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Minute 242 and beyond: Challenges and Opportunities for Managing Transboundary Groundwater on the Mexico-U.S. Border

Stephen P. Mumme

STEPHEN P. MUMME*

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ABSTRACT

Sharing transboundary groundwater remains one of the most pressing and difficult issues in Mexico–U.S. relations despite Minute 242 of the International Boundary and Water Commission, signed in 1973, which acknowledges the need to develop a comprehensive groundwater agreement for the border region. This essay profiles the numerous groundwater disputes along the border and analyzes current institutional and political opportunities for resolving them. Common pool resources theory and recent work in prescriptive international law are utilized to identify opportunities for greater binational cooperation. Given the history and complexity of the transboundary water dispute, this paper concludes with four recommendations: first, that the two countries continue to strengthen and share technical knowledge; second, that they strive for incremental solutions; third, that they prioritize settling their most tractable disagreements; and finally, that they support international efforts to further develop prescriptive international legal principles as articulated in the recent Convention on the Law of the Non-navigational Uses of International Watercourses and the Bellagio Draft Treaty on transboundary groundwater.

INTRODUCTION

On the list of enduring controversies in Mexico–U.S. relations, few disputes have proven as intractable as the allocation and management of transboundary groundwater. Over a quarter century has passed since the two countries signed the landmark agreement, Minute 242, which expresses their joint commitment towards resolving this issue.[1] Today the

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* Stephen P. Mumme (Ph.D. Arizona 1982) is Professor of Political Science at Colorado State University, Fort Collins, Colorado. He may be contacted by phone (970-491-7428) and email (smumme@lamar.colostate.edu).

1. *See* Int'l Boundary & Water Comm'n, *Minute No. 242: Permanent and Definitive Solution to the International Problem of the Salinity of the Colorado River*, 15 NAT. RESOURCES J. 2, 2-9 (1975) [hereinafter *Minute 242*].

goal of Minute 242 remains unfulfilled. Despite a train of intermittent discussions and localized problems, little progress has been made since 1973. The inevitable result is the current unsustainable yet escalating race amongst parties on both sides of the border to drain these vital resources. This state of affairs defies the sustainable management of these joint resources, serves as a source of real friction in Mexico–U.S. relations, and deserves the concerted attention of those gathered here today.

Before proceeding any further I wish to pay homage to an individual who, more than any other, dedicated his genius and will to the resolution of this dispute, the late professor Albert E. Utton. Over a career of 30 years, Al Utton strove to harness the best thinking in international and domestic law to solve the transboundary groundwater dispute. With a dignity and grace that few can match he prodded government, academe, and the private sector to address this issue with the persuasive belief that it could be solved amicably, cooperatively, and bilaterally. When and if the letter and spirit of Minute 242 is eventually realized it will be in no small measure the result of Utton's vision and enduring faith in the triumph of cooperative solutions to transboundary disputes over natural resources.

From his vantage point as editor of the *Natural Resources Journal*, Al Utton understood that Minute 242 was one of those important moments when two nations accomplish more than they intended.[2] Minute 242 and its groundwater provisions are ambitious. Not only does it commit Mexico and the United States to developing a "comprehensive" transboundary solution to the extant and emerging groundwater disputes along the border, it provides for the development of a cooperative management solution to the divisive Colorado River salinity dispute, and contains a site-specific, practical, and cooperative solution to the groundwater war then in progress at San Luis.[3] Additionally, Minute 242 arguably brought groundwater within the orbit of the 1944 Water Treaty,[4] which provides a principled basis for dialogue and joint action on the somewhat taboo issue of equitable apportionment.

Certainly, numerous obstacles to effective dispute resolution and cooperative management of transboundary groundwater remain. Most of these barriers are based on the economics and politics of scarce resources.

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2. *See* Albert E. Utton, *Mexican International Waters*, *in* 5 WATERS AND WATER RIGHTS 126, 126-27 (Robert E. Beck ed., 1991).

3. For a discussion of the San Luis groundwater war see Michael D. Bradley & Kenneth J. DeCook, *Groundwater Occurrence and Utilization in the Arizona-Sonora Border Region*, 18 NAT. RESOURCES J. 29, 36-38 (1978).

4. *See* Albert E. Utton, *The Transfer of Water from an International Border Region: A Tale of Six Cities and the All-American Canal*, 16 N.C. J. INT'L L. & COM. REG. 477, 489-90 (1991); C.R. Bath, *Transboundary Resource Management Models: Applicability to the El Paso–Ciudad Juárez Region for Groundwater Management*, 10 TRANSBOUNDARY RESOURCES REP. 1, 1-3 (1996).

Along the border, demographic and economic pressures on water resources have steadily mounted in the past quarter-century. Within both countries, accelerated rural to urban transfer has led to rising urban water demand and the inevitable press for more efficient water uses. This greater demand has raised market water value and caused rural and agricultural interests to become ever more protective of their water rights and stocks. Contiguous border-adjacent cities, such as El Paso, Texas, and Ciudad Juárez, Chihuahua, have scrambled to augment and secure their water supplies. Along with these pressures, differing political jurisdictions and variations in sub-national water management regimes complicate the search for bilateral consensus on groundwater management.

