciudad, sino también aquellos ubicados en el lado de los E.U. El buscar esta opción no será bien recibido en El Paso ante la ausencia de un acuerdo binacional sobre un plan de manejo compartido del agua a largo plazo.

Las tendencias anteriores conducirán a una crisis binacional de abastecimiento de agua caracterizada por recortes y conflictos, en la ausencia de un esfuerzo para: incrementar a través de la conservación la cantidad y calidad de los servicios de agua a partir de fuentes disponibles, proteger reservas subterráneas manteniendo un balance entre el bombeo y la recarga, lograr el consenso de los actores clave sobre cómo asignar las dotaciones del agua disponible

a aquellos usos con la más alta utilidad económica y social, y respetar los reclamos de Las poblaciones indígenas así como los requerimientos mínimos para ecosistemas dependientes del agua. Los componentes necesarios para lograr este esfuerzo incluyen:

- Mejores datos y análisis de dónde proviene el agua y a donde se va, particularmente en México.
- Creación de nuevos incentivos económicos, vías de financiamiento y programas de asistencia técnica para la conservación en todos los sectores.
- Planeación conjunta entre la Comisión Nacional del Agua de México, agencias federales de los E.U., autoridades del agua-locales y estatales en ambos países, la Comisión Internacional de Límites y Aguas (CILA), la Comisión de Cooperación Ambiental Fronteriza, y el Banco de Desarrollo de América del Norte (BANDAN) para brindar asistencia a los distritos de riego y otros agricultores usuarios de agua para conservar agua actualizando sistemas de irrigación y distribución, cambiando a cultivos que generen mayor valor económico por unidad de agua consumida, y reduciendo la cantidad de terreno siendo irrigado a cambio de incentivos económicos apropiados.
- Un proceso político, involucrando a todos los actores clave, que producirá el acuerdo sobre una asignación mas realista a largo plazo del agua superficial y subterránea disponible entre usuarios competidores, incluyendo el honrar los reclamos legítimos de Nativos Americanos y proteger ecosis temas críticos.

Dicho acuerdo solo será posible si los actores clave hacen uso creativo de la tecnología, los mercados, y reforma de políticas dentro del marco aquí discutido.

An Historical Perspective

Binational diplomacy concerning water in the border region dates back to the convention of March 1, 1889, between the United States and Mexico establishing an International Boundary Commission.[4]

The 1889 convention was followed by the convention of May 21, 1906,[5] providing for the distribution between the United States and Mexico of the waters of the Rio Grande above Fort Quitman, Texas, for the 89-mile international boundary reach of the Rio Grande through the El Paso-Juárez Valley. The convention allotted 60,000 acre-feet per year to be delivered to Mexico's Acequia Madre just above Juárez. To bring water to irrigators in southern New Mexico and far west Texas and to facilitate those deliveries, the United States constructed, at its expense, the Elephant Butte Dam in its territory. The convention further provides that deliveries to Mexico and to U.S. irrigators downstream of the Elephant Butte Dam should be reduced proportionately in the event of a serious drought or irrigation accident.

The 1906 convention was a response to the impact on Mexico of the reduction of Rio Grande flows resulting from the rapid expansion of irrigated agriculture starting in the San Luis Valley in the 1870s. This expansion accelerated on the U.S. side of the border as dams and other water-supply infrastructure were built in response to the Reclamation Act of 1902. As water resources on both sides of the border were increasingly appropriated to transform the desert into farms, orchards, and cities during the first part of the twentieth century, it became apparent that the allocation of water resources between the two countries needed to be better defined and the commission given greater authority and resources.

Accordingly, on February 3, 1944, the United States and Mexico entered into a treaty relating to the "(u)tilization of the waters of the Colorado and Tijuana Rivers and of the Rio Grande."[6] The 1944 treaty allocates to Mexico all of the waters reaching the Rio Grande from the San Juan and Alamo Rivers, two-thirds of the flow in the main channel of the Rio Grande from the Río Conchos and five smaller tributaries from Mexico, and one-half of all other flows occurring in the main channel of the Rio Grande downstream from Fort Quitman.

The treaty allocates to the United States all of the waters reaching the main channel of the Rio Grande from the Pecos and Devils Rivers and five smaller tributaries from the United States; one-third of the flow reaching the main channel of the river from the Río Conchos and the other above-mentioned tributaries from Mexico, providing that this third shall not be less, as an average amount in

cycles of five consecutive years, than 350,000 acre-feet annually; and one-half of all other flows occurring in the main channel of the Rio Grande downstream of Fort Quitman.

The 1944 treaty further commits the United States to deliver to Mexico a guaranteed annual quantity of 1.5 million acre feet of Colorado River water and an additional 200,000 acre-feet per year in times of surplus. In accordance with the Colorado River Compact of 1922, the upper and lower basins of the Colorado were each to supply half of the amount of Colorado water allocated to Mexico under the treaty. The treaty said nothing, however, about the quality of this water, an issue that was not explicitly addressed until 1973 in a separate agreement.

It is the provision of the 1944 treaty allocating 350,000 acre-feet annually from the Río Conchos and other specified Mexican tributaries to the Rio Grande that has given rise to Mexico's current water debt to the United States. Although for many years flows from the Conchos were sufficient to provide the United States with substantially more than that amount, drought conditions during the last five years have caused Mexico to substantially under-deliver and build up a cumulative water debt to the United States that was as high as 1.8 million acre-feet (it has subsequently been reduced to 1.2 million acre-feet). Since, under normal rainfall conditions, the Conchos provides two-thirds of the surface water required to sustain the economy and ecology of the lower Rio Grande basin, this ongoing shortfall presents a challenge to both countries. On the institutional side, the treaty changed the commission's name to the International Boundary and Water Commission (IBWC) and assigned to the IBWC the task of carrying out the principles of all past and present treaties. The IBWC maintains the status of an international body and is composed of two independent sections, one in the United States and one in Mexico.

During the years following the World War II, the process of transforming the desert along the U.S.-Mexican border accelerated. Agricultural and municipal demands steadily increased with the growth of irrigated agriculture and cities. Industries such as mining, smelting, and metalworking had existed for some time in the border region. They were joined by new manufacturing industries responding to growing demand for consumer products in both countries. The Mexican maquiladora (maquila) program, under which products

could be assembled in Mexico from imported components and then shipped to the United States without payment of duty, greatly accelerated this process from the late 1960s on. The new maquila plants and the housing required for their workers not only use significant amounts of water but also generate large amounts of water pollution.

By the end of the twentieth century, the border region had been transformed from a sparsely populated desert region characterized by irrigated agriculture and small cities (with the exception of San Diego) to an increasingly industrialized region of more than 10 million people concentrated in 14 sister-city pairs, characterized by industrial areas full of factories and maquila plants and, at least in Mexico, rapidly growing cities, several of which had more than 1 million inhabitants. One thing that had not increased was the supply of usable water.

