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MANAGING WATER ON THE U.S.-MEXICO BORDER: THE BINATIONAL CHALLENGE

Stephen Mumme, Ph.D.
Nonresident Scholar, Center for the United States and Mexico

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Introduction

It is hardly an exaggeration that while water literally defines and constitutes two thirds of the U.S.-Mexico boundary—along the Rio Grande and a short stretch of the Colorado River—it is the lack of water that so often defines the border region. From the Gulf Coast to the coastal Pacific, the boundary traverses some of the most arid lands of North America. This hydrological fact drives the development of the border region. Water availability, including its use and disposition, is central to the livelihoods and well-being of border communities from Brownsville and Matamoros to San Diego and Tijuana. It is also the basis of some of the most important agreements of record between the United States and Mexico. Today, in the early decades of the 21st century, sharing and husbanding the border's scarce water resources are more important than ever, and more challenging.

This paper profiles the current state of water management in the border region with particular attention to the manner in which regional growth dynamics and changing patterns of water availability are presently altering the region's water security and challenging existing institutional arrangements for managing water resources. It does not purport to offer an in-depth analysis of the many particular water management dilemmas in the border region, but instead aims to identify the principal sources of binational contention and the prospects for further binational cooperation in confronting the twin challenges facing the region today. These twin challenges—rising water demand and persistent long-term diminishment of the region's reliable riparian water supply—are presently on a collision course, avoidance of which will demand significant adjustments in the way water is managed at both the domestic and international levels. The focus here, however, is on the binational aspects of border water management and strengthening cooperation between the United States and Mexico in meeting these challenges.

This paper is divided into seven sections. The first section briefly summarizes prevailing hydrological forecasts of water availability in the border region. The second section examines current patterns of water use in border agriculture and municipalities. The third section looks at the international arrangements in place for managing scarcity on the treaty rivers, how persistent drought is challenging these arrangements, and where international cooperation on shortage sharing has advanced and where it has not. The fourth section considers the problem of sharing transboundary aquifers. Section five examines the problem of transboundary sanitation and the challenge of managing wastewater along the boundary. The sixth section looks at a recent instance of water conflict along the boundary as an example of rising tensions over water in the border region, but also notes how conflicts are driving the quest for solutions to water scarcity. The paper concludes by listing a range of needed policy reforms both the U.S. and Mexican governments should consider as they strive to shore up water security and manage water hazards along the border.

I. Hydrological Trends in the Border Region: An Overview

Water availability along the border is largely tied to the ebbs and flows of the two major rivers serving the region—the Rio Grande and the Colorado River—as well as more than a dozen substantial transboundary aquifers, most of which are at least loosely linked to the riparian flows of the watersheds of the two major river systems. Other river systems, which, in their natural state, are independent of these larger river systems, do exist as seen with the Tijuana River on the Pacific Coast or the Rio Sonoyta that crosses the Arizona-Sonora boundary. Yet the principal river systems, the Rio Grande and the Colorado River, remain the dominant hydrological mainstays of the border region's human settlements, agriculture, and industrial productivity today, with significant contributions to energy production through hydropower as well. An estimated population of 5.5 million people along the river's boundary rely on the Rio Grande's water for their well-being (TCEQ 2021). If we include the river's upper basin, an estimated 40 million people in the seven U.S. basin states (USBR 2021a), and another 7 million in the Mexican states of Baja California and Sonora, are directly and indirectly served by the Colorado River (INEGI 2020).

That both major river systems are now in the throes of a protracted drought of nearly 30 years duration (starting as early as 1993)—the longest period of sustained drought in the modern historical record for either of the two major river basins—is a fact on which climate scientists agree.[1] Stream flows for the major Southwestern rivers of the United States between 2001-2010 (including the Rio Grande and the Colorado River) were 5% to 37% lower than the averages for the entire 20th century, and average daily temperatures for the 2001-2010 period were the highest in the Southwestern region for the entire 1901-2010 era (Overpeck 2013, 3). Climate scientists expect precipitation throughout the border region to become more variable, with significant contractions along the Arizona-Sonora border and the coastal California-Baja California zone (GNEB 2016, 2). Analysts also expect periods of drought and extreme heat will intensify in the 21st century, diminishing the reliability of riparian flows on which border populations depend (GNEB 2016, 3; Wilder et al. 2013, 345).

These prognostics are certainly playing out on the treaty rivers. The state of Texas witnessed its worst one-year drought on record in 2011, and its Rio Grande planning zone reported that 2021 might well produce its worst drought on record (TWDB 2021, A36-A38). Mexico's inability to satisfy its Rio Grande treaty water delivery obligations has proven a source of vexation for Texas water users since 1997, with Mexico falling well behind delivery expectations in both water accounting cycles during the past decade. Chronic shortages on the Colorado River since the mid-1990s have driven basin-wide conservation plans and international agreements on shortage sharing, marked most recently by the U.S.

[1] In 2012, Mexico's National Water Commission, CONAGUA, reported that the Rio Conchos basin—the principal source of flows to the middle and lower Rio Grande, accounting for over 80% of supply in this section of the river—is among Mexico's most vulnerable rivers to acute drought (CONAGUA 2012). Other Mexican climate analysts anticipate precipitation in the Rio Conchos to fall between 15%-21% toward the end of the 21st century compared to the historical average rainfall through 2009 (Martinez-Austria et al. 2018, 90).

Bureau of Reclamation's (USBR) first-ever invocation of water-rationing measures in the lower basin, including Mexico as provided by international agreement (USBR 2021b). Recent hydrological assessments portend long-term reductions in available precipitation through the end of the 21st century (Salehabadi et al. 2020).

In sum, the hydrological prospect for the border region in the 21st century is one of diminishing and more variable water availability in the face of a changing climate. These circumstances, coupled with the contemporary dynamic of urban development and greater competition for water resources among the border region's competing users, ensure that water will be at the forefront of the border region's natural resource concerns for the foreseeable future.

II. Water Consumption and Utilization in the Border Region

The U.S.-Mexico border region—whether defined as the states, counties, and *municipios* at the boundary; the zone of 100 kilometers north and south of the border denominated by the La Paz Agreement; or the river basins that span the international boundary—contains one of the fastest growing urbanized populations in North America (see Table 1). Population growth is certainly one of the principal drivers of changing water consumption patterns in the border region today, which, coupled with drought and greater hydrological uncertainties, affects the demand for water in the border region.

Table 1. Binational Population Data in Sister Cities along the Rio Grande (Population Growth in Sister Cities along the Texas-Mexico Boundary)

City/Municipio, State (Sister City Pairs)	1990 Population	2000 Population	1990-2000 Percent Increase	2010 Population	2000-2010 Percent Increase
El Paso, Texas (MSA)	591,610	679,622	14.9	800,647	17.8
Cd. Juárez, Chih.	798,499	1,217,818	53.0	1,332,131	9.4
Presidio, Texas	3,072	4,167	35.6	4,426	6.2
Ojinaga, Chih.	23,910	24,313	2.0	26,304	8.2
Del Rio, Texas	30,705	33,867	10.3	35,591	5.1
Cd. Acuna, Coahuila	56,336	110,388	96.0	136,755	23.9
Eagle Pass, Texas	20,651	22,413	8.5	26,248	17.1
Piedras Negras, Coahuila	98,185	127,898	30.0	152,806	19.5
Laredo, Texas (MSA)	133,239	193,117	44.9	250,304	29.6
Nuevo Laredo, Tamaulipas	219,468	310,277	41.0	384,033	23.8
McAllen-Edinburg-Mission, Texas	383,545	569,463	48.5	774,769	36.1
Reynosa, Tamaulipas	282,667	419,776	49.0	608,891	45.1
Brownsville-Harlingen-San Benito, Texas (MSA)	260,120	335,227	28.9	406,220	21.2
Matamoros, Tamaulipas	3003,293	416,428	37.0	489,193	17.5
All 7 Texas Cities	1,422,942	1,837,876	29.2	2,298,205	25.0
All 7 Mexican Cities	1,758,448	2,602,585	48.0	3,130,113	20.3
Total of Sister City Pairs	3,181,390	4,440,461	77.2	5,428,318	22.2
State of Texas (for comparing)	16,986,510	20,851,820	22.8	25,145,561	20.6

Source: Texas Commission on Environmental Quality (TCEQ)