On the other hand, not all of the multiple forces and interests in the border region are inimical to the deepening of binational cooperation in managing scarce groundwater resources. In fact, the past quarter century has seen great institutional development and a stated, if still unrealized, commitment to achieving sustainable development in the border area. The emergence of new institutions and the evolution of old ones has fostered a greater awareness of Mexico–U.S. interdependence and has shed light on the necessity of broadening and strengthening cooperative approaches to managing transboundary groundwater. At the international level, progress is being made towards a universal understanding of the legal requisites necessary for managing international drainage basins and a consensus is evolving on the appropriate norms and customary laws that ought to apply in allocating and administering these resources. The Bellagio Draft Treaty on International Groundwater Management, authored by professors Robert Hayton and Albert E. Utton, is a fine example of this advancement.[5] Additionally, though still inadequate, the quality of geophysical information on groundwater presence and availability is better than ever before. Since 1973, numerous studies and reports detailing the availability of groundwater stocks have been generated, and this information is being used to create an integrated picture of groundwater location, availability, and quality. Moreover, since 1973, the public has grown increasingly appreciative of the importance of groundwater in the border region, its economic value, its place in the hydrologic cycle, and the need for managing those resources in a sustainable way.

In sum, while it is possible to view the obstacles as greater than ever, the past quarter century has brought progress in other areas germane to the strengthening of bilateral cooperation in husbanding transboundary groundwater. Understanding the possibilities for moving the two countries ahead on this issue is an essential precondition for breaking through the

5. ROBERT HAYTON & ALBERT E. UTTON, TRANSBOUNDARY GROUNDWATERS: THE BELLAGIO DRAFT TREATY (1989).

current diplomatic impasse. This paper provides an overview of these possibilities. In order to gain a better understanding of the current situation, section I profiles the various transboundary groundwater basins on the border and catalogs location, utilization, and management practices. These basins, and their attendant characteristics of use, will need to be carefully considered in any effort to advance binational management of transboundary groundwater. Section II turns to an examination of the institutional and political opportunities for discussing and developing this management plan. Specifically, general theory on international cooperation in transboundary resource disputes and recent developments in international law are applied to the practical realities of the current situation to identify potential opportunities for further cooperation. Section III examines the institutional developments that may help facilitate a resolution. Finally, section IV consists of observations and suggestions for further progress on this pressing and complex issue.

I. CURRENT AND POTENTIAL GROUNDWATER DISPUTES ON THE MEXICO–U.S. BORDER: AN OVERVIEW

The complexity of the transboundary groundwater dispute is particularly evident when considered on a border-wide basis. The general literature on groundwater conditions along the Mexico–U.S. border supports the proposition that there are at least 18 different problem areas scattered across eight geographic zones.[6] Considering the distinctive nature of the disputes currently in play along the border, the divisiveness of the interests involved, and the lack of awareness of additional problem areas, this is arguably a conservative estimate. It is necessary to consider this wide range of problems because they both influence, and will be influenced by, any attempt to create a more cooperative approach towards managing transboundary groundwater.

This broad range of current problems and potential controversies is listed below in table form. Table 1 orders these problem areas according to location, from west to east, and contains a list of their salient characteristics. Table 2 classifies these problem areas according to their dominant issue-type (allocation or water quality) and their demographic setting (rural or urban).

This inventory of transboundary groundwater basins reveals that there is an elaborate combination of actual and potential conflict situations

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6. *See generally* Stephen P. Mumme, Groundwater Management on the Mexico–United States Border (Dec. 1996) (unpublished report submitted to the Commission on Environmental Cooperation, Montreal, Quebec, Canada, as part of the Mexico-United States-Canada Transboundary Inland Water Project, on file with author).

along the border. A majority of these disputes are located along the land boundary, while a lesser number are located along the Rio Grande limitrophe, (and even fewer if we exclude problems in the Hueco and Mesilla Bolsons). Several upstream-downstream situations also exist, with Mexico often in the downstream position along the land boundary. Yet Mexico is best described as the upstream partner in a number of basin sites. Also, a majority of basins are demographically complex, in that they host both urban demographic water demands and those more traditionally associated with rural areas. Further, as we look at patterns of utilization and associated problems, the majority of these are not simply matters of quantity but also quality and security of the water supply.

Tables 1 and 2 also reveal certain deficiencies in the current management situation, including the fact that the data on groundwater presence and utilization is still incomplete. In large areas of the border region very little is known about the stock and flow of groundwater resources. Additionally, these tables support the conclusion that groundwater management practices are poorly institutionalized and generally deficient for purposes of achieving a sustainable yield of the resource. Most groundwater withdrawals are unregulated and, with a few notable exceptions, are not undertaken pursuant to a regime of conjunctive management of surface and subterranean resources. Additionally, it appears as if the quantity and quality of groundwater stocks are better monitored and conjunctive management approaches are more likely to be found in urban areas, where the presence of large concentrated populations has compelled the two governments to pay more attention to the limited availability of water. In the aggregate, this complex situation, including the lack of complete data and the inadequate management practices, makes a compelling case for greater binational cooperation in managing this resource.