The impacts of these changes on water availability and quality did generate a number of legal, institutional, and physical responses during this period. One such impact, referred to above, is the deterioration in quality of the Colorado River water crossing the border into Mexico. The water-quality problem was caused in large part by the Wellton-Mohawk Irrigation District development in Arizona and the dumping of its agricultural drainage waters into the Colorado River. The salt content of river water entering Mexico increased from approximately 800 parts per million (ppm) to approximately 1,500ppm.

An effort was made to solve the resulting dispute through an addendum to the original 1944 U.S.-Mexican treaty titled Minute 242,[7] stipulating that the water received by Mexico should have salinity levels no more than 115ppm higher than the water arriving at Imperial Dam. To help meet the Minute 242 obligation, Congress passed the Colorado Basin Salinity Control Act of 1974, which, among other things, authorized construction of desalting plants at Yuma, Arizona, as well as a 10,000-acre reduction in irrigable acreage in the Wellton-Mohawk Irrigation District.

The post-war period also witnessed continued construction of dams and other infrastructure designed to supplement or redirect flows of the Colorado that were no longer sufficient to cover commitments made in the Colorado River Compact of 1922, which assumed an average annual flow at Lee's Ferry of 18 million acre-

feet. The Colorado River Storage Project Act of 1956, which authorized construction of the Glen Canyon Dam, and the Colorado River Basin Project Act of 1968, which authorized construction of the Central Arizona Project, were milestones in this effort. Similar efforts, although on a much smaller scale, were mounted on the Mexican side of the border. A common characteristic of all of these projects is that the irrigators and other users of the water supplied by the projects have paid only a small fraction of the projects' cost.

Starting in the 1970s, attention in the United States began to shift from simply providing the water required to accommodate further development to addressing some of the environmental problems associated with the development that had already taken place. In addition to the salinity problem in the lower basin of the Colorado discussed above, the environmental community and other concerned citizens in the United States pressed for greater attention to other negative impacts of existing water-rights allocations, dam operations, or water management procedures on aquatic habitats and species and other environmental resources. U.S. federal environmental statutes, including the Clean Water Act, the Endangered Species Act, and the National Environmental Policy Act (NEPA), were increasingly referred to in strengthening the case for maintaining in-stream flows at levels sufficient to protect aquatic species and water-dependent ecosystems.

In 1989, for example, the U.S. secretary of the interior called for a full assessment of the environmental impacts of the operation of the Glen Canyon Dam. The resulting expanded Glen Canyon Environmental Studies Research Program was a critical factor in the passage of the Grand Canyon Protection Act of 1992, which ensures that water released from the Glen Canyon Dam will stay within a range that protects the safety of Grand Canyon river rafters and boaters and better maintains the sand beaches along the river used by the these boaters. This legislation marks the first time that protection of downstream river resources was identified as a primary purpose of a Colorado River dam.

Also, starting in the 1970s, the Mexican federal government began to pay greater attention to the environmental consequences of rapid post-war development. In 1971, the federal government promulgated its first comprehensive anti-pollution law, the Law for Environmental Pollution Prevention and Control, which strength-

ened and enlarged the scope of prior ecological standards. In 1982, a more comprehensive Federal Law of Environmental Protection was enacted, and the first ministerial-level environmental agency, the Urban Development and Ecology Ministry, was established.

In 1987, the Mexican Constitution was amended to impose ecological obligations on private property owners and to empower the national Congress to pass laws that established common standards at the federal, state, and municipal levels. Based on this amendment, the Ley General del Equilibrio Ecológico y la Protección al Ambiente (General Law of Ecological Balance and Environmental Protection, in Spanish LGEEPA), which consolidated and strengthened prior laws and standards, was promulgated in 1988.

In an effort to improve water management, the Comisión Nacional del Agua (National Water Commission, in Spanish CNA) was established in 1989 with sole authority in matters of water management within the federation. In 1992, the Territorial Waters Act was amended to regulate the use of territorial waters and to protect their quality. Since 1992, Mexico has modernized its water-management and planning systems with the help of a World Bank loan. Specifically, it has greatly improved its water-rights registry, which should help quantify who holds what water rights and thereby provide the basis for the market-based transfers proposed below. Although additional political resolve will be required to implement these laws, and additional resources will be required to make them effective, it is clear that water development and management in Mexico, including the border region, is increasingly subject to ecological constraints.

Against this backdrop of increased attention to the environmental consequences of historical water-development practices at the national level, the 1980s witnessed growing binational cooperation in addressing the environmental problems of the border region, including those related to water. During his campaign for president in 1980, then-Governor Ronald Reagan of California was confronted with sewage flowing north from Mexico onto the beaches south of San Diego, and he was asked what he was going to do about it if elected president. His campaign pledge to clean up the mess led to the negotiation of the La Paz Agreement[8] on the protection and improvement of the environment in the border area, signed by Presidents Reagan and Miguel de la Madrid in 1983.

The La Paz Agreement established a basic framework for binational cooperation for addressing the environmental problems of the border region; more specific obligations were spelled out in a series of annexes. The first such annex addressed the municipal wastewater issue and led to the construction more than 10 years later of an international sewage-treatment plant south of San Diego, which is today treating a substantial portion of the sewage generated in Tijuana. Four subsequent annexes deal with preparedness and response in the case of industrial accidents, transboundary movement of hazardous waste, copper-smelter emissions, and air pollution.

The La Paz Agreement also led to the creation of a series of permanent binational working groups to address environmental issues in specific media (air, water, chemicals) or subject areas (waste management, emergency response, enforcement). Although these working groups made progress in understanding and addressing specific environmental problems in the border area, it became apparent as the decade progressed that environmental conditions along the border would continue to deteriorate absent a much greater investment in environmental infrastructure than had taken place to date.

The event that made much of that investment possible and set the stage for addressing the water and other environmental problems of the border region in a more comprehensive fashion was the negotiation of the North American Free Trade Agreement (NAFTA).[9] When Presidents George Bush and Carlos Salinas announced their determination to negotiate an agreement extending the U.S.-Canada free trade agreement to Mexico and thereby transforming all of North America into a free trade zone, the U.S. environmental community saw an opportunity to exert political leverage toward requiring Mexico to bring its environmental performance up to the U.S. levels. By allying themselves with the labor unions, which opposed the agreement as posing a threat to U.S. jobs, U.S. environmental organizations did, in fact, achieve considerable leverage and caused certain environmental provisions to be inserted into the treaty text.