Water utilization in the border region remains dominated by agricultural uses, including farming and ranching, that today account for nearly 80% of the region's overall water demand, followed by municipal and industrial uses and energy production, a pattern that prevails on both sides of the boundary (Frisvold et al. 2013, 219; Wilder et al. 2013, 369). Agricultural water use is irrigation-driven and heavily concentrated in four major agricultural zones along the boundary: two in the lower Colorado River zone—including the Imperial and Mexicali Valleys straddling the California-Baja California boundary and the Yuma and San Luis Valleys linking Arizona and Sonora—the third in the upper Rio Conchos region of Chihuahua, and the fourth in the lower Rio Grande region of South Texas, Nuevo Leon, and Tamaulipas. Agriculture in Baja California's Mexicali Valley consumes 84% of available water supply, exceeding Mexico's border state average of 84% for agricultural consumption (CONAGUA 2017, 84). Over 97% of the water supply in the adjacent Imperial Irrigation District (IID) is utilized for irrigated agriculture (IID 2021). Remote sensing analysis of border area water use between 1992 and 2011 shows that while U.S. border region agricultural uses have modestly contracted by 4% in this period, Mexican agricultural cropland expanded by 2.8% (18,000 square meters), with Chihuahua and Tamaulipas leading the expansion (Bohn et al. 2018). This data suggests that trade-related export production may have boosted Mexican agricultural water use in this period—which coincides with the implementation of the North American Free Trade Agreement (NAFTA). The contraction in U.S. border area water use is at least partially attributable to greater water scarcity and shifts to less water-intensive crops, particularly evident in the central Arizona corridor (Bohn et al. 2018).

Municipal and industrial water consumption accounts for 14%-16% of the border's water supply, with thermoelectric energy production accounting for 2% of the total water budget. Municipal and industrial uses in Mexican border states, according to data from Mexico's national water commission (CONAGUA), run slightly below these figures with municipal-industrial consumption pegged at 12%-14% and thermoelectric water use at 2% of overall water consumption (Wilder et al. 2013, 367). Municipal water consumption is expected to steadily grow throughout the border region with prodigious growth in certain areas. The Texas Water Development Board's 2022 State Water Plan, for example, projects a 23% statewide increase in municipal water demand over 2020 by 2040 (TWDB 2021, A-53). By 2070, municipal demand over 2020 is projected to grow by 63% (TWDB 2021, A-53). Municipal demand in Texas' lower Rio Grande region, however, is projected to more than double by 2040, increasing from 35,487 acre-feet annually to 117,113 acre-feet annually and reaching 296,472 acre-feet annually by 2070, an eightfold increase over 50 years (TWDB 2021, A-183). Municipal water demand in the United States is also expected to rise elsewhere along the border, though at a more modest pace. The San Diego Water Authority's 2020 planning forecast expects demand to grow from 537,000 acre-feet in 2020 to 655,000 acre-feet in 2040, a 22% increase. However, this is lower than earlier projections that put 2040 demand at 719,000, a 34% increase over 2020, with the net reduction attributable to demand-side conservation measures in the face of region-wide drought (Water News Network 2018; Elmer 2021b).

There is little doubt that hydrological trends portend growing pressure on the border region's water utilization, especially for an area that depends so heavily on the output of the principal transboundary rivers and a limited number of transboundary aquifers for its water supply. The long-term persistence of region-wide drought coupled with population growth and rising urban water demand places new demands on the treaty system that undergirds binational cooperation on shared water resources, generating recent adjustments and likely to require more in the future. It is also energizing efforts to strengthen investments in border sanitation and driving the adoption of technologies for utilizing and augmenting the surface and groundwater resources available to border water stakeholders. The new reality of sustained water scarcity is also directing needed attention to environmental protection and ecological restoration in the border region. As a leading expert on the hydrology and management of the Colorado River has observed, "The past century is no longer a guide to water management" (Udall as quoted in Wilder). Adjustments must be made.

III. International Management: The Treaty Rivers

The principal rivers on which the United States and Mexico rely in the border area are governed under the authority of the landmark binational agreement—Utilization of Waters of the Colorado and Tijuana Rivers and of the Rio Grande—signed in 1944 and ratified by the two countries in 1945. The Mexican-American Water Treaty, or the 1944 water treaty, as commonly known today, is one of the most remarkable agreements ever signed between the two countries and an agreement that has proven its worth for more than three-quarters of a century. Fully incorporated in the law of the major transboundary rivers of the two countries, it is the architectural foundation and centerpiece of the binational water regime.

The long-term success of the treaty system, however, belies the stresses to which the treaty has been subjected since the mid-1990s. The changing hydrology of both major treaty rivers, the Rio Grande and the Colorado, has compelled the two countries and stakeholders on each river to grapple with the greater variability of flows and sustained shortages to an unprecedented extent. Important adjustments have been made in recent binational agreements, or are presently being sought, that directly and indirectly target prolonged drought as a central element of adapting the treaty regime to meet contemporary needs. The border region's hydraulic future turns substantially on the ability and willingness of both countries to advance this agenda. Though drought presently affects all of the 1944 treaty's named rivers, the adaptive challenges are shaped by each river's hydrology, the conditions for shortage sharing set forth in the treaty for each river, and stakeholder politics affecting the rivers in each country.

The 1944 water treaty regime is distinctive in treating shortage sharing for each named river differently, establishing particular obligations for water allocation and management for the Rio Grande and the Colorado River. The tasks of monitoring treaty compliance and resolving disputes that arise under its terms are entrusted to the International Boundary and Water Commission (IBWC). This body is comprised of two national sections, each with diplomatic portfolio, whose joint agreements, recorded as "minutes," interpret and apply

the treaty to particular circumstances (Treaty 1944, art. 2). This is a key virtue of the treaty system. Within certain fixed parameters, the treaty allows for continuous adjustments in its application to each river as needed by the parties. The hitch in this system is that unless otherwise agreed by the parties, applications and solutions applicable to one river's needs are not formally transitive to another.

The Rio Grande

The evolution of responses to the long-lasting dispute over Mexico's water delivery obligations on the middle-lower stretch of the Rio Grande, a situation affected by persistent drought on Mexican tributaries to the river, exemplifies the flexibility of the treaty system as well as its shortfalls. The 1944 treaty conditions for the Rio Grande are set out in Articles 4-9, stipulating a Mexican obligation to provide the United States (Texas) with 350,000 acre-feet of water annually as measured over a five-year cycle, effectively 1.75 million acre-feet (maf) every five years. Article 4 also provides that in the instance Mexico should be unable—on account of extraordinary drought—to meet its five-year cycle obligation, it may ask forbearance of the United States, allowing it to fulfill its earlier cycle obligation in the subsequent cycle while also fulfilling its second cycle obligation. A further proviso stipulates that when each country's storage capacity in the two major storage dams on the Rio Grande are filled, all of Mexico's debts are cancelled and a new cycle shall commence (Treaty 1944, art. 4). This accounting system was reiterated and further specified in the IBWC's Minute 234 in 1969 (IBWC 1969). Taken as a set of treaty conditions, the Rio Grande obligations allow Mexico a certain flexibility in meetings its downstream treaty obligations.

Figure 1. Rio Grande River Basin and Tributaries

Source: IBWC

The Article 4 Mexico delivery and compliance system has been sorely tested over the past three decades. The onset of drought influencing Mexico's capacity to meet its treaty obligations set in as early as 1993, diminishing Mexico's water releases to the Rio Grande in the 1993-1997 cycle and provoking a water debt rollover request that the United States then granted. The seriousness of Mexico's shortage situation was underscored in 1995 when Mexico approached the United States for an emergency water loan from U.S. storage to meet the needs of its municipalities downstream of the Amistad Dam (IBWC 1995). But Mexico continued to fall arrears in the 1997-2002 delivery cycle, fulfilling its earlier obligation but missing its 2002 commitment. It invoked the treaty's "extraordinary drought" clause and again requested a water debt rollover, an unprecedented situation not anticipated by the treaty's negotiators, nor permitted by a strict reading of Minute 234 (Szekely 2003; IBWC 1969). Despite millions of dollars in damages to Texas growers, Texas' skepticism of Mexican scarcity claims, and intense political lobbying by Texas state

officials and legislators, the United States, in Minute 308, allowed the rollover on condition that Mexico undertake extensive conservation measures in the Rio Conchos basin, financed in part by U.S. assistance, with the expected water savings to be dedicated to treaty compliance (IBWC 2002). Minute 308 also, for the first time, framed the measures in terms of the need for sustainable development of the Rio Grande and suggested that the IBWC establish a basin-wide advisory body to improve its ability to anticipate shortages and pursue better means of treaty compliance (IBWC 2002). Mexico, however, continued arrears until heavy precipitation in 2005 filled all storage capacity in the international reservoirs, vacating its debt and initiating a new accounting cycle (IBWC 2005).