II. INSTITUTIONAL BASES FOR COOPERATION IN MANAGING TRANSBOUNDARY GROUNDWATER ON THE MEXICO–U.S. BORDER: THEORY AND PRACTICE

To assess the prospects for moving ahead in transboundary groundwater management, it is useful to consider this problem in the context of applicable institutional theory. Today a significant body of literature is dedicated to analyzing potential institutional bases for cooperative or joint management of common resources and related dispute resolution. One strand of this discussion, founded on international river disputes, identifies a variety of incentives for cooperation in managing shared river basins or common water bodies. According to LeMarquand, the potential for cooperation is greatest where the resource can be converted to a sustainable public good, where the resource takes the form

of a common pool, where there are integrated development possibilities, and where no party enjoys asymmetrical control over the resource in question.[7] While transboundary groundwater disputes are not, in the strictest sense, hydrologically analogous to international river disputes, sufficient similarities warrant a comparison.

Analyzed within this framework, the potential for developing a cooperative transboundary groundwater management scheme is neither great nor poor. First, since groundwater is appropriated through a system of private property rights on both sides of the border, it is doubtful that it could easily be converted into a pure public good. This system enables rights-holders to deny others access to the resource and creates a potential conflict between rights-holders and claimants to those same rights. In this sense, groundwater is treated as a divisible resource, the antithesis of a pure public good. Never the less, transboundary groundwater is a classic common pool resource at both domestic and international levels.[8] Additionally, at various locations along the border, the possibility for integrated development exists. Unfortunately, however, control is asymmetrically centered in the United States, adding to the burden of difficulty in achieving any solution to this binational problem.

Pursuing this line of inquiry further, the rich literature on managing common pool resources identifies a number of other conditions that are generally propitious for cooperative management. Elinor Ostrom and her colleagues at the University of Indiana have identified four basic characteristics that help facilitate cooperative management solutions for common pool resource disputes: first, that the resource is not depleted beyond recovery; second, that resource conditions can be reliably determined; third, that the resource is sufficiently predictable; and fourth, that resource distribution is localized such that it can be evaluated and regulated.[9] These characteristics can be seen to a certain degree within the Mexico–U.S. transboundary groundwater dispute. However, the varying and numerous appropriation rules at the national and sub-national level, which are premised on notions of divisiblity and subtractability, complicate the adoption of cooperative management solutions. Additionally, asymmetrical control over groundwater resources on the binational level creates a strong disincentive against cooperation.

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7. *See* DAVID G. LEMARQUAND, INTERNATIONAL RIVERS: THE POLITICS OF COOPERATION 7-11 (1977).

8. A common pool dilemma exists where two or more parties share a valuable common resource in the absence of clearly specified rules or regulations concerning its use, thereby enhancing each party's incentives to appropriate the resource to the point of degradation or exhaustion, eventually reducing its utility to all interested parties.

9. *See* ELINOR OSTROM, GOVERNING THE COMMONS 31-40 (1990); J. Burger & M. Gochfeld, *The Tragedy of the Commons 30 Years Later*, 40 ENV'T 8 (1998).

The first predicament represents the classic problem associated with common pool resources, in that the resource is divided by two different national resource regimes. Ostrom calls these "constitutional" regimes that define property rights and access to the resource.[10] These regimes, being only loosely defined on both sides of the border, contribute to user uncertainty and, in turn, strengthen the incentives to deplete the resource. This problem of constitutional uncertainty is amplified by the asymmetry of control, where one nationally situated community of users is positioned to deny another access to resource benefits. In this situation, in the absence of adequate constitutional authority applicable to the commons, uncertainty exists on a variety of levels (1) as to whether the resource does, indeed, constitute a commons; (2) as to the stock and flow of the common resource; (3) as to the possible joint benefits of treating and managing the resource as a commons; and (4) as to the nature of the principles or rules that ought to govern such a hypothetical commons. In this case, common pool theorists argue that it is rational for the superior party to continue to regard the resource as its own and use it according to such conventional practices as exist in that national and sub-national constitutional setting.[11]

What factors, if any, might be conducive to extricating disputing parties from this predicament and persuading them to move towards a cooperative solution? The literature on common pool resource management suggests utilizing the following variables as incentives to promote greater cooperation: increasing the quality and accessibility of information for the community of users; publicizing the mutual benefits and/or mutual harms arising from current, or status-quo rules and practices by comparison to proposed rules and practices; developing a common frame of reference for the design of rules and regulations at the constitutional and collective action levels; and embracing the opportunity for incremental change.[12]

The dissemination of accurate knowledge concerning the character, diffusion, availability, and value of the resource is critical to developing an understanding of the need to redefine the rules of allocation and management, and to reaching an agreement on the values at stake on the individual and institutional levels. The perception of mutual benefits that improve the status quo and/or prevent mutual harms constitute essential incentives to the search for alternative and preferable rules and regulations. The convergence of different users around common frames of reference helps to establish mutual trust and direct the parties toward mutually

10. *See* OSTROM, *supra* note 9, at 43-52.
11. *See* LEMARQUAND, *supra* note 7, at 10-11.
12. *See* OSTROM, *supra* note 9, at 139-42, 210-14.

acceptable rules and regulations to manage the resource. The likelihood that competing parties will unite around a common set of understandings and adopt mutually acceptable rules is, in turn, affected by the magnitude of the differences amongst the competing parties. If the changes to be made are profound, rather than incremental, the stakes are higher, and this makes reaching an agreement more difficult.