With the election of President Bill Clinton in 1992, this leverage was greatly enhanced by the new president's need to deal with the labor and environmental movements as core constituencies of the Democratic Party. As a result, President Clinton forced Mexico and Canada to accept side agreements on labor and the environment and

somewhat stronger language in the treaty itself as the price for agreeing to sign NAFTA. The environmental side agreement[10] created a North American Commission for Environmental Cooperation (CEC), which is empowered to develop and implement environmental cooperation programs, to consider submissions from citizens groups asserting that one of the three countries is failing effectively to enforce its environmental laws, to prepare factual records in response to those submissions (Articles 14 and 15 of the side agreement), and to issue reports initiated by the secretariat on specific environmental problems (Article 13). The secretariat has already addressed water-management issues in the border region in its report on the San Pedro riparian area straddling the Arizona-Sonora border. The report describes an approach to water management in the area that would both meet human needs for water and protect the San Pedro ecosystem (CEC 1999).

Another group that exerted leverage during the NAFTA negotiations in a manner even more relevant to the water problems of the border region is the Congressional Border Caucus. Led by Congressmen Esteban Torres and Kika de la Garza, the Border Caucus insisted that new financial resources be dedicated to improving social and environmental conditions in the border region by providing adjustment assistance to U.S. workers who lost their jobs because of NAFTA and by financing needed environmental infrastructure on both sides of the border. In order to gain the support of these members for the NAFTA package, in 1993 the U.S. and Mexican governments entered into an agreement creating two new binational institutions to help develop environmental infrastructure in the border region: BECC and NADBank.[11]

BECC and the NADBank were given complementary missions. The two main functions of BECC are to:

- Assist states, localities, public agencies, and private investors in developing environmental infrastructure project proposals by helping them analyze the technical, environmetal, and financial aspects of the projects, evaluate their social and economic benefits, and arrange financing for the projects in concert with the NADBank
- Certify applications for project financing to the NADBank and other sources

The BECC also provides technical assistance for project planning and design through the Project Development Assistance Program (PDAP) funded by the U.S. Environmental Protection Agency (EPA). Finally, BECC promotes public participation in the project certification process by holding public meetings to hear comments on projects being considered for certification, organizing public participation mechanisms at the community level, and conducting other outreach activities.

The three main functions of NADBank are to:

- Provide technical assistance for project financing and implementation
- Promote public and private investment in border projects
- Supplement such investment with NADBank loans and guarantees

The United States and Mexico have each pledged to contribute $1.5 billion of capital to NADBank for a total capitalization of $3 billion. Of this amount, $450 million is paid-in capital, and the remainder is callable capital. To date, $303 million of the $450 million has been paid in.

Through its Institutional Development Cooperation Program (IDP), NADBank promotes the long-term financial health of water utilities through initiatives such as management assessments and user-rate studies. In 1999 NADBank used the IDP to create the Utility Management Institute, which trains border community utility professionals in long-term utility organization, administration, finance, and management. Finally, NADBank has recently set aside a portion of its retained earnings to subsidize solid-waste projects, which are ineligible for grant funds from the EPA.

BECC and NADBank have accomplished much since they began operations in 1994. As of March 31, 2002, BECC has certified 57 projects with a total value of approximately $1.2 billion, of which 12 have been completed and are in operation and 21 are under construction. Thirty projects have been certified in Mexico and 27 in the United States with 55% of the total funding going to U.S. projects and 45% to Mexican projects. Wastewater treatment plants and associated infrastructure account for the largest number of projects, followed by drinking-water systems and municipal solid-waste projects.

In addition to moving a number of projects through the pipeline

and thereby substantially improving environmental conditions in the border region, BECC and NADBank have provided millions of dollars of technical assistance to smaller communities on both sides of the border and thereby enhanced their capacity to plan, build, operate, and maintain water-treatment and drinking-water systems. Through its public participation process involving the users and providers of water services, BECC has given citizens groups and community representatives opportunities to voice their concerns and influence investment decisions affecting their communities, which they had never had before, particularly in Mexico. Finally, the sustainable development criteria included in the BECC project certification guidelines represent the first such criteria adopted by any international organization.

Despite these accomplishments, the first six years of experience with BECC and NADBank have disclosed some shortcomings in their effectiveness. First, the charters of the two institutions focus their efforts on water treatment and drinking water. Although there is general language within the charters permitting BECC to certify and NADBank to lend for other projects that improve environmental conditions within the border region, the two institutions have, to date, interpreted their mandates narrowly. Therefore they have not addressed air quality, hazardous waste, and other environmental problems that have a negative impact on the health and quality of life of border residents. Even with respect to water, the two institutions have focused their efforts on improving water quality rather than increasing the quantity of available water services.

There are a number of reasons for this limited focus. Water pollution and lack of potable water are immediate problems requiring a political response. Helping border communities to build needed wastewater and drinking-water infrastructure is politically easy, provided that projects are sufficiently subsidized to keep rate increases, particularly for poor users, small. Changing the status quo regarding the allocation, cost, and method of delivery of water services more broadly, on the other hand, is bound to meet resistance from existing users. It is for this reason that the two governments have not given BECC or NADBank authority over water-rights allocation or administration. Finally, there is a backlog of $1 billion to $3 billion in needed wastewater and drinking-water projects in the border area that could be worked through without addressing broader water issues.

Nevertheless, in 2000, BECC and NADBank did decide in principle to expand their respective mandates to address other environmental problems, including water-management issues. The reason for this decision was NADBank's failure to use more than a tiny fraction of its lending capacity on BECC-certified projects. The U.S. communities in which those projects have been built have been able to find lower-cost funding from the municipal bond market and other U.S. lenders. The Mexican communities with projects have not been able to afford the currency-risk adjusted rates charged on NADBank loans. Therefore the bulk of the public funding for projects on both sides of the border has come from grants from the EPA. Through March 31, 2002, EPA has channeled $330 million in water-infrastructure grant funds to border projects, $305 million of which has already been disbursed or committed. In comparison, NADBank loans for these projects have totaled only $23 million.

NADBank's inability to use its more than $2 billion dollars in lending capacity gave rise to criticism on both sides of the border. The Mexican government in particular became concerned that an institution to which it had contributed more than $150 million in paid-in capital was not making a greater contribution to addressing Mexico's unmet social needs. During his 2000 presidential campaign, then-candidate Vicente Fox presented a vision of economic and social integration of Mexico with the United States, assisted by transition funds flowing from the United States to Mexico, following the model of the European Union. Fox pointed toward using NADBank to perform this function.

In response to this political interest, the NADBank board discussed how the bank could make better use of its lending capacity by offering to finance other types of environmental projects. At its meeting on November 16, 2000, the board agreed to set aside $50 million of its capital to lend at subsidized rates for projects in key sectors and to give management authority to make equity investments in certain types of projects on a case-by-case basis. Among the new types of projects approved for future certification and funding are water-conservation projects in the agricultural sector. NADBank is already exploring projects that would finance investments to improve the efficiency of irrigation in Texas irrigation districts through the sale of conserved water to nearby municipalities, and it hopes to explore similar projects on the Mexican side of the border.