Backed by conservation improvements in the Rio Conchos drainage, Mexico remained compliant through the 2005-2010 cycle but then fell arrears again, ending that cycle behind and again requesting a rollover that was granted. It repaid that debt in 2016 but continued arrears to the point that, approaching the intensive summer growing season in 2020, it was more than a year's quota behind in deliveries (USIBWC 2021). That situation, as widely reported, led to serious stakeholder opposition to CONAGUA's decision to meet its U.S. obligations at the expense of Chihuahua growers in the upper Rio Conchos watershed (Associated Press 2020). Even so, CONAGUA hedged, allowing the *Comisión Internacional de Límites y Aguas* (CILA), the IBWC's Mexican section, to authorize the transfer of stored Mexican water in the treaty dams to the United States at the very last moment in October 2020, just two days before the 2015-2020 cycle closed (IBWC 2020a). The decision to transfer Mexico's depleted storage water to the United States placed Mexican downstream cities in jeopardy of water shortages during the winter of 2022. Fortunately, these cities managed to avoid serious 2022 deficits following the agreement.

The 2020 water transfer agreement, IBWC Minute 325, doubles down on the need for further Mexican water conservation on the tributaries feeding the Rio Grande and establishes two joint advisory bodies—one a technical assessment group, the other a policy analysis group—to advise the IBWC on methods of achieving a lasting mechanism to assure Mexican compliance with the 1944 treaty (IBWC 2020b). Mexico has agreed to employ a common technology for dynamic monitoring and modeling of hydraulic conditions. The IBWC is tasked with finding a lasting solution to the long-standing compliance dilemma by 2023.

When considering the trajectory of the Rio Grande water dispute, it is evident that while some progress has been made toward strengthening water conservation in Mexico and its capacity for treaty compliance, there is little in the way of binational acknowledgement of the problem of persistent drought and climate change in the several agreements struck by the IBWC since 2002. Neither is there any progress on defining the term "extraordinary drought" that has bedeviled treaty managers for years (Mumme, Ibanez, and Verdini 2018). That may be attributed to Texas stakeholders' resistance to the idea that Mexico's cyclic water obligation be adjusted on the basis of drought. Hence, the onus has been on Mexico to perform to the terms of the treaty, with some U.S. financial assistance supporting conservation projects provided through the North American Development Bank (NADB). The latest agreement, Minute 325, contains no reference to advancing sustainable

development, nor does it address environmental concerns on the river, though it does embrace the use of IBWC advisory bodies in search of a long-term solution (IBWC 2020b). The solutions seen so far on the Rio Grande conform to proprietary, sovereignty-assertive approaches to treaty compliance, even though both countries independently acknowledge the threat of basin-wide persistent drought and long-term climate change (TWDB 2021; CONAGUA 2021). Whether this approach will prove to be an adequate and sustainable response to drought conditions on the Rio Grande remains to be seen. For the moment, these recent solutions appear to be temporary and not lasting solutions to the Mexican water debt dispute.

The Colorado River

Drought-related treaty developments on the Colorado River, similar to what we see on the Rio Grande, are traceable to the late 1990s. Following a wet decade in the Colorado River basin during the 1980s, water managers were slow to react to the onset of drought conditions in much of the basin in the 1990s. By 2001, however, stakeholder concerns north of the boundary were sufficient to unite U.S. basin states behind a plan to gradually ratchet down water consumption to their assigned law-of-the-river quotas as determined by the 1922 Colorado River Compact and subsequent adjudications.[2] This new rule particularly affected California, which had long exceeded its official allotment, and set in motion rationing protocols for the state's major Colorado River stakeholders.[3] It also sparked a basin-wide dialogue on the need for additional conservation measures as drought persisted.

[2] The USBR's Interim Surplus Criteria Guidelines were adopted in 2001. See U.S. Department of the Interior 2001.
[3] The Quantification Settlement Agreement was adopted in 2003. See Water Education Foundation 2021.

Figure 2. The Colorado River Basin

Source: Carter, Mulligan, and Stern 2018

On a parallel track, environmental groups on both sides of the boundary worried about the stark loss of flows south of the Northerly International Boundary where Mexico takes most of its treaty water bound for the Mexicali Valley. As early as 1997, a binational meeting was staged to raise the alarm concerning the loss of natural habitats and the adverse impact on fauna and flora along the barren 60-mile riparian corridor below the Southerly International Boundary to the river's terminus at the Gulf of California (Pacific Institute 1998). Environmentalists—including the Sonoran Institute, Pronatura, Environmental Defense, and Defenders of Wildlife, among others—mounted a steady campaign to direct the governments' attention to the problem (Gerlak 2017). This campaign bore fruit in 2000 when the IBWC agreed to support a technical study of the ecological conditions in the lower reach of the Colorado River.

As drought concerns deepened in the Colorado River basin after 1999, there was initially little resort to the 1944 water treaty for a solution, with the singular exception of environmental concerns. That changed by 2004 when the state of California, with support from the U.S. Bureau of Reclamation, determined to proceed with a long-stalled project to line the vital All-American Canal (AAC) to recapture groundwater seeping to Mexico. The lining project, a part of the suite of conservation measures on which California was embarking, posed a serious threat to groundwater users in the Mexicali Valley, with an estimated annual loss of 80,000 acre-feet of water when the project was completed. An environmentally predicated lawsuit aimed at halting the project failed, blocked by California's successful effort in the U.S. Congress to pass a law asserting the 1944 treaty trumped any effort to use U.S. domestic environmental law to halt the project (Umoff 2008). An environmental lawsuit brought in 2003 by Defenders of Wildlife seeking to leverage U.S. environmental law to claim water for the Colorado River Delta had previously failed (U.S. District Court, D.C. 2003).

Despite these setbacks, environmentalists were able to gain access to water conservation talks among U.S. basin states in 2007, arguing that Mexico should be drawn into the ongoing discussions on shortage sharing (Verdini 2017). The U.S. Department of the Interior reached an agreement with Mexico, indirectly bringing them into the conservation talks on the river. The environmental discussion centered on an USBR pilot project to operate the mothballed Yuma Desalination Plant that would reclaim saline drainage from Arizona irrigation districts, as provided in a 1973 agreement, IBWC Minute 242 (IBWC 1973). Saline water previously discharged to a Mexican wetland, the *Cienega de Santa Clara*, would be reclaimed, leaving only highly concentrated brine-water for the *Cienega* and threatening the quality of its natural habitats. Environmentalists succeeded in averting that threat by purchasing and allocating needed water for the *Cienega* in collaboration with the governments. An IBWC agreement signed in April 2010, Minute 316, for the first time directed treaty water to serve an ecological function (IBWC 2010a).

Minute 316, ironically, came just more than a week prior to a major earthquake that struck the Mexicali Valley, decimating its irrigation infrastructure on April 10, 2010 (Klienfleder 2010). Mexico promptly approached the United States for the opportunity to store its treaty water in U.S. dams. Mexico's request came at the right time, as Lake Mead's storage was plummeting. The ensuing negotiations produced a remarkable set of linked agreements that set a framework for future negotiations. These new IBWC minutes acknowledged the problem of drought and the threat posed by climate change, provided for temporary storage of Mexican treaty water, reached a five-year agreement on binational shortage sharing on the Colorado River, and allocated a limited amount of water to ecological restoration below the Southerly International Boundary (IBWC 2010b; 2010c).

To appreciate this achievement, it is necessary to consider the 1944 water treaty's provisions for the Colorado River, a much simpler arrangement than seen on the Rio Grande. Under Article 10, Mexico is allocated 1.5 maf annually of Colorado River water, with the United States entitled to the remaining flow (Treaty 1944, art. 10). The accounting is annual. Should severe drought or damage to U.S. reclamation infrastructure upstream

occur, the two countries are to reduce their consumptive uses of treaty water in proportion (Treaty 1944, art. 10). It bears noting that, despite the ongoing drought, this treaty provision has never been formally invoked. In 2010, it was Mexico's irrigation infrastructure that was damaged, not the other way around.