To what extent are these conditions present along the border? Spurred by NAFTA based binational initiatives such as Border XXI,[13] the two countries are collaborating on the development of shared groundwater databases in a number of basins. Other binational initiatives, such as the Texas-based Transboundary Resources Inventory Project (TRIP),[14] and the joint project by the U.S. Department of Interior and Mexico's environmental ministry (SEMARNAP) to develop Geographic Information Systems (GIS),[15] have contributed to extant knowledge about the hydrological eco-region and cross-basin aspects of the border region.[16] As this common database is critical to understanding the possibilities for sustainable development along the border, further progress in these areas is essential in order to have a sufficient knowledge and technical basis for binational discussion and negotiation of transboundary groundwater disputes.

Accurately characterizing the perception of mutual benefits and harms associated with current groundwater management along the border is risky indeed, and well beyond the scope of this essay. What can be said with relative confidence is that the current situation is shaped by national asymmetry regarding the extraction and control over these resources. It may also be safely said that there is a considerable dissatisfaction amongst non-traditional stakeholders—such as environmental organizations, governmental natural resources managers, and the interested public—concerning the adequacy of current practices in meeting the goals associated with sustainable development.[17] Furthermore, binational

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13. *See* ENVTL. PROTECTION AGENCY, PUB. NO. EPA 160-R-96-003, U.S.-MEXICO BORDER XXI PROGRAM FRAMEWORK DOCUMENT (1996).

14. This project was recently transferred from the Texas General Land Office to the Texas Natural Resource Information System: Borderland Information Center (512) 463-8337.

15. *See* ENVTL. PROTECTION AGENCY, PUB. NO. EPA, 160-R-98-001, U.S.-MEXICO BORDER XXI PROGRAM, 1997-1998 IMPLEMENTATION PLANS AND 1996 ACCOMPLISHMENTS REPORT (1997) [hereinafter BORDER XXI PROGRAM 1997-1998 IMPLEMENTATION PLANS].

16. For a list of such projects see ENVTL. PROTECTION AGENCY, PUB. NO. EPA 160-R-98-003, U.S.-MEXICO BORDER XXI 1998 IMPLEMENTATION PLANS (1998).

17. For a comprehensive look at public views on environmental protection on the border see ENVTL. PROTECTION AGENCY, PUB. NO. EPA 160-R-96-001, U.S.-MEXICO BORDER XXI PROGRAM, SUMMARY OF DOMESTIC MEETINGS (1996). For a focused look at a coalition of environmentalists' views on U.S.-Mexican water management along the Rio Grande River, see the Rio Grande/Rio Bravo Basin Coalition website at <http://www.rioweb.org/>.

discussion of these issues has been largely confined to the work of the International Boundary and Water Commission (IBWC). This may indicate a very low level of trust associated with the high stakes of border groundwater allocation. Thus, viewed with a wide lens, it is fair to characterize the current situation as one where significant stakeholders on both sides of the border, though not all, perceive significant harm in the perpetuation of present practices.

Further complicating the resolution of the current groundwater situation is the absence of a common frame of reference for the design of management rules concerning the appropriation and use of the resource. The existence of two national groundwater management regimes, Mexico's being centralized and directed by federal authorities, and the United States' regime being decentralized and managed under varying state control may significantly impede the achievement of any real comprehensive solution to border groundwater management. It is not as serious an obstacle to the achievement of basin-by-basin, or case-by-case negotiations, since these approaches allow a greater degree of flexibility in tailoring solutions to the varying forms of institutional practices now in place. However, in the absence of significant binational progress since Minute 242 was adopted, the border-wide groundwater situation may be generally characterized as a high stakes problem, requiring immediate non-incremental changes to current practices. Viewed from a border-wide perspective, then, the institutional barriers to resolving current groundwater disputes are high, despite apparent progress in the development of databases and data-sharing across the border.

A worst case scenario in light of these criteria is found in the dispute over the All-American Canal (AAC).[18] Here, a decision by the U.S. Bureau of Reclamation to line the AAC with concrete to prevent seepage has provoked an open dispute over transboundary groundwater along the border. The Bureau's decision has the support of most water rights holders in the Imperial Valley and Southern California region including key institutional players such as the Imperial Irrigation District, Coachella Irrigation District, Metropolitan Water District of Southern California, and the San Diego County Water Authority. These agencies downplay the measure as merely a practical water conservation practice when, in fact, it will substantially augment regional supply in one of the most competitive

18. The literature on the All-American Canal dispute is fairly extensive. In addition to press reports, interested readers should consult the following sources: Douglas L. Hayes, *The All-American Canal Lining Project: A Catalyst for Rational and Comprehensive Groundwater Management on the United States–Mexico Border*, 31 NAT. RESOURCES J. 803 (1991); Utton, *supra* note 4; T. Waller, *Southern California Water Politics and U.S.–Mexican Relations: Lining the All-American Canal*, 7 J. BORDERLANDS STUD. 1 (1992); U.S. BUREAU OF RECLAMATION, DRAFT ENVIRONMENTAL IMPACT REPORT: ALL-AMERICAN CANAL LINING REPORT (1991).