The U.S. and Mexican governments have been engaged in ongoing discussions about how to reform BECC and NADBank in order to enable the two institutions to work more effectively together. The two governments seriously considered merging the two into a single institution but backed away from the idea in the face of strong pressure from border states and community groups. Two changes that have been preliminarily agreed upon are to combine the boards of the two institutions and to extend the geographic area for projects eligible for market-rate loans from 100 kilometers to 300 kilometers south of the border.

The two governments have not, however, reconciled their different agendas for the two institutions. From a U.S. perspective, the primary role of BECC and NADBank is to reduce the environmental and social impacts of current patterns of economic activity and resource use in the border region. From a Mexican perspective, the primary role of the two institutions is to expedite the economic and social development of northern Mexico, making up the shortage of infrastructure funding from Mexican public sources with as much U.S. grant funding as possible. The tension between these two perspectives is inherent in the basic difference in economic circumstances between the two countries and it is unlikely to be resolved in the foreseeable future.

The Current Situation

These developments could mark a turning point in moving toward a less-fragmented approach to water management along the border. Management of water resources in the border region is fragmented in three respects.

First, it is fragmented geographically. The Colorado draws from two separate basins whose water resources have been allocated among competing U.S. jurisdictions with a residual amount committed to Mexico. The Rio Grande/Río Bravo has two different flow regimes upstream and downstream of the Río Conchos.

Upstream of the Río Conchos the river's flow has derived primarily from the melting of snow in the Rocky Mountains. This flow has been captured by a series of dams, reservoirs, and diversions, most notably the Elephant Butte Dam, to provide water for irrigation and municipal uses. After flowing through El Paso and Ciudad Juárez,

where substantial additional quantities are withdrawn, the river enters the 80-mile reach to Fort Quitman, which is substantially dewatered and has to be periodically dredged to maintain its flood capacity. The subsequent 180-mile reach between Fort Quitman and Presidio (the "Forgotten" River Reach) has very little flow and is a shadow of its predevelopment state.

Only when it is joined by the Río Conchos flowing out the Mexican highlands after the Presidio does the Rio Grande/Río Bravo again become a great river worthy of its history. Thus the river can conveniently be divided into two discrete hydrologic segments: an upstream segment, in which the United States is the upper riparian nation with treaty obligations to deliver a quotient of water to Mexico; and a downstream segment starting with the Río Conchos confluence, in which Mexico is the upper riparian nation with treaty obligations to deliver a quotient of water to the United States.

Second, management of water resources along the border is fragmented legally and institutionally. As mentioned above, allocation of these resources, is governed by a kaleidoscope of binational treaties, interstate compacts, reclamation projects, water rights, and contracts. In the Paso del Norte area alone, water management is governed by binational treaties; the federal laws of the United States and Mexico; the laws of Texas, New Mexico, and Chihuahua; and the legal regimes of El Paso, Ciudad Juárez, and Las Cruces.

These treaties, laws and regimes are implemented by a plethora of government institutions, including the Texas Commission on Environmental Quality, Texas Water Development Board, New Mexico Office of the State Engineer, Interstate Stream Commission of New Mexico, CNA, Rio Grande Compact Commission, and IBWC. Also, a plethora of water providers are involved, including El Paso Water Utilities, El Paso County Water Improvement District, Las Cruces Water Resources Department, Junta Municipal de Agua y Saneamiento de Ciudad Juárez, and Distrito de Riego 009, a division of CNA dedicated to delivering irrigation water to members of its district (Paso del Norte Water Task Force 2001).

These institutions and an even larger number of private organizations are all stakeholders in the process of transforming the current fragmented system into a more integrated decision-making process for managing the border's water resources, which recognizes the real value of those resources and prioritizes their uses on the basis of

some calculus of social welfare.

The final discontinuity in the management of water resources along the border is that water-user communities and the other stakeholder communities simply do not communicate with each other enough. This is particularly true with respect to the water needs of the threatened ecosystems and the rights of Native-American communities. Private institutions such as Instituto Tecnológico y de Estudios Superiores de Monterrey (ITESM), the Universities of Texas at Austin and El Paso, the Pacific Institute, the Texas Center for Policy Studies, Environmental Defense, and the Natural Heritage Institute are working to develop comprehensive hydrological analyses and management options that could be the basis for stakeholder dialogues on a regional basis, but they have not yet received sufficient support from the two governments or binational institutions (ITESM 2001).

Partially as a result of the fragmented management structure described above, the cost of water to most users in the border region is only a small fraction of its true value. Agricultural irrigators, which account for more than 80% of the water consumed on both sides of the border, pay almost nothing for their water in Mexico (50 centavos per cubic meter) and only a small fraction of its marginal cost in the United States. Municipal users pay more, but their rates are subsidized, particularly for poor households. In Mexico, failure to meter water use in a majority of households means that many people do not even pay the subsidized price. Larger industrial users frequently pay prices that reflect the market value of the water they use, but they often cannot obtain the additional water supplies they need to expand their operations because there is no market mechanism for obtaining those supplies.

The predictable result of this underpricing is lack of investment in maintaining and upgrading water systems and massive waste. CNA estimates that 60% of the water supplied for irrigation in Mexico is lost through evaporation, seepage, or other unplanned diversions (CNA 2001b). The situation is somewhat better in the United States, but irrigation losses are still close to 50% on average. In a report completed as part of the Texas Senate Bill 1 regional water-planning study for the Rio Grande region (Region M), Professor Guy Fipps of Texas A&M University determined that there was significant potential for water savings in irrigated agriculture in

the region's 28 irrigation districts (2000).

Professor Fipps determined that the average conveyance efficiency in the 28 districts was only 70.8%. Out of a total of 1,459 miles of distribution canals, 552 miles were lined, 613 were unlined, and 294 were unknown. The condition of the lined canals was rated as poor, with many canals showing high rates of seepage loss due to poor construction and inadequate maintenance. Farm practices and methods also had much room for improvement with 34% of the irrigated acreage in five larger districts still using field ditches to deliver water to their crops as opposed to tubing, pipes, or drip-tape.

His overall conclusion was that, out of average annual diversions by all districts in Region M of approximately 900,000 acre-feet, the combined water-saving potential from improving district conveyance efficiency from 70% to 90% and improving on-farm practices and methods was 354,000 acre-feet, or nearly 40% (Fipps 2000). Based on a capital cost of $127 per acre-foot (in 1988 dollars) for the Imperial Irrigation District's comprehensive water-conservation program with the Municipal Water District, and assuming that the capital investment would be written off over 10 years, such savings could be realized at a cost equivalent to buying the water for $10 to $20 per acre-foot, which is well below the subsidized price for incremental supplies today.