Mexico's need to find storage for its treaty water thus coincided with the larger threat of drought affecting the entire Colorado River system and with binational talks that had been intermittently engaged since 2007. Minute 317 formally established a series of technical advisory groups addressing various needs on the river and brought Mexico, for the first time, into discussions on systems operations aimed at conserving water basin-wide (IBWC 2010b). This was an unprecedented level of binational cooperation on the river. With the United States agreeing to safeguard Mexico's annual allotment of treaty water as needed until Mexicali's irrigation system was rebuilt, Mexico joined the talks on basin-wide conservation measures, side-stepping the treaty's technical language in Article 10. Both Mexican and U.S. stakeholders accepted graduated reductions, calibrated to declining water levels at Lake Mead. That agreement, and a further concession supporting a one-time release of restoration water for the delta with small, sustained annual allocations for ecological maintenance, were written into the IBWC's Minute 319, signed in November 2012. Though set to expire in 2017, the agreement was revised and extended until 2026 in the IBWC's Minute 323 (IBWC 2017).

The resolutions of the Rio Grande and the Colorado River shortage problems should be treated as short-term solutions that require further refinement and development as the two countries labor to adapt to the longer-term challenge of a changing climate and all that portends. Additional agreements are projected for both rivers in the near term, in 2023 for the Rio Grande and 2026 for the Colorado River, intended to build on the achievements realized thus far. Those achievements are significant. On the Rio Grande, where tensions are sharpest, the need for more efficient water utilization has been embraced with both nations contributing to the improvement of Mexico's irrigation infrastructure on the river's tributaries. There has also been limited acknowledgement of the need to adopt a watershed perspective that takes some account of the sustainable development needs of the middle-lower reach of the watershed. However, this view, expressed in Minute 308 in 2002, and raised informally in the IBWC's 2005 Rio Grande Summit, has not been formally reinforced in subsequent agreements (IBWC 2002; 2005). The most recent accord, Minute 325, establishes binational task forces to address both the technical-engineering and policy dimensions of Mexico's capacity to satisfy treaty conditions, a significant concession of sovereignty on Mexico's part, enabling common fact-finding conducive to further cooperation in addressing the problem of shortage. Whether this leads to an iterative series of short-term agreements or a more long-term and sustainable solution remains to be seen. For the moment, however, the Rio Grande shortage problem is still defined—through the lens of Article 4 and Minute 234—as a Mexican problem requiring a largely Mexican solution, U.S. financial and technical assistance excepted.

The agreements on the Colorado River over the past decade go further toward a sustainable solution to drought-driven shortage than those seen on the Rio Grande. Both countries are sharing the shortage. Not only has the IBWC officially framed the shortage problem as a watershed management issue, but it has also formally acknowledged the threat of climate change. Both countries recognize the need for sustained binational cooperation in sharing the burden of scarcity and the water rationing that goes with it. The binational technical task forces that emerged and became enshrined in subsequent IBWC minutes have nurtured binational confidence in the factual basis of discussions guiding decisions on conservation and shortages. Moreover, both Minutes 319 and 323 commit the governments to recognizing environmental values on the river as legitimate objects of binational concern that entail not only working with government agencies, but also partnering with nongovernmental and private sector stakeholders on ecological restoration. Additionally, these agreements commit the parties to further cooperation in developing alternate water sources, ranging from undeveloped groundwater resources to wastewater reclamation, as well as groundwater and seawater desalination to augment existing freshwater supplies. This is a broad agenda that holds promise for lasting cooperation in managing the very real prospect of enduring shortages on the Colorado River.

In sum, though facing what are arguably the most serious hydrological threats since the 1944 treaty entered into force,[4] the United States and Mexico have used the treaty as the basis for adapting to challenges on each of the major rivers serving the border region. The prospect for a sustained shortage, however, is certainly a limiting factor in regional development that is already requiring adjustments in water utilization and driving disputes among stakeholders in different localities along the international boundary. These conflicts may well intensify in coming decades.

IV. Managing Groundwater, or Not

A reliance on groundwater figures into the water budgets of irrigation districts and municipalities along the border where many of the aquifers utilized are known to straddle the boundary. The actual number of transboundary aquifers abutting or spanning the boundary is still a matter of study, but at least 18 aquifers are known to exist coast to coast, and recent studies suggest that there are as many as 53 distinct subterranean water bodies along the Texas-Mexico border alone (Sanchez and Eckstein 2020). Despite not knowing the exact number of aquifers in the area, what *is* known is that numerous border communities and irrigators depend in whole or in part on pumped water.

As a matter of record, the negotiators of the 1944 water treaty deliberately set aside addressing groundwater in the treaty, seeing the matter as complicating the agreement on shared surface waters (Enriquez Coyro 1976, 913). Binational concern with groundwater persisted, however, and in 1973, as part of the settlement of a long-standing dispute over the salinity of the Colorado River, groundwater was addressed and effectively brought

[4] On the Rio Grande, the 1950-59 period is used as the baseline drought for Texas drought planning. At its height, this drought was more intense than annualized droughts since 2000.

under the mantel of the treaty (IBWC 1973). The IBWC's Minute 242, the salinity accord, regulates groundwater extraction on the San Luis Mesa east of the Colorado River and specifically suggests that the two countries negotiate a comprehensive agreement addressing transboundary aquifers (IBWC 1973). Nearly 50 years later this has yet to occur.

It would be inaccurate, however, to say no progress toward greater binational cooperation on groundwater management has been made. Growing concern with groundwater depletion and contamination in known transboundary aquifers—such as the Hueco Bolson and the Mesilla, Conejos-Medranos aquifers at El Paso-Cd. Juárez and the Santa Cruz River-Nogales Wash aquifer at Ambos Nogales—has led to informal discussions among sister city water managers and scientific exchanges that have drawn the interest of the IBWC. In the 1990s, the commission sponsored studies of several aquifers along the boundary as strictly technical exercises and published the data analysis on its website (IBWC 1998). Further progress came in the form of U.S. federal legislation—the Transboundary Aquifer Assessment Act of 2006 (TAAP)—in response to concerns of Arizona, New Mexico, and some Texas congressmen (TAAP 2006). That measure authorized studies of the Hueco and Mesilla Bolsons in the El Paso-Cd. Juárez-Sunland Park area adjacent to the Rio Grande, as well as studies of the San Pedro River and Santa Cruz River aquifers on the Arizona-Sonora boundary. The practical necessity of involving Mexican technical experts in these studies necessarily drew the IBWC into the picture, which reached an informal agreement among its principal engineers, supported by CONAGUA, to assist these studies (IBWC 2009). The principal engineers' agreement sets out important criteria for binational cooperation on aquifer research that is likely to guide future efforts of this type. While the TAAP's 10-year authority lapsed in 2016, the exercise arguably deepened cross-boundary engagement on groundwater issues in these regions. Even today, there continues to be some political support in the United States for renewing and extending the TAAP exercise.

Binational interest in groundwater is being boosted by other developments in border water management. Since 1983, both countries have agreed to cooperate in addressing pollution problems in the border area. Under the La Paz Agreement (Agreement 1983), the two countries are to share data on developments that could generate environmental harms in the neighboring country. The agreement is an important instrument enabling national environmental agencies charged with monitoring pollution in the border area to share their water quality concerns binationally, partnering with the IBWC on any diplomatic initiatives. Such water quality concerns have already surfaced regarding the Santa Cruz River aquifer as well as the Tijuana River aquifer.

Groundwater functions as an important hedge against drought and the scarcity of surface water along the boundary. Despite the real contention that arose over the project to line the All-American Canal, for example, groundwater development is contemplated in recent agreements on the Colorado River as an important supplemental resource that may assist the two countries in meeting water needs in the lower Colorado River region. Growing interest in desalination is contributing to this trend, since the Colorado River aquifer and others along the boundary are known to contain sizeable reservoirs of brackish

groundwater that are more economical to desalinate than seawater. New municipal desalination plants in El Paso and Brownsville have already taken advantage of this previously underutilized resource (El Paso Water 2021b).

Furthering binational agreement on transboundary groundwater, however, confronts the long-standing difficulty of adjusting Mexico's more centralized and federally dominated system of groundwater management with the state-centric, decentralized system of groundwater management that prevails north of the boundary. Different water property and groundwater capture regimes are found in each of the four U.S. border states, complicating any effort to negotiate a common or comprehensive agreement on groundwater with Mexico (Mumme 1988). This is why there is growing scholarly consensus that if the IBWC is to advance binational cooperation on groundwater, it may need to do so by means of an overarching framework agreement that allows for the development of future agreements to reflect the needs of stakeholders in particular localities in the border region (Megdal et al. 2021).