water demand situations in the country.[19] The binational controversy arises because the AAC, which runs very close and parallel to the international boundary, is a major source of groundwater recharge to the Mexicali Valley.[20] Consequently, the lining project will undoubtedly diminish inflows to the Mexican side, reducing the net stock of groundwater available for irrigated agriculture and other uses. Due to this, Mexico has informally charged that the United States is unilaterally retaining groundwater supplies in violation of international law and practice. The United States, in turn, argues that under the terms of the 1944 Water Treaty it is entitled to the water saved by lining the canal.[21]

According to common pool resource theory, the AAC represents a classic impasse with little prospect of solution on its own terms. First, the quality of information available to the binational set of affected users is highly unequal. While the two countries have followed the terms of Minute 242 in informing each other of pending developments on their respective sides of the border, they are both reluctant to share basic hydrographic information or consider the impact of development in basin-wide environmental terms.[22] Second, the two nations differ in both their social construction of the AAC lining and in their costs/benefits analysis of this project. U.S. interests define the project as a purely internal one, involving the just distribution of national surface waters.[23] In contrast, Mexico views the project as an unjust taking of groundwater from a transboundary aquifer that it has substantially relied on for decades.[24] Additionally, there are several impediments to developing a common frame of reference that would enable both nations to adopt common rules for allocation and management of transboundary groundwater on both the national (federal and state) and international level. At present, groundwater management

19. *See generally* U.S. BUREAU OF RECLAMATION, DRAFT ENVIRONMENTAL IMPACT REPORT: ALL-AMERICAN CANAL LINING REPORT (1991); ENVTL. PROTECTION AGENCY, PUB. NO. EPA 160-R-96-001, U.S./MEXICO BORDER XXI PROGRAM, SUMMARY OF DOMESTIC MEETINGS (1996).

20. *See id.*

21. *See* Hayes, *supra* note 18, at 2-3; Waller, *supra* note 18, at 18-19. The best presentation of the legal arguments that could be advanced by Mexico and the United States in this case is found in Utton, *supra* note 4, at 477-95.

22. *See generally* L. Jones et al., *Assessing Transboundary Environmental Impacts on the U.S.–Mexican and U.S.–Canadian Borders*, 12 J. BORDERLANDS STUD. 73 (1997).

23. *See* Utton, *supra* note 4, at 479.

24. The concern for water quality is minimal and has thus far not entered into the framing of the issue though important water quality issues related to groundwater are found within the basin.

practices in northern Mexico and California vary considerably.[25] Apart from a distant similarity in favoring prior appropriation and the general provisions of Minute 242, which requires prior notification in the case of pending national development of groundwater along the border, there is little common ground upon which to frame a cooperative approach to managing this resource. However, the evolving work of the international legal community and the deepening of U.S. and Mexican joint commitments to certain regional and international environmental practices may constitute a ray of hope.[26] Finally, both the unilateral nature of the U.S. action to withdraw the resource by lining the AAC and the magnitude of this withdrawal constitute a significant, not an incremental, alteration in the status quo that aggravates tensions and complicates the search for a joint solution.

In contrast, a very different set of circumstances confronts water managers and publics in the Hueco Bolson straddling the Texas-Chihuahua border. Here, virtually all water pumped from the aquifer is used to support the urban domestic and industrial demand of the contiguous cities of El Paso, Texas, and Ciudad Juárez, Chihuahua, or as locals call it, EPJAZ.[27] One of the defining features of this basin is that a great many people exclusively depend on this resource and demand is rising rapidly on both sides of the border. Another defining feature of this basin is that a great deal is known about it: most importantly, that it is finite, and that at current and projected rates it will be depleted in about 30 years. Additionally, the mingling of sweet and saline water as well as domestic and industrial contamination overlying the basin have lowered the groundwater quality.[28]

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25. Mexican national water law provides for private ownership and utilization of groundwater subject to the presumption that groundwater is a national resource that may be regulated in the national interest to include provision for the establishment of protected areas, while groundwater regulation is a matter of state law in the United States. California water law treats groundwater as private property and applies the doctrine of "correlative rights" to groundwater appropriations. *See* COMISION NACIONAL DEL AGUA, LEY DE AGUAS NACIONALES (1992) [hereinafter LEY DE AGUAS NACIONALES]; R. Wehmhoefer, *Water Law in the Southwest*, WATER AND THE FUTURE OF THE SOUTHWEST 29-30 (Z. Smith ed., 1989).

26. *See* International Law Association, *Resolution on International Groundwaters*, *in* THE WORK OF THE INTERNATIONAL LAW ASSOCIATION ON THE LAW OF INTERNATIONAL WATER RESOURCES 39, 39-41 (Int'l Transboundary Resources Ctr. ed., 1996).

27. *See* LYNDON B. JOHNSON SCHOOL OF PUBLIC AFFAIRS, WATER AND DEVELOPMENT: THE RIO GRANDE/ RIO BRAVO (Jurgen Schmandt ed., 1992/93).