The agricultural sector's combined water-saving potential is even greater on the Mexican side of the border where conveyance efficiency is lower and on-farm practices and methods are less advanced than in the United States. CNA has a plan to upgrade Mexico's water-conveyance infrastructure for the agricultural sector at an estimated cost of 40 billion pesos. It estimates that the planned investments will generate annual water savings of 10 billion cubic meters (CNA 2001a).

These estimates translate into a cost of 4 pesos per cubic meter. With municipalities and industry willing to pay 5 pesos to 15 pesos per cubic meter for additional water supplies, CNA's investment could in theory be recouped in one year or less. The problem is that CNA is not likely to receive the necessary investment funds from the Mexican federal budget given the overall budget constraints and other priorities. And, the legal framework and mechanisms for raising those funds through the sale of conserved water rights to municipalities and industry are yet to be developed.

Although it accounts for only 10% to 15% of total water consumption in the border area, the municipal sector also offers significant water-saving opportunities. The greatest such opportunity is repairing the water-distribution systems in Mexican border cities. CNA estimates that on average 35% of the water delivered to such systems leaks from water pipes before it reaches intended users (CNA 2001b). In some Mexican border cities, the leakage rate exceeds 50%.

Most water utilities in Mexican border cities are caught in a vicious cycle. Lack of metering and a culture of nonpayment lead to low collection rates for water deliveries, which in turn lead to lack of investment in and maintenance of water-distribution systems, which in turn leads to a low quality of service, which reinforces the culture of nonpayment. The situation is better on the U.S. side of the border, although meaningful savings could be realized by upgrading municipal distribution systems.

There are also significant savings to be realized in the municipal sector from water conservation by end users. Conservation programs in Los Angeles, Phoenix, and Tucson, have achieved reductions in per capita water consumption of 20% or more. Similar programs should be instituted in U.S. and Mexican border cities. For such programs to succeed, particularly in Mexico, currently unmetered end users will have to be metered, enforcement will have to be strengthened, and homeowners and small business owners will have to be given technical and financial assistance in installing water-efficient equipment.

The industrial sector offers the smallest water-savings opportunities because it accounts for the smallest percentage of total water consumption and pays the highest prices for its water supplies. The greatest conservation opportunity in the industrial sector lies in recycling wastewater from the municipal and agricultural sectors, which does not have to be treated to drinking-water standards to be used in many industrial applications. There are also industry-specific opportunities to reduce water consumption per unit of output through process improvements.

Finally, it would be remiss not to mention the natural sector, which has been deprived of the water it needs by surface water and groundwater diversions to service the other sectors discussed above. As mentioned earlier, the U.S. Endangered Species Act and provisions in Mexican federal laws, as well as the public trust doctrine,

prohibit or restrict water withdrawals for human activities when they would threaten the existence or health of endangered species or ecosystems. It has proven difficult to enforce these laws, however, in the face of political pressure from people benefiting from those withdrawals. Fortunately, water conservation in other sectors may provide an opportunity to provide additional water to the natural sector.

Instruments for Change: Technology, Markets, and Policy Reform

The instruments to bring about conservation and thereby provide additional water resources to meet the needs of competing users without further depletion of groundwater reservoirs in a manner that maximizes social welfare are at hand. These instruments are technology, market mechanisms, and policy reform.

Technology

As indicated above, this is already enough technology to conserve a substantial portion (at least 35% to 40%) of the water diverted for agricultural, municipal, and industrial uses in the border region. The bulk of those savings can be achieved by rebuilding and properly maintaining water-conveyance, distribution, and storage systems and by metering water deliveries from those systems to end users. The concrete, liners, pipe, pumps, gates, meters, and other components of such systems are easy to obtain. More difficult to obtain is the equity and loan capital to rebuild the systems. Most difficult of all is to create operator and user communities that have internalized a culture of social accountability, prompt payment, regular maintenance, and long-term planning.

Additional savings can be achieved by deploying more sophisticated irrigation technologies. Irrigation efficiency can be improved even beyond the results achieved in the Imperial Irrigation District in California by deploying computer integrated underground drip irrigation systems. In these systems daily, weekly and monthly weather projections are fed into software that has already been programmed with optimal water-delivery cycles for the crop in question. This software then generates instructions for timed water

releases under the root systems of each plant to optimize plant growth and seed creation per unit of water released. Unfortunately the high capital and operating costs of these systems can only be justified with higher marginal water prices and higher value-added crops than exist in most border irrigation districts today.

Further savings can be obtained in the municipal and industrial sectors by deploying more efficient end-use technologies. In the municipal sector, these technologies include low-flow faucets and showerheads, low-flush toilets, water-efficient dishwashers, and more efficient chillers in cooling systems. The savings from these technologies can be enhanced by improved operating practices such as restricting lawn irrigation and car washing and encouraging reuse of sheets and towels in hotels. In the industrial sector, enterprises should be encouraged to conduct water-conservation audits similar to the energy-efficiency and pollution-reduction audits that have already produced eco-efficiency improvements in the refining, petrochemical, metal plating, and other industries. In both sectors, governments and binational institutions such as NADBank will have to provide technical and financial assistance to ensure that the potential savings identified are actually achieved.

In addition to technologies that can reduce the demand for water, there are desalinization technologies that can increase the supply of usable water. As these technologies have improved and their cost has declined, they have become a viable option for some communities in areas with little rainfall or access to surface water or groundwater supplies. The City of Hermosillo in Sonora is finalizing a $250-million contract with Aguas de Saltillo, S.A., to purchase water from a reverse osmosis desalinization plant 150 miles away at a cost of 8.22 pesos per cubic meter (Aguas de Saltillo, S.A. 2001). The cost of transporting the water this distance uphill via aqueduct accounts for about half of the total cost, with the cost of desalinization accounting for the other half.

Market Mechanisms

A necessary condition to capturing the water-saving potential of the technologies discussed above is the creation of market mechanisms that place an economic value on each unit of water used or saved at the margin that approximates its true long-term social value. These

mechanisms will have to be created within the interstices of the existing fragmented structure of water rights within the border region. A broader renegotiation of water treaties, compacts, laws, allocations, and practices may, in the end, be necessary,[12] but this can only be achieved incrementally. The initial steps in this process should be designed to give existing water users economic incentives to make additional supplies available for higher-value uses through a combination of conservation and transfer of water rights.

The legal rules governing water rights that have developed in the United States and in Mexico have not encouraged conservation or market-based transfers. In the United States, the "first-in-time, first-in-right" prior appropriation doctrine developed in the western states to give farmers, miners, and other appropriators clearly defined property rights to water has increasingly been circumscribed by court decisions and state regulation based on the riparian doctrine borrowed from English common law. Initially, miners and irrigators used the prior appropriation doctrine to create private water markets in which rights could be bought and sold from one use to another. Private institutions, notably commercial and mutual irrigation companies, were created to develop the water resources needed for their operations. The resulting system gave participants the ability to determine, and the incentive to pursue, the uses of water most beneficial to them at the time.