V. Municipal Potable Water and Sanitation

Dating as far back as the period leading to the 1944 treaty, the International Boundary Commission, IBWC's predecessor, was compelled to reckon with the water and sanitation needs of co-adjacent urban communities along the international boundary. Water quality is a chronic problem in the border area (GNEB 2012). Article 3 of the 1944 water treaty tasked the IBWC with finding solutions to transboundary sanitation problems (Treaty 1944). Binational sanitation was one of the key issues behind the adoption of the 1983 La Paz Agreement, which backstopped the IBWC's mandate to address all transboundary sanitation problems (Agreement 1983). Binational attention to the municipal water concerns of border cities deepened with NAFTA, spawning side agreements that created new agencies—the Border Environment Cooperation Commission (BECC) and the North American Development Bank (NADB)—driven, in part, by the recognition that border area environmental infrastructure was sorely inadequate in the face of rapid industrialization and urbanization (American Medical Association 1990; Audley 1993, 1997).

A major thrust of these new NAFTA-generated institutions, and the more programmatic and coordinated binational effort to implement the La Paz Agreement that came with them, was the development of needed water infrastructure along the border—specifically, better potable water systems to serve burgeoning populations and industries, and improvements to urban sanitation systems, whose deficiencies in a number of localities threatened neighboring cities and contaminated boundary rivers. The U.S. Environmental Protection Agency (EPA), as early as 1996, partnered with NADB to support investments in water infrastructure that pumped funding and technical assistance into specific urban water projects along the boundary. NADB's 2020 annual report affirms that, since its inception, 91 border communities have benefitted from the Border Environmental Infrastructure Project (BEIF) fund dedicated to this purpose (NADB 2021, 15). The same NADB report tallies a total of 118 projects in operation (11 potable water projects, 77

wastewater, and 30 potable water and wastewater treatment projects) with $1.9 billion[5] invested in these border area water projects of various types (NADB 2021, 15). BEIF funds enable communities to leverage other funding sources to support needed projects. Mexico has received a modestly greater share of this BEIF investment, which has also thrown a lifeline to small U.S. communities lacking the capacity to develop water treatment and sanitation facilities on their own. Binational investment in these works still falls short of even the more conservative estimates of border needs when NAFTA was being debated in the early 1990s (U.S. Trade Representative 1997) but remains vital for enabling cash-strapped border cities to meet essential water needs.

Transboundary sanitation problems persist, however, and continue to aggravate binational relations at various locations along the boundary, including chronic problems at San Diego-Tijuana, Mexicali-New River, Ambos Nogales, and along the Rio Grande. Binational engagement on Tijuana sewage spilling into the Tijuana River dates to the 1960s when an emergency interceptor linking Tijuana's wastewater system to San Diego's Pacific Ocean outfall at Point Loma was constructed (IBWC 1965). Improvements to Tijuana's sanitation system in the 1980s proved inadequate, and the continuing spillage led to an IBWC agreement to construct an international sewage treatment facility in the early 1990s, the South Bay International Wastewater Treatment Plant (SBIWTP). Financing and construction of the facility were delayed by prolonged wrangling over the question of secondary treatment compliance with the U.S. Clean Water Act, the proposed ocean outfall, and concerns regarding the protection of California's coastal communities. The SBIWTP's primary treatment module was operational in 1997, but its secondary treatment facility was not completed until 2010. Even then, problems associated with inadequate maintenance and periodic breakage of Tijuana's aging sewage collector systems and renegade flows from unconnected *colonias* persisted (Elmer and Calderón 2021; Elmer 2021a).

The highly contaminated New River, which crosses the boundary on the western reaches of Mexicali to flow another 70 miles northward to its terminus in the Salton Sea, is another pollution threat that has long eluded effective management. The New River is a man-made stream forged by century-old Colorado River spillages and sustained by agricultural runoff and municipal-industrial sewage that drains to the river south of the boundary. Its toxicity earned its reputation as the Western Love Canal. Successive IBWC discussions dating as far back as 1947 culminated in a 1980 agreement, Minute 264, by which the United States would assist Mexico with improvements to Mexicali's sanitation system. In return, Mexico agreed to improve water quality at the boundary, with the IBWC monitoring its commitments (IBWC 1980). Mexico's ability to comply with the agreement was hobbled by its economic crisis in the 1980s, while U.S. assistance was hampered by greater fiscal austerity during this decade. An agreement in 1987 resolved to invest $1.2 million (shared binationally in equal parts) in the construction of new Mexicali sanitation works, including a new sewage treatment plant (IBWC 1987). Completed in 1988, the new Mexican facilities were judged inadequate at their inception as Mexicali's population surged, with more than a third of its citizens unserved by the city's collector system. Further diplomacy in 1992

[5] All amounts in this paper are in USD.

produced a planned, two-stage project of improvements to the existing system and the development of a new sanitation system serving Mexicali's rapidly growing and underserved eastern district (IBWC 1992). The implementation of these projects was initially delayed by Mexico's inability to finance its costs but eventually got underway with support from NADB-BECC's BEIF project assistance funds. Public opposition in Mexicali to the new wastewater treatment facility's siting led to further delays, but the project was finally completed in 2007 (IBWC 2007).

Similar problems to those seen at San Diego-Tijuana and Mexicali stymied the sanitation solutions at Ambos Nogales where a small international wastewater treatment plant (NIWTP) was first constructed north of the boundary in 1951. Improved and expanded in 1967 to accommodate Nogales, Sonora's rapid growth, the plant's capacity was badly eclipsed just a decade later and also beset by the deterioration of Nogales, Sonora's collector system. Periodic floods washing across the boundary and an expansion of the *maquiladora* industry that pushed more toxics into Nogales, Sonora's collector system further heightened contamination risks (Fisher 1983). During the mid-1980s, even the NIWTP's treated effluent was found to be tainted. Plant expansion, authorized in 1988, also became entangled in disputes over funding but was eventually completed in 1992 (IBWC 1988). Designed to meet the binational communities' needs through 2010, the plant was nearly at capacity when it opened, and it continued to be embroiled in controversy over the proper application of U.S. clean water standards, which required a further NIWTP upgrade in 2001 (Sprouse 2004). The expanded and upgraded facility struggled to meet the needs of a combined population that in 2005 exceeded 200,000—with over 85% housed in Nogales, Sonora. A further overhaul supported by NADB-BECC funding was completed in 2009 (Wilder et al. 2012), but at the ribbon cutting it was still capacity-short, facing a service community of 252,000 in 2010 and needing repairs to the international collector system serving the plant. Catastrophic flooding, worsened by hardened barriers at the boundary, further exposed deficiencies and led to overloaded sewers and uncontrolled wastewater being flushed across the boundary (IBWC 2014; Norman 2019).

These problems along the land boundary are echoed at the Rio Grande where border cities historically drained their sewage to the river. The development of better sanitation systems and compliance with U.S. federal clear water regulations reduced U.S. contamination of the river by the 1980s, but sanitation improvements lagged in Mexico's Rio Grande cities. The problem of renegade sewage pollution of the river is most evident at Nuevo Laredo, where, at times, it is so severe that the IBWC and federal environmental agencies express concern that eutrophication of downstream Lake Falcon might result during periods of drought (RGISC 2019). In 1989, the IBWC worked out joint financing for an international wastewater treatment plant constructed in Nuevo Laredo that also required pretreatment of wastewater issuing from Nuevo Laredo's *maquiladoras* and strengthened the monitoring of pollutants in the river (IBWC 1989). The plant was finally completed in 1996. Even so, 25 years later, pipe breakages and new sewage flumes from informal settlements continue to contaminate the river, dumping as much as 6 million gallons a day into the Rio Grande and fouling the water for downstream communities (Vargas 2019; Dougherty 2018; Satija 2013).

These persistent binational sanitation problems spotlight the failure of municipal sanitation investments to keep pace with the urban expansion in many localities along boundary—both in terms of the development of new facilities and in the inadequate maintenance of existing infrastructure. Different national standards and priorities complicate and protract needed solutions, ensuring a chronic lag in meeting the needs of paired communities along the boundary. An ad-hoc, crisis-driven pattern of binational responses to sanitation problems prevails. The need for long-term binational planning for urban expansion and reliable infrastructure maintenance has long been recognized, contributing to the establishment of new institutions dedicated to project development along the border. Yet this project-by-project approach, while strengthening local capacity to address infrastructure needs, still operates as a band-aid for a problem-lagging system, bedeviled by a decentralized approach to appropriating funds and U.S. resistance to subsidizing Mexican projects.