28. *See id. See also* TEX. WATER DEV. BD., WATER FOR TEXAS: TODAY AND TOMORROW (1990); TEX. WATER COMM'N, REGIONAL ASSESSMENT OF WATER QUALITY IN THE RIO GRANDE/RIO BRAVO 55 (1992); Int'l Boundary & Water Comm'n, *Transboundary Aquifers and Binational Groundwater Database City of El Paso/Ciudad Juárez Area* (last modified Aug. 8, 1999) <http://www.ibwc.state.gov/RIOGRAND/tranaqui.htm> [hereinafter *Transboundary Aquifers Database*]; Mauricio G. Mercado & Ma. Del Rosario Diaz A.,

In terms of the elements necessary for cooperative institution building, the Hueco Bolson problem appears more tractable than the AAC lining dispute. First, the quality and accessibility of information to users is the best on the border. The two countries have shared nationally gathered information on this basin for nearly a decade and are currently co-developing computer groundwater flow models of the Hueco Bolson aquifer.[29] Detailed information concerning current uses, demand-consumption rates, and other socio-economic data are also shared binationally. Water managers at the municipal levels in both countries have developed working relationships with each other and are generally comfortable discussing municipal water issues and sharing information. Additionally, the IBWC's national sections are in the process of developing a formal binational groundwater-monitoring network to exchange information.[30] Thus, there is growing trust based on cooperative information sharing practices on which the two countries rely.

Second, the private and public sectors on both sides of the border are beginning to fully recognize the costs and benefits in similar terms. The potential harm of sustaining current binational water use is mutual. Likewise, there is a growing binational appreciation of the benefits to be gleaned from cooperatively developing a more sustainable approach to transboundary water management. Important here is the absence of a clear asymmetry of resource control. While both countries have access to the resource, neither can effectively deny the other access. Moreover, both sides recognize that the current race to deplete the resource harms everyone's interest in sustaining a reliable source of urban water beyond the near future. This growing understanding has manifested in national efforts to conserve water resources in the basin, which, even if not truly cooperative, are at least based on a common sense approach towards the reality of resource depletion.

Third, despite the fact that groundwater resource regimes vary considerably from nation to nation along the border today, there is a comparatively greater common frame of reference due, in large part, to the growing public recognition of the common pool aspects of local water resources. In 1993, EPJAZ became the first binational conurbation on the border to enter into a joint cooperative arrangement for managing the transboundary air shed.[31] While different from the groundwater situation,

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Problematica del Recurso Agua y Accion para su Conservacion y Mejoramiento en Ciudad Juárez, Chihuahua (unpublished manuscript presented at Association of Borderlands Studies, Annual Meeting in Reno, Nevada, Apr. 22, 1996, on file with author).

29. *See* Transboundary Aquifers Database, *supra* note 28; BORDER XXI PROGRAM 1997–1998 IMPLEMENTATION PLANS, *supra* note 15.

30. *See* Transboundary Aquifers Database, *supra* note 28, at 16.

31. *See* BORDER XXI PROGRAM 1997–1998 IMPLEMENTATION PLANS, *supra* note 15, at 30.

this arrangement provides municipal leaders invaluable experience in local binational resource management and improves the climate for considering similar ventures. Finally, these cooperative efforts are proceeding incrementally, and, as such, they provide needed experience and nurture mutual trust in cooperative management approaches.

This discussion of two transboundary groundwater problems within a common pool resources management framework demonstrates that the Hueco Bolson is a more suitable candidate for a cooperative management solution than the AAC. While this theoretically informed comparison fails to capture all the variables in play, it does suggest that moving beyond Minute 242 will depend on discerning and prioritizing the basin disputes that are comparatively more resolvable.

Additionally, this comparison highlights the need to address each of the basin situations along the border individually. An incremental approach that recognizes the uniqueness of these individual cases will not only help build a body of binational managerial experience, but will also strengthen the social bases for cooperative efforts in this area. Moreover, this comparison emphasizes the need to build a greater basis of mutuality as well as the need to perfect and build national commitments to principled bases for joint management. Consequently, it is important to look carefully at the current institutional base for binational cooperation, recent institutional trends, and new developments in international prescriptive law that may contribute to progress on these issues.

III. INSTITUTIONAL TRENDS AFFECTING THE PROSPECTS FOR COOPERATIVE TRANSBOUNDARY GROUNDWATER MANAGEMENT ON THE MEXICO–U.S. BORDER

Over the past 25 years, a number of important institutional developments have brought Mexico and the United States closer to resolving the transboundary water dispute. These developments have contributed to the basis of mutuality necessary for co-management and aided in addressing the constitutional order of decision making affecting extant management practices in transboundary groundwater basins. Such trends include a broadening of the binational regime for dealing with environment and water problems along the border and recent developments in international law concerning shared management of transboundary groundwater basins. As these trends may be useful in settling actual and potential conflicts, a brief discussion is warranted.