Starting in the 1880s, however, courts and legislatures in western states began to restrict the free operation of water markets by using the riparian doctrine that each user of water from the stream has only the temporary right to use part of a common resource. States passed laws providing that water rights could only be established by diverting water from a stream and that claims to water left in the stream were not legitimate rights. The "use-it-or-lose-it" rule requires appropriators to use their entire water right or risk forfeiting it. The "salvaged water rule" prohibits users from keeping or selling water that became surplus through conservation efforts such as lining ditches, repairing pipes, or installing more efficient irrigation systems. Under the "beneficial use" doctrine, states determine which uses of water were "beneficial" and which were not. Until recently, for example, maintaining in-stream flows was not recognized as a beneficial use. States and counties have begun passing area-of-origin protection laws that prohibit or limit transfers of

water out of originating basins. Finally, courts have used the public trust and federal reserved rights doctrines to override legally established water rights to protect the environment or to uphold claims to water for Indian reservations, national parks, and other federal lands.[13]

These restrictions on private water rights and the operation of water markets have been justified on public interest grounds such as protecting downstream water users, conserving the environment, and Native American rights, or avoiding speculation and monopoly control. Their actual effects, however, are often contrary to their alleged purposes. By removing economic incentives to conserve water, these restrictions have encouraged waste and reduced the amount of water available to other users. By denying appropriators any legal rights to water returned to the stream or even prohibiting such return as a "nonbeneficial use," they have damaged water-dependent ecosystems. By preventing market forces from allocating water, they have enabled users to capture above-market rents by persuading political authorities to protect and subsidize uneconomic uses.

Mexican water law derives from a continental European legal tradition very different from the Lockean "labor theory of value" law tradition upon which the prior appropriation doctrine is based. Under the Mexican Constitution and relevant statutes, water is part of the national patrimony and cannot be owned or transferred as private property. CNA, on behalf of the state, grants irrigation districts, municipalities, and other users temporary rights to use a portion of this patrimony for their private purposes.

But what the state grants it can take away without payment or compensation. This is precisely what has happened to irrigation districts in the Río Conchos basin in order to pay back a portion of the water debt to the United States. The districts have received a small voluntary payment from CNA for the reduction in deliveries, but are not entitled to demand compensation equal to the economic value of the water withdrawn from their use as they would be in the United States.

CNA's authority to allocate temporary water rights to users as it sees fit has led to the use of water as a political patronage tool. The government in power has had an incentive to keep the prices charged to farmers and poorer urban residents low in order to retain their

political support. Low prices have in turn contributed to the waste of water in the agricultural and municipal sectors described above. The conservation investments and market-based transfers needed to correct this situation will therefore require at least a partial "depoliticization" of, and reduction of CNA control over, water rights in Mexico.

The legal and political disincentives to promoting water conservation through the market mechanisms described above have been compounded in both countries by federal water subsidies. In the United States, the federal government began to subsidize construction and operation of massive water-storage and delivery projects starting with the Reclamation Act of 1902. The New Deal accelerated this process as the federal government built hundreds of dams for flood control, irrigation, and hydropower production through the Tennessee Valley Authority, the Public Works Administration, and the Columbia Basin Project.

Initially, the costs of these projects were to be repaid within 10 years by the recipients of the water, but the political temptation to accommodate vocal beneficiaries in western states by spreading these costs over all taxpayers became irresistible and interest-free repayment schemes, together with deferrals and extensions of the repayment period, raised the value of the subsidy to more than 90%. The political attraction of these subsidies was demonstrated by Congress's refusal to allow President Carter to stop funding a number of subsidized water projects in 1979. As recently as 1993, Congress authorized construction of the Central Utah Project, which will charge irrigators $8 per acre-foot for water that it costs $300 to $400 per acre-foot to deliver.

Following the U.S. example, the Mexican government has also subsidized dams and other water-storage infrastructure for irrigation, flood control, and hydropower. These projects have been characterized by many of the same economic and environmental problems as in the United States. In the state of Nuevo León, for example, CNA has constructed several dams that have failed to store water in periods of drought, caused rapid buildup of silt, and damaged local ecosystems. If the billions of pesos spent on these dams had been spent to upgrade the existing conveyance and storage infrastructure in the area, water users and the environment would both have been far better off.

Despite these impediments, there have been a number of cases where water prices have been allowed to rise and conservation and higher-value uses thereby encouraged. In 1989, for example, the California State Water Resources Control Board found that Central Valley cotton growers who paid for federal water from the Central Valley Project used 20% less water and produced 20% more output than did nearby growers who received their water at no cost under senior water rights (Anderson and Snyder 1997). Between 1985 and 1995, the price of water delivered to farmers in California's Westlands Water District rose from $16.25 to $58.11 per acre-foot in response to declining supplies. Farmers responded by fallowing all but their best lands, growing crops that yielded higher returns, and installing drip irrigation systems (Anderson and Snyder 1997).

Water banks have proven to be an effective mechanism for encouraging transfers and promoting conservation. Because they are sanctioned by government and set prices, water banks are more politically acceptable than unregulated private markets. Idaho's water market has been functioning since 1979 and several hundred thousand acre-feet change hands annually. In 1991, California established a Drought Water Bank that purchased 800,000 acre-feet of water at $125 per acre-foot and sold half of it for $175 per acre-foot. The success of this experiment led California to repeat it in 1992 and 1994 and to consider establishing a permanent State Drought Water Bank (Anderson and Snyder 1997).

Policy Reform

The power of market mechanisms to encourage conservation and to allocate scarce water resources to higher value uses has been demonstrated in many individual cases, including the examples cited above. The challenge is to make these mechanisms the norm rather than the exception. The critical step in meeting this challenge is to allow water prices to rise at the margin. As long as water is free or priced far below its real value, users will have little or no incentive to conserve water or to apply it to the highest-value uses. In the United States, the price of marginal water supplies has been rising in many agricultural areas and cities in response to declining availability and increasing demand. As a result, all four U.S. border states project only modest growth in total water use over the next 20 years

with growth in municipal consumption being partially offset by declines in agricultural use.

The long-term state water plans upon which these projections are based, however, are unrealistic in three respects. First they assume unsustainable rates of groundwater withdrawal. If the aquifers supplying the Paso del Norte and other populated areas along the border continue to be depleted at current rates, the groundwater supplies assumed in state water plans will simply not be available in the out years. Second, they make no allowance for returning water to streams for ecosystem protection or honoring Native-American claims. Third, they make no allowance for the higher temperatures or changes in precipitation and soil moisture likely to result from climate change. Once these three factors are taken into account, much greater reductions in surface and groundwater withdrawals for irrigation and municipal use will be required to bring water budgets into balance.