These problems are well recognized and figure prominently in the water quality objectives of the latest iteration of the La Paz Agreement's binational border environment cooperation program, the Border 2025 Program (EPA 2021). Its six objectives include improving sanitation management in the Tijuana River watershed; building needed wastewater management infrastructure; strengthening operations and maintenance of existing jointly funded facilities; promoting water reclamation, reuse, and conservation; supporting projects that reduce deposition of trash and sediments to transboundary water bodies; and improving access to water quality data along the boundary (EPA 2021, 1-18). Notably, however, funding commitments supporting these projects remain unspecified in the plan.

The most recent effort to address border sanitation problems, a U.S. $300 million appropriation that came with the United States-Mexico-Canada Agreement (USMCA) in 2019, targets the chronic and worsening Tijuana sewage problem at San Diego (objective No. 1 of the Border 2025 Program), with little directed to other needy border cities. Multiple projects have been contemplated, including enhancements to the SBIWTP, construction of new facilities, and projects in Tijuana strengthening the city's wastewater treatment capacity (Fry 2021). As these plans are unfolding, knowledgeable critics are on record saying this is well short of what is needed, pegging the cost of longer-term solutions somewhere between $500 million and $2 billion (EPA 2020; Solis 2019; Elmer 2021a; Fry 2021). The ad-hoc approach to border sanitation clearly marches on.

VI. Wrestling for Water Along the Border

The border region's status as one of the most rapidly urbanizing regions of North America, when coupled with climate-driven uncertainty as to the reliability of traditional surface water supplies, is driving greater regional competition for water resources. Stakeholders from Tijuana to Brownsville are striving to shore up access to the water supplies on which they depend. This greater water insecurity is expressed in various ways—in stakeholder clashes over water-intensive development, in the quest for new water sources, and in the assertion of environmental claims to existing water resources as a defense against the steady erosion of ecological values in the border area. At the binational level, these conflicts

have already generated fresh approaches to managing border water, which—though in their infancy—hold promise for advancing binational cooperation on managing shared water resources.

The competition for water among stakeholders in the border region is evident in many localities today, expressed in binational conflicts over treaty interpretation (as seen above) and in domestic conflicts between municipalities and agricultural water users (as well as within the municipalities themselves) on both sides of the border. Water conservation plans on the Colorado River, for example, have not only required each nation to ration water, but as that decision ripples across the region, regional water providers, tribal authorities, and irrigation districts have been compelled to ratchet back allocations to water users. The Central Arizona Project (CAP), which ships Colorado River water to Phoenix and Tucson, has already squeezed irrigators—some of whom are relying more heavily on groundwater, while others are throwing in the towel after generations of farming in the region (Fonseca 2021). On the Rio Grande, the El Paso Water Authority has been steadily purchasing agricultural water rights to shore up its access to surface water (El Paso Water 2021c). The lower Rio Grande region has also seen urbanization steadily encroaching on agriculture, with agricultural lands shrinking by 28% in the 1996-2006 decade alone. This has resulted in water rights transfers and numerous irrigation management challenges (Bonaitti and Fipps 2018, 273, 278).

The challenge of water provision is particularly evident in the lower Colorado River region where the competition between agricultural and municipal water needs has generated both binational disputes and domestic quarrels. The binational AAC dispute (mentioned earlier) is directly tied to California's Quantification Settlement Agreement conservation plans that prodded the Imperial Irrigation District (IID) to surrender water resources to San Diego and amplified demands for lining the AAC (Umhoff 2008). Across the boundary, Mexicali's Irrigation District 14 has been steadily pressured to surrender more of its treaty-allocated water to Tijuana to accommodate the coastal city's rapid growth.

Water Conflict at Mexicali

This mounting pressure on the Mexicali Valley's finite, treaty-denominated water supply helps explain popular opposition to Baja California's approval of the Mexican beer-making giant Constellation Brands' 2015 application to build a giant brewery in Mexicali. Constellation Brands' Mexican subsidiary, *Compañía Cervecera de Baja California,* internationally known for its Modelo, Pacifico, and Corona labels, conceived the project as an export platform to amplify its already substantial brewing capacity at Ciudad Obregon, Sonora. It promoted the project as a major employment opportunity in Mexicali that would generate as many as 750-1000 manufacturing jobs and 4,000 indirect employments among suppliers servicing the operation (Cortez Lara 2020, 8). Construction of the nearly $2 billion facility began in 2017 over vociferous, sustained opposition centered on the plant's adverse impact on water availability in Irrigation District 14 and for the municipality of Mexicali.

As proposed, the brewery would rely principally on groundwater, tapping the already overused Mexicali aquifer (Cruz Aguirre 2017). The volume of water at issue, just over 16,000 acre-feet, for purposes of comparison, amounted to slightly over 1% of Mexico's 1.5 maf claim to the Colorado River. Yet this needs to be gauged against Tijuana's take of more than 70,000 acre-feet of Mexico's treaty allotment, the potential loss of up to 80,000 acre-feet of groundwater from the lining of the AAC, and the threat of drought-driven water losses to the Mexicali Valley arising from the IBWC's agreements in 2012 and 2017, scenarios well-known to Mexican irrigators. It also mattered that the brewery's water claim exceeded the water demands of all other industries in Mexicali combined (Agren, quoting Cortez Lara 2020). The prospect of further water losses to a foreign corporation, whose water manufactured into beer (a form of virtual water) would quench the thirst of U.S. consumers, appeared to many as highly inequitable, especially for Mexicali's rural farmers (Cortez Lara 2020).

The dispute, as it played out over five years, is the most successful instance of popular resistance to a single water allocation decision yet witnessed in the border region. Mass protests in Mexicali in 2017 attacked the rationale for the plant on grounds of water availability, social equity, and environmental damage. Critics pointed to the lack of transparency associated with the plant's initial proposal and approvals, the loss of water and employment to rural irrigators, and the adverse environmental impacts to Mexicali's residents from plant construction and operations. As construction proceeded, the opposition intensified, with violent clashes in January 2018 as demonstrators blocked access to the construction site, gaining national visibility for the movement (Villa Lugo 2018). Demands were voiced to Baja California's Electoral Institute for a popular referendum on the plant's future—demands that gained the attention of the newly installed Mexican president, Andrés Manual López Obrador, who convened a special commission to study the matter in March 2019 (Cortez Lara 2020). These measures provoked Constellation Brands to offer concessions on its possible water use and assurances of non-alienation of water rights to Mexicali's irrigators. But these assurances came too late. With opinion polls revealing a majority of Mexicali's residents—both urban and rural—opposed to the plant, López Obrador, risking the ire of foreign investors, authorized a popular vote on the question in March 2020. The referendum concluded with a strong 76% majority of participating voters rejecting the plant.[6] On this basis, the Mexican federal government, acting through CONAGUA, denied Constellation Brands its water permit, effectively mothballing the three-quarters completed, $1.4 billion facility (Agren 2020; El Financiero 2020).

Though one of the most visible conflicts over water allocation in recent years, the Constellation Brands imbroglio certainly has company, as seen in the September 2020 violent protests in Chihuahua's upper Rio Conchos over Mexico's Rio Grande treaty water payments. Other potential disputes are simmering along the boundary. One such problem is evident at Ambos Nogales where utilization of Nogales, Sonora's treated effluent at the

[6] The "*consulta popular*" was criticized for its organization and the small number of voters participating, just over 3% of the eligible voting pool. See Vera de la O 2020.

NIWTP now supports a nearly 30 mile stretch of riparian vegetation and wildlife habitats along the depleted Santa Cruz River north of the boundary (Wilder et al. 2012).