What, in Ostrom's terms, may be called the institutional status quo for dealing with transboundary groundwater problems is both a function of domestic water law and international agreements. As stated earlier, national legal regimes governing the appropriation and use of groundwater vary greatly along the border, ranging from Mexico's

centralized system of national controls to the decentralized system of state water law found in the United States. Under Mexican law, groundwater is principally a national resource. It may be privately owned and utilized subject to the state's authority to regulate withdrawals, establish protected zones, and protect the interests of private citizens.[32] Mexico's National Water Commission (CNA), a semi-autonomous federal agency under the authority of SEMARNAP, manages groundwater in the national interest and has the authority to declare protected zones and limit the taking of water in these areas.[33] Responsibility for implementing the nation's water quality regulations is shared between CNA and SEMARNAP.[34] Despite this infrastructure, the Mexican government has generally neglected to manage groundwater. Along the border, there are few protected zones, a factor that has contributed to substantial overdrafts and water quality problems.[35] A recent World Bank report found Mexican groundwater management practices suffered from various deficiencies, including inadequate monitoring systems, a lack of quantitative studies of aquifers, the absence of a comprehensive information system to process groundwater data, and a dearth of essential environmental and socio-economic assessments of groundwater extraction activities.[36]

In the United States, groundwater management is largely a function of state law.[37] Three of the four border states, Arizona, California, and Texas, use some variation of common law property rights to establish ownership and limits on groundwater withdrawals, while New Mexico uses the legal doctrine of prior appropriation (first in time, first in right) and grants permits to authorize takings.[38] While the border states are gradually moving towards greater regulation, and may be subject to federal pressure to do so in the future,[39] they have thus far been slow to

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32. *See* LEY DE AGUAS NACIONALES, *supra* note 25.

33. *See id. See also Reglamento de la Ley de Aguas Nacionales*, DIARO OFICIAL (12 de Enero, 1994).

34. SEMARNAP's authority is grounded in the Federal Environmental Law and references to the Federal Environmental Law within the National Water Law. *See* LEY GENERAL DEL EQUILBRIO ECOLOGICO Y LA PROTECCION AL AMBIENTE, arts. 117-32 (1988, revisado 13 de Deciembre 1996); LEY DE AGUAS NACIONALES, *supra* note 25, at art. 86.

35. *See* THE WORLD BANK, REP. NO. 15435-ME, STAFF APPRAISAL REPORT: MEXICO WATER RESOURCES MANAGEMENT PROGRAM 12, Annex C, tbl.C-3 (1996).

36. *See id.*

37. Except where inter-state conflicts arise or where federal environmental and public health laws apply.

38. *See* Wehmhoefer, *supra* note 25; Wells A. Hutchins, *Water Rights Laws in the Nineteen Western States*, (Dep't Agric., Miscellaneous Pub. No. 1206, 1971).

39. Though state law predominates in groundwater regulation in the United States, the potential for greater federal involvement derives from the more recent managerial approach to water use and allocation at the federal level and possible applications of the

limit groundwater withdrawals. Only a few high-risk zones along the border are presently subject to direct regulation or withdrawal limits.[40] Groundwater thus remains largely available to those property owners, public and private, with the capacity and will to extract the resource.

On the Mexico–U.S. border, transboundary surface water management has largely been entrusted to the IBWC, while management of transboundary groundwater basins remains essentially unregulated. The architects of the IBWC's mandate deliberately avoided making any reference to transboundary groundwater, regarding this and other matters as ancillary to the agreement.[41] However, the IBWC's mandate was narrowly extended by Minute 242 to address the San Luis groundwater dispute in 1973.[42] This extension of authority has not gone unquestioned, as some governmental and institutional stakeholders in the United States have expressed concern that Minute 242 lacks the authority for such an application.[43]

While the institutional authority of the IBWC has not fundamentally changed in this area, since 1973 the institutional context has changed quite substantially. In 1983, the adoption of the Border Environment Cooperation Agreement (La Paz Agreement) created the first institutional arena and agenda for ongoing bilateral discussions on a range of environmental questions including water resources.[44] While groundwater questions were not initially addressed and have never loomed large in the deliberations under the La Paz Agreement's binational Water Working Group, some groundwater quality issues have received attention. From this modest basis, the two governments have broadened their water resources agenda such that it now extends to the collection and sharing of basic data on groundwater dynamics along the border, with specific projects directed at the Trinity Edwards aquifer in the Del Rio/Eagle Pass region, the Hueco Bolson, the New Mexico–Chihuahua border area, and the Santa Cruz River basin at Ambos Nogales.[45] The governmental participants in these projects include the IBWC, EPA, CNA,

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federal Clean Water Act, Endangered Species Act, and the 1986 Federal Power Act Amendments to groundwater situations. *See* W. WATER POLICY REVIEW ADVISORY COMM'N, WATER IN THE WEST: CHALLENGE FOR THE NEW CENTURY 3.38-39 (1998).

40. *See* Mumme, *supra* note 6.

41. *See* Utton, *supra* note 4, at 488-89.

42. *See Minute 242*, *supra* note 1.

43. *See* Ival V. Goslin, *Colorado River Development*, *in* VALUES AND CHOICES IN THE DEVELOPMENT OF THE COLORADO RIVER BASIN 18, 56-57 (Dean F. Peterson & A. Berry Crawford eds., 1978).

44. Agreement on Cooperation for the Protection and Improvement of the Environment in the Border Area, Aug. 14, 1983, U.S.-Mex., T.I.A.S. No. 10,827.

45. *See* BORDER XXI PROGRAM 1997–1998 IMPLEMENTATION PLANS, *supra* note 15.