Achieving these reductions will require far more extensive use of market mechanisms than has taken place to date. Government authorities responsible for water-delivery and storage infrastructure, irrigation districts, and other users need to create mechanisms that will compensate suppliers and users for conserving water or transferring it to higher-value uses. The optimum theoretical model for such mechanisms might be regional water exchanges for each of the three most populated regions along the border (California-Baja California, Paso del Norte, and the Lower Valley) in which water rights could be as freely traded as stocks in New York or pork bellies in Chicago.

In such an exchange, holders of historical water rights would enter the market with their rights intact but would be free to sell those rights or buy additional rights as they saw fit. Futures, hedges, and other contractual devices could be created to manage risk and to improve market efficiency. The exchange would be subject to government regulation to ensure transparency and to prevent fraud and manipulation, but the regulatory authority would not attempt to control the prices at which rights were traded or the purposes for which the water was used.

The need to reserve water for public purposes such as ecosystem protection, negative attitudes toward treating water as a market commodity, and the history of government regulation and subsidiza-

tion discussed above make this model difficult to implement on a regional scale. It should, however, be implemented through pilot projects on a local scale. California and Texas have created precedents for such projects through the Imperial Valley-Municipal Water District agreement discussed above, the California Drought Water Bank, and several conservation projects being implemented by the Texas Water Development Board with local irrigation districts. No such projects have yet been implemented in Mexico, but CNA, other Mexican federal agencies, and local governments have all expressed support for the concept, and several large irrigation districts in Tamaulipas have shown interest.

The central elements in the U.S. projects implemented to date are:

- Transfer of a specific quantity of water at a negotiated price from an irrigation district to a nearby municipality
- Use of all or a portion of the proceeds to conserve water by financing improvements in delivery and storage systems and on-farm practices
- Presence of a government intermediary with control over volumes and prices

Future projects could improve on these precedents by including additional participants such as other districts and municipalities, local industrial enterprises, conservation organizations, and state agencies themselves, which could sell additional water rights in the local area and use the proceeds to invest in conserving water locally or elsewhere in their systems. Including additional parties would allow greater scope for true market transactions based on competitive bids and offers and constitute an initial step toward creating the broader markets discussed above.

Providing greater scope for market forces to influence water allocation in the border region will be controversial. Irrigators and their advocates in state and local governments are already concerned that more and more water is being allocated to municipalities and less and less to agriculture. Market-based reforms are perceived as accelerating this trend. Citizens groups are concerned that permitting water rights to go to the highest bidder will deprive many poorer agricultural workers in the border region of the low-cost water that sustains their livelihood and force them to move into the cities.

More broadly, many people with roots in the region are saddened by the prospect of losing a way of life built around farms and ranches that "made the desert bloom."

Giving greater scope to market forces also contradicts the basic philosophy underlying the Reclamation Act of 1902. In the words of the Western Water Review Advisory Commission, "(a)chieving these efficiency benefits through the reduction or elimination of irrigation subsidies…would fundamentally undermine the historic justification of the western reclamation program and would negatively impact many farming communities, suggesting that the true value of water in the West can only partially be understood by the concept of pricing" (Western Water Policy Review Advisory Commission 1998). These communities are capable of exerting considerable political leverage to protect their access to subsidized water, as demonstrated by the resistance to withdrawal of federal water from irrigators in the Klamath Basin in Oregon and Northern California.

These concerns do not, however, justify stopping or delaying the pursuit of market-based policy reforms in the border region for a number of reasons. First, there is no realistic alternative. Water conservation in the agricultural sector is a critical element in meeting the future water needs of the border region, and the investment necessary to achieve that conservation is not likely to be forthcoming from government sources, particularly in Mexico. Second, Mexican irrigators already face a reduction in available water and have a strong incentive to support projects that will enable them to generate greater value from less water. Third, any transfers from agricultural to urban uses will be voluntary and will only result in reductions in agricultural production if the producers involved choose that outcome.

Finally, a continuing shift of rural population out of agriculture into other occupations is a necessary component to improving the quality of life of border residents. To suggest that the sons and daughters of current agricultural workers do not have better choices for their future is to deny them the economic opportunities they want and deserve. The challenge is to work together toward a pattern of economic growth in the border region that creates those opportunities while at the same time protecting the environment and providing necessary social services. Viewed through the prism of water, the challenge is to generate the greatest amount of social wel-

fare from a limited supply of water. Market-based mechanisms have an important role to play in meeting that challenge.

The concerns expressed above should, however, be addressed in developing those mechanisms in three respects. First, they should be developed through a transparent, participatory process involving all relevant stakeholders. New market-based approaches to water management cannot be imposed from the top down and will succeed only if all affected parties are involved in developing them. Second, the market transfers involved will have to have direct government involvement and sanction, particularly in Mexico where CNA has the sole legal authority to create and transfer water rights. Third, these market-based approaches will have to be tested in carefully selected pilot projects before they are applied more generally.

To maximize the utility of these pilot projects, however, four prior steps need to be taken. First, government agencies and other key stakeholders require a better understanding of where water is coming from and where it is going in the border region, particularly with respect to return flows. This is especially true in Mexico, which does not yet have water data of the same quality and reliability as the United States. Texas Senate Bill 1 has appropriated funds to gather and analyze such data, and the state government has contracted with Texas universities to carry out this task. The U.S. federal government, other U.S. border states, and the Mexican government should do the same, using the expertise of border institutions such as ITESM. U.S. charitable foundations and other private funding sources should also be asked to contribute to this effort.

Second, this data should be analyzed to identify specific opportunities to conserve water or to transfer it from one use to another that will achieve the greatest benefit at the lowest cost. Such an effort is being mounted by a binational private-sector consortium of universities, environmental organizations, and other institutions with relevant expertise (Instituto Tecnológico y de Estudios Superiores de Monterrey and the National Heritage Institute 2001). The consortium will use sophisticated software called River Ware to model water sources and uses in the border area and to identify opportunities for conservation or transfers to higher-value uses. The U.S. and Mexican federal governments, and international organizations such as the NADBank and the Inter-American Development Bank should also support this work.

Third, water budgets incorporating the conservation and transfer opportunities identified through the efforts described above should be developed for each of the three most populated areas along the border. These budgets should provide for a balance between groundwater withdrawals and recharge and set aside appropriate quantities of water for ecosystem rehabilitation and Native-American claims. They should also make realistic assumptions about users' responses to price signals, including shifting from cotton and alfalfa to higher-value crops, fallowing acreage, transferring water from agricultural to municipal uses, and end-use conservation in urban areas.

Finally, existing institutions need to be better coordinated, and laws and regulations may in some cases need to be modified to create the space necessary for the pilot experiments with market mechanisms proposed above to take place.