Bolstering Water Supplies

These actual and looming distributional and equity challenges arising from water insecurity are prodding border communities to embrace both greater water conservation and efforts to augment existing stock. Recent years have witnessed greater investment in water reclamation and reuse, groundwater extraction, and desalination as hedges against drought and an increasingly limited water future. Wastewater reclamation is now a major water augmentation strategy for the San Diego Water Authority and increasingly touted as a partial solution to Tijuana's overtaxed water supply that would also diminish the threat of transboundary sewage flows to the Tijuana River and San Diego (Elmer 2021b; Navarro-Chaparro, Rivera, and Sánchez 2016). Mexicali's recent sanitation improvements, aimed at alleviating harm to the New River, are also generating reclaimed water for Colorado River ecological restoration projects. U.S. cities like Tucson and El Paso have long deployed recycled waste for irrigating public parks and golf courses as well as downstream irrigation (El Paso Water 2021; Prokop 2021). Ciudad Juárez, across the boundary, historically directs its *aguas negras* to irrigate farms along the Rio Grande, but recent sanitation improvements harbor potential for municipal use (CONAGUA 2014).

Border cities are also turning to desalination and reverse osmosis water purification methods to supplement supplies. Brownsville, since 2004, relies on a brackish groundwater desalination facility to supplement its municipal water supply. Expanded in 2010, the Southmost Regional Water Authority desalination plan provides nearly 20% of the Brownsville Public Utility Board's potable water supply (City of Brownsville 2009, 303). El Paso Public Utility's Kay Bailey Hutchinson desalination plant is the world's largest inland desalination plant, taking advantage of the Hueco Bolson aquifers' vast stores of brackish groundwater (El Paso Water 2021; *El Paso Herald Post* 2020). Inaugurated in 2007, it has already seen expansion and is being expanded again, increasing its capacity from 27.5 to 33.5 million gallons per day when the latest enhancements are completed (*El Paso Herald Post* 2020). At the Ciudad Juárez suburb of Anapra, reverse osmosis is now used to purify drinking water. Farther west, desalination of brackish groundwater is considered a possible augmentation option in the most recent IBWC agreement, Minute 323, on the Colorado River. At Tijuana, where a small desalination plant at Rosarito has operated for 50 years, a large new desalination project was under development until cancelled in 2020 by the López Obrador administration (*The Baja California Post* 2020). Tijuana's turn to desalination mirrors development in north San Diego County where the largest seawater desalination plant in the Western Hemisphere was inaugurated in 2015 (City of Carlsbad 2021). Some U.S. border cities are also looking at the longer-term prospect of Mexican seawater desalination as a possible resource to supplement their municipal water supplies (Mumme et al. 2017).

VII. Conclusion: Scarcity, Innovation, and Challenges

The preceding vignettes highlight contemporary concerns for water security in the border region and point to the real potential for conflicts among border water stakeholders confronting shrinking surface water supplies and groundwater depletion. Yet the water shortage threat has also opened new avenues for binational cooperation. The reality of water shortages is driving greater cooperation on the treaty rivers and, on the Colorado River, has led to an unprecedented binational engagement in rationing scarce water resources. Concerns with water quality and stream management have drawn attention to the need to manage whole watersheds, with the IBWC adopting an unofficial watershed orientation that, since 2010, encourages greater attention to ecological protection, as recent agreements on the Colorado River and the Tijuana River illustrate. Transboundary Aquifer Assessment Act (TAAP) studies, mentioned above, marry quantity and quality concerns (at least at the fact-finding stage of binational groundwater cooperation), suggesting that any future agreements on groundwater will address more than just the zero-sum quantitative-allocative concerns.

Recent agreements on the Colorado and Tijuana Rivers also reveal the value of approaching broad-spectrum transboundary water concerns through the mechanism of framework agreements that set out the parameters for binational negotiations in specific issue-areas on the water agenda. Binational framework agreements brokered by the IBWC have the virtue of accommodating the many political, administrative, and economic differences seen along the boundary. They allow the tailoring of particular, region-specific solutions guided by a common interest in the stewardship of shared resources and a mutual embrace of the procedural requisites for establishing diplomatic confidence in the technical facts and opportunities for each country to pursue its national interests. This approach enables the two countries to set ambitious goals for cooperation on sharing transboundary resources while progressing cautiously and incrementally toward realizing those larger objectives.

As described earlier, much of the difficulty in advancing cooperative binational stewardship of transboundary water resources is a function of the well-recognized economic and political asymmetry between the United States and Mexico that manifests in different policy priorities and a sovereign wariness by each country of the others' capacities and intentions. Addressing and overcoming these asymmetries is essential for advancing the binational water agenda and shoring up water security in the border region. The greater openness, transparency, and technical-policy access evident in recent agreements of the Colorado River, the Rio Grande, and the Tijuana River represent significant strides toward strengthening the level of understanding and confidence each country has in the other's management of transboundary water resources. It is necessary to bridge the capacity gap in financing needed border water infrastructure and maintenance demands by recognizing that Mexico's urbanization and sanitation problems along the boundary are, in fact, shared problems affecting U.S. border populations. These problems, for the foreseeable future, require some negotiated level of U.S. assistance, adhering—at minimum—to the IBWC's historic posture of assigning project construction costs

according to the benefits received by each country and extending this principle to long-term project maintenance. Overcoming the historic problem of lagged, ad-hoc crisis responses to transboundary sanitation hazards means investing in binational, long-term planning on the basis of a realistic understanding of urbanization dynamics and dedicated financial support that is not captive to the annual vagaries of national budgetary politics in each country. Neither the IBWC, the two countries' federal environmental agencies, the NADB, nor municipal and state water agencies should be perpetually held hostage to these short-term budgetary authorities if reliable long-term border sanitation infrastructure planning is to occur and succeed. Both the IBWC and NADB require additional authority and resources in order to advance durable solutions to these transboundary and border region problems.

Fortunately, the present treaty regime for managing transboundary water relations—coupled with a nearly 40-year record of largely cooperative relations in addressing border region environmental problems, and aided by NAFTA-generated institutions tasked with directing financial resources to support environmental infrastructure needs in the border area—provides a flexible platform for meeting many of these challenges. The 1944 water treaty remains one of the real gems in the U.S.-Mexico relationship, sufficiently flexible to meet the challenge of water scarcity and adaptable for partnerships with other binational and domestic agencies to address transboundary sanitation needs. The challenge in the current moment is not our binational cooperative agreements, as such, but making them work.

Advancing Sustainable Water Solutions Along the Boundary: Policy Recommendations

The panorama of challenges for border water management charted in this paper are formidable, not least the current reality of diminished flows on the major treaty rivers. As this analysis and other studies of border water management—including those of the Good Neighbor Environmental Board (GNEB)—have previously argued (GNEB 2001, 2005, 2012, 2016), there is much that can and should be done to strengthen water management along and across the U.S.-Mexico boundary.

The following policy recommendations focus on the problem of binational cooperation on border water issues and address challenges related to the treaty system for surface water, the treaty's application to groundwater, the challenge of strengthening binational cooperation sanitation, and the challenge of addressing ecological conservation and environmental values related to water management along the boundary. Few of the following recommendations are novel—many of these ideas have been advanced, in whole or in part, by knowledgeable observers, the GNEB, the new Border 2025 Program, scholars and practitioners participating in the IBWC's 2005, 2012, and 2019 border water summits, and more recent scholarly settings such as the Permanent Fora on Binational Waters' (PFBW's) 2020 groundwater conference, as noted below.

A. Strengthening the Treaty Regime for Surface Water Management

- A.1. General Recommendations
  - The IBWC, with the approval of the foreign ministries, should consider adopting a formal guidance requiring future negotiations on shortage sharing and conservation on transboundary rivers to proceed with reference to the watershed in question. Note: This would simply formalize what the IBWC has been guardedly moving toward in recent binational agreements. See GNEB 2001, 2005, 2012.
  - The IBWC, with approval of the foreign ministries, should establish binational watershed advisory councils at the sub-basin level to assist the commission with strategic planning on the treaty rivers. See IBWC Minute 308; IBWC 2005, 2012; GNEB 2012.
  - The USIBWC and CILA should strengthen support for existing citizen advisory councils and consider conducting joint annual meetings for U.S. and Mexican councils in shared riparian systems.
  - The IBWC, with approval of the foreign ministries and with reference to recent agreements on the treaty rivers and to the La Paz Agreement, should strengthen its protocols for sharing data on the hydrology, quality, and management of the treaty rivers, with particular focus on the short-, medium-, and long-term impacts of climate change. See GNEB 2005, 2012, 2016.
  - The IBWC, with financial support from the federal governments and private sector, should host binational water summits every five years with an emphasis on how climate change is and is likely to impact transboundary water availability, quality, and management. The summit would also assess current practices and identify avenues for strengthening sustainable and reliable utilization of shared water resources. Note: The IBWC has hosted such meetings since 2005 but on an ad hoc basis.
  - The IBWC, with support of the foreign ministries, should adopt more specific criteria concerning the elements of meaningful consultation related to water-related projects undertaken in the border region that impact the other country. Note: Both Minute 242 and the La Paz Agreement require consultation on specific matters, but the diplomatic character and quality of the consultation are undefined.
  - The meaning of the still undefined treaty term “extraordinary drought” should be revisited for the purpose of achieving a better understanding of how to establish common drought parameters and planning for shortages on both the Rio Grande and the Colorado River. See IBWC 2005.
  - The U.S. Department of the Interior and the Department of Agriculture should strive to reach data-sharing agreements that harmonize and make compatible the analysis and collection of hydrological data for surface and groundwater in those basins and aquifers spanning the boundary. See IBWC 2005, 2012; GNEB 2012.

- A.2. The Rio Grande
  - The IBWC should fulfill its Minute 325 commitment to identify solutions facilitating Mexico's treaty compliance by December 2023.
  - Newly created binational technical hydrology and policy workgroups should be made enduring and standing, and other advisory groups should be adopted, taking those established for the Colorado River as a point of reference.
  - Minute 308's recommendation for establishing an international advisory council to assist the commission in efforts to advance the sustainable development and drought planning for the Rio Grande, including citizen and non-governmental organizations, should be considered. See IBWC 2002.
  - The IBWC and federal environmental agencies in both countries—including CONAGUA and NADB—should increase their investment in water conservation practices throughout the middle-lower Rio Grande river basin including the art. 4 named tributary sub-basins and the San Juan River basin.
  - The IBWC, on conclusion of its Minute 325 commitment to facilitate Mexican compliance with art. 4 conditions, should engage both countries on the problem of shortage sharing in response to climate change and achieve equitable and mutually beneficial management responses to sustained drought, including possible amendments to Minute 234.
  - The IBWC should sustain its monitoring of Rio Grande/Rio Bravo water quality, partnering with the Texas Clean Water Program, Mexico's Secretariat of Environment and Natural Resources (SEMARNAT), and CONAGUA. See IBWC 2005.

- A.3. The Colorado River
  - The IBWC should, as practicable, renew and sustain Minute 323's commitments to shortage sharing and environmental restoration when the current minute ends in 2026.
  - The IBWC's established work groups for the Colorado River should be maintained after 2026.
  - The IBWC's established task forces should continue to incorporate short-, medium-, and long-term climate projections in planning river operations.
  - The IBWC should partner with NADB, EPA, CONAGUA, and other applicable subnational entities, the private sector, and non-governmental organizations in developing alternative water sources, including desalination of brackish groundwater/seawater and water reclamation and reuse, to help meet the needs of Mexico's rapidly developing border cities in the lower Colorado region. See GNEB 2012.
  - The IBWC should continue to support emergency transfers of Mexico's Colorado River treaty water to Tijuana via U.S. infrastructure when asked to do so.
  - The IBWC should work with municipal governments and the private sector to facilitate binational commerce in desalinated water if and when such facilities—like the proposed Rosarito desalination plant—are developed. Local water needs should be prioritized over international sales.

- A.4. The Tijuana River
  - The IBWC should continue to support the work of local task forces established under Minute 320 authority and Border 2025 authority to address sedimentation, flooding, garbage deposition, pollution, and other hazards to the lower Tijuana River basin. See EPA 2021.
  - The IBWC should consider using Minute 320 authority to develop a binational task force focused on whole-of-the-watershed conservation, including a basin-wide strategy for greenbelt maintenance and ecological restoration in the Tijuana River riparian corridor.
  - The IBWC should strengthen its program for real-time monitoring of effluent discharge and flows to the Tijuana River and real-time monitoring of wastewater treatment plants serving communities along the Tijuana River corridor. See EPA 2021.
  - The IBWC and NADB should work with Tijuana municipal officials, the *Comisión Estatal de Servicios Públicos de Tijuana*, and CONAGUA to facilitate improvements to existing facilities and development of new sanitation infrastructure for Tijuana. See EPA 2021.
  - The IBWC should work with the EPA, SEMARNAT, CONAGUA, NADB, state and municipal sanitation authorities, the private sector, and citizen stakeholders to develop solutions to Tijuana's chronic sanitation capacity deficits and the hazards posed to downstream stakeholders—including the Tijuana River National Estuarine Research Reserve and south San Diego County municipalities. See EPA 2021.

<u>B. Strengthening the Treaty Regime for Groundwater Management</u>

- The TAAP transboundary groundwater assessment initiative should be renewed and, if possible, extended to include other aquifers along the U.S-Mexico boundary. See IBWC 2012.
- The Principal Engineers' procedural guidelines for TAAP binational cooperative research should be applied to any further assessment activities along the international boundary.
- The IBWC and NADB should explore opportunities to strengthen CONAGUA's capacity to monitor and assess groundwater withdrawals in transboundary aquifers. See PFBW Conference 2020 for a more general framing of this point.
- The IBWC, partnering with the U.S. Geological Survey, the U.S. Fish and Wildlife Service, CONAGUA, and other relevant agencies, should develop common, harmonized metrics and conduct binational studies for assessing climate effects on transboundary aquifers. See GNEB 2001, 2012; IBWC 2005.
- The IBWC, with support of the foreign ministries, should begin work on a framework agreement on transboundary aquifers, fulfilling the promise of IBWC Minute 242. Such a framework agreement should provide for the tailoring of aquifer-specific agreements that comport with U.S. state groundwater property and management rules and federal rules in Mexico, and take into account the needs of local stakeholders. Water quality and sustainable

use of groundwater should be prioritized for binational concern in any such framework agreement on transboundary aquifers.

C. Bolstering Transboundary Sanitation Cooperation

- Complementing the IBWC's Article 3 lead role in devising solutions to transboundary sanitation problems, the two countries should consider establishing a border region binational sanitation authority as a partner to the IBWC, NADB, and national environmental agencies for the purpose of long-term planning and mobilizing investment in infrastructure development and professional maintenance of wastewater conveyance and treatment systems. By virtually any measure, the current ad hoc, crisis-driven system for addressing transboundary sanitation problems is not adequate to meet the needs of border communities. Neither the IBWC's project-specific efforts to mobilize federal funds in each country, nor the NADB's EPA supported BEIF and Border Water Infrastructure Program, when joined with state and local resources, have proven adequate to keep pace with border area sanitation needs.
- The IBWC's historic practice of financing binational sanitation investments by allocating costs to each country according to the level of benefits received should be sustained in the interest of practicability and equity.
- NADB and the EPA should support and help finance training for operators of wastewater treatment, sanitation, and stormwater infrastructure facilities in Mexico's border cities. See GNEB 2012.
- Absent a new binational sanitation authority, U.S. federal agencies, including the USIBWC and NADB, should assist Mexico with investments in sanitation infrastructure and maintenance in its border sister cities. This would include provision of emergency power to prevent interruptions in sanitation services. See GNEB 2012.
- The IBWC and NADB should facilitate public participation in project development and conduct post-project assessments of the public participation process for each project undertaken. See IBWC 2012.

D. Advancing Environmental Stewardship on Transboundary Rivers and Aquifers

- The IBWC should sustain and strengthen its treaty-grounded Minute 323 commitments to ecological restoration in the lower Colorado River region.
- The IBWC, following recent practice on the Colorado River, should add environmental workgroups to its advisory teams for the Rio Grande and Tijuana River.
- The IBWC, partnering with NADB, EPA, SEMARNAT, and state environmental agencies, should identify and maintain an inventory of needed ecological restoration projects on the treaty rivers and other transboundary streams crossing the international boundary. See IBWC 2005.
- The IBWC should consider reaching a framework agreement/minute on ecological conservation on transboundary rivers and streams that broadens its limited treaty authority in this issue-area. See IBWC 2005.

- The IBWC, in concert with other federal agencies in both countries, should pay special attention to protecting and preserving riparian wetlands on the treaty rivers and other transboundary rivers and streams. See IBWC 2005.
- The IBWC should continue to partner with federal natural resource agencies in controlling invasive species on the treaty rivers and other transboundary rivers and streams. See IBWC 2005.
- The EPA and SEMARNAT should better use the La Paz Agreement annex procedure to reach agreements that strengthen environmental cooperation related to water resources in the border region.
- The IBWC should explore negotiating a long-term lease agreement for ecological utilization of Mexico's treated wastewater released to the Santa Cruz River.

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