The Way Forward

The question is how to make the changes in the existing legal framework and to create the institutional arrangements necessary to enable market mechanisms to achieve their potential for conservation and reallocation of water to higher-value uses. A first step is to conduct the data-gathering and analysis of conservation and reallocation opportunities described above. The results of this effort could then be combined with a number of existing regional studies of how those mechanisms might operate and what their results might be.

In its study on the sustainable use of water in the Lower Colorado River Basin, for example, the Pacific Institute describes how improvements in irrigation efficiency, shifts in cropping patterns, and fallowing of irrigated land could save 1.24 million acre-feet of water per year in Arizona alone (Morrison, Postel, and Gleick 1996). The study recommends that market mechanisms, including properly designed pricing structures, water-depletion taxes on groundwater overdraft, and voluntary water transfers from lower- to higher-value uses, be used to help achieve those savings and that a portion of the water saved be allocated to maintaining minimum flows in the Ciénega de Santa Clara and the Colorado River Delta (Morrison, Postel, and Gleick 1996).

A next step would be to feed the results of those analyses and studies into regional planning projects at the state level. Texas has

taken the lead among U.S. states by establishing regional water-planning entities with participation by all interested stakeholders and support from the Texas Water Development Board. The Far West Texas Planning Group and the Regional Water Planning Group for the Lower Rio Grande Valley are already developing water plans for their sub-basins. Other U.S. border states and the Mexican federal and state governments should follow the Texas example. (Mexico has established a consultative council for the entire Río Bravo basin, but it has inadequate resources and has not yet engaged in water planning.)

But, it is not sufficient to create water-management plans on a state-by-state basis when critical water resources are shared between states and between the United States and Mexico. The two countries must create binational fora in which integrated regional management plans and budgets for both sides of the border can be developed. Three nongovernmental institutions—the Houston Advanced Research Center, New Mexico State University, and the Universidad Autónoma de Ciudad Juárez—have shown the way by creating the Paso del Norte Water Task Force. The task force will develop policy recommendations for integrated water management in the region after fact-finding and consultations with stakeholders, according to the agreement that established BECC and NADBank.

To transform private initiatives such as this into public processes with the ability to make binding recommendations or decisions will require a binational public institution with authority to coordinate the activities of existing public institutions at all levels of government. Some commentators have suggested creating an entirely new institution or institutions to perform this role. The Pacific Institute study referred to above, for example, recommends the formation of "an Overarching International River Basin Commission" with authority to develop a comprehensive, integrated, environmentally sustainable, long-term management plan for the Colorado River (Morrison, Postel, and Gleick 1996).

Another approach, which may be more politically feasible, would be to give an existing binational institution the additional powers and resources it needs to create and coordinate the implementation of integrated regional water plans and budgets. Dr. Jurgen Schmandt, director of the Houston Advanced Research Center, recommends that the IBWC be used for this purpose (Schmandt 2001).

In addition to its current functions—river water allocation, reservoir management, and flood control—the IBWC would, among other new functions, be given the authority to establish a Rio Grande Basin Council (or, perhaps, Rio Grande-Lower Colorado Basin Council). The council would have reporting to it the binational regional water task forces for each of the four hydrological sub-basins of the Rio Grande, perhaps even the lower basin of the Colorado task force. Based on advice from these task forces and other subsidiary bodies, the expanded IBWC would then develop and submit action and project recommendations to other binational institutions in the border area.

The two binational organizations best qualified to act on these recommendations are BECC and NADBank. BECC would then develop specific project proposals to implement the recommendations after consultation with public and private stakeholders, and then submit those proposals to a certification process with full public participation. NADBank would assemble the technical assistance and financial resources necessary to implement the project.

One critical element not referred to in Dr. Schmandt's paper is removal of obstacles in current laws and agreements to using market mechanisms to promote conservation and transfers to higher-value uses. Rather than negotiating ad hoc regimes or amendments for each project, amendments to existing laws and agreements that would achieve minimum consistency between the United States and Mexico should be developed and submitted to federal and state legislatures in both countries. Only with this legal integration and consistency will market mechanisms be able to fully contribute to achieving the goals of the integrated binational water plans and budgets discussed above.

Conclusion

The United States and Mexico have an opportunity to transform water management in the border region from a source of strain and possible conflict in their relationship to a source of cooperation and mutual benefit to their citizens. They have the technology, the resources, the institutions, and the policy tools to make this transformation a reality. The journey will be long and challenging, but the time to start is now.

Endnotes

[1] In the United States, the river is referred to as the Rio Grande; in Mexico as the Río Bravo.

[2] Ley Federal de Aguas, 1972, Article 27.

[3] The Wagstaff Act 1031 established seven priorities: domestic and municipal, industrial, irrigation, mining, hydroelectric, navigation, and recreation. It was amended in 1985 to add an eighth-priority, bays and estuaries.

[4] Convention between the United States and Mexico to Avoid the Difficulties Occasioned by Reason of Changes that Take Place in the Beds of the Rio Grande and Colorado River, signed March 1, 1889, 26 Stat. 1512.

[5] Treaty between the United States and Mexico Relating to the Waters of the Rio Grande, signed at Washington, D.C., May 21, 1906; entered into force January 16, 1907; 34 Stat. 2953; Treaty Series 455.

[6] Treaty between the United States and Mexico Relating to Utilization of Waters of the Colorado and Tijuana Rivers and of the Rio Grande, signed at Washington, D.C., February 3, 1944; protocol signed at Washington, D.C., November 8, 1945; Stat. 1219; Treaty Series 944.

[7] Minute No. 242 of the International Boundary and Water Commission, United States and Mexico, approved by the governments of the United States and Mexico on August 30, 1973.

[8] The United States-Mexico Agreement on Cooperation for the Protection and Improvement of the Environment in the Border Area, signed at La Paz; Baja California Sur, Mexico, August 14, 1983, T.I.A.S. 10,827.

[9] North American Free Trade Agreement, signed December 17, 1992, reprinted in 32 I.L.M. 289 (1993).

[10] North American Agreement on Environmental Cooperation, signed September 1, 1994, reprinted in 32 I.L.M. 1489 (1993).

[11] Agreement Concerning the Establishment of a Border Environment Cooperation Commission and a North American Development Bank, signed November 18, 1993, entered into force January 1, 1994, reprinted in 32 I.L.M. 1545 (1993).

[12] Mexican commentators have already proposed a renegotiation of the 1944 treaty to allocate total water resources in the Río Conchos Basin between the two countries on a more equitable basis.

[13] For an excellent discussion of the evolution of water law in the western United States, see T.L. Anderson and P.S. Snyder, "Priming the Invisible Pump," *Political Economy Research Center Policy Series*, Issue Number PS-9, February 1997.

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