U.S. Geological Survey (USGS), and various state agencies on both sides of the border.[46]

Trade integration has also contributed to the broadening institutional context for groundwater management on the border. The advent of the Mexico–U.S. Border Environment Cooperation Commission (BECC), in particular, has drawn attention to the issues of water quantity, water quality, and the need to achieve "sustainable solutions" to these problems.[47] Additionally, the BECC has fostered a more intensive and collaborative approach among border institutions, engaging established institutions like the IBWC in environmentally centered discussions. This engagement has pushed the limits of the IBWC's traditional mandate and constructively drawn it into the broader debates occurring within each country and across the border.[48] As the only binational organization with an organic focus on sustainable development, the BECC has brought other binational institutions into the sustainability debate. Moreover, it has also provided a forum for the public to express its environmental concerns, a forum that did not exist prior to 1994.

Another NAFTA inspired institution, the trinational Commission on Environmental Cooperation (CEC), has also contributed to the new emphasis on sustainable development in the border region. The CEC supports the development of multilateral agreements that promote and protect the environment. Where compelling arguments are made that national governments are not living up to their legal commitments to protect the environment, the CEC can investigate and engage in fact finding, as well as engage in other activities aimed at educating and supporting the trinational public's capacity to act in support of environmental protection.[49]

While the Mexico–U.S. border region is but one part of the CEC's large geographic mandate, its trinational focus enables it to draw linkages and raise issues within a broader regional context. This is helpful in building and strengthening national commitments to environmental protection on the constitutional level by establishing norms and regulations for use of common pool resources.[50] For example, the CEC is presently pushing trinational commitment to a protocol requiring international

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46. *See id.*

47. Lenard Milich & Robert G. Varady, *Openness, Sustainability, and Public Participation: New Designs for Transboundary River Basin Institutions*, 8 J. ENV'T & DEV. 258, 292-93 (1999).

48. *See id.* at 292-95. *See also* Stephen P. Mumme & S. Moore, *Innovation Prospects in U.S.–Mexico Border Water Management: The IBWC and the BECC in Comparative Perspective*, 17 GOV'T & POL'Y C: ENV'T & PLAN. 753, 768-770 (1999).

49. *See* PIERRE MARK JOHNSON & ANDRE BEAULIEU, THE ENVIRONMENT & NAFTA: UNDERSTANDING AND IMPLEMENTING THE NEW CONTINENTAL LAW (1996).

50. *See id.* at 121-30.

cooperation among the parties in addressing the transboundary environmental impacts of domestic activities.[51] Such a protocol may come too late to assist in solutions to problems like the dispute over the AAC,[52] but it may contribute to greater binational cooperation in dealing with other groundwater problems along the border.

In yet another example, a CEC advisory panel's recent investigation and report on the management of the Upper San Pedro River on the Sonora-Arizona border recommends the two countries move towards a more comprehensive binational management of the basin's water resources, and adopt a variant of the El Paso de Norte Air Quality Management Task Force approach to binational oversight and policy development.[53] The CEC report further suggests that the IBWC and BECC "in cooperation with federal, state, and local officials and private citizens...play an integral role in developing the proposed body and making it operational." Short of this, the report outlines a number of practical measures that may be taken concurrently within each country to improve joint—at least coordinate—management.[54] The CEC, together with the BECC and the Water Working Group may very well facilitate the development of an IBWC Environmental Minute that would lend support to efforts to protect the quality and sustainable use of groundwater along the border.[55]

Coupled with this broadening institutional and public concern is an evolution in legal thinking. While these developments have not yet led to the Holy Grail of customary international law, a treaty specifically directed at resolving international disputes over both fluvial and confined basin groundwater, they provide a basis of hope that agreements addressing groundwater will eventually be adopted. Until then, other relevant treaties inform binational discussions on resolving transboundary groundwater disputes and, as such, warrant attention.

The first treaty worthy of attention is the Bellagio Draft Treaty on Transboundary Groundwaters (Draft Treaty).[56] The Draft Treaty, which

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51. *See* COMM'N ON ENVTL. COOPERATION, ANNUAL REPORT (1997).

52. For discussion of the very limited international aspect of environmental impact assessment in the AAC case, see Jones et al., *supra* note 22.

53. *See* COMM'N ON ENVTL. COOPERATION, ADVISORY PANEL REPORT ON THE UPPER SAN PEDRO RIVER INITIATIVE (1998).

54. *See id.*

55. In the past year scholars have called for a reinterpretation of the 1944 Water Treaty's Article 3 defining the priority of uses of treaty waters to incorporate environmental values. *See* William Snape, *Adding an Environmental Minute to the 1944 Water Treaty: Impossible or Inevitable*, Workshop Proceedings: Water and Environmental Issues of the Colorado River Border Region Roundtable Workshop vi-viii (1999). See also comments by law professor David Getches in the same workshop.

56. *See* HAYTON & UTTON, *supra* note 5.

builds on the evolving work by the professional International Law Association (ILA) and the United Nations' prestigious International Law Commission (ILC), was catalyzed in part by the ILC's controversial conclusion that groundwater must be redefined as "one of the 'hydrographic components' of any watercourse system."[57] This important conceptual breakthrough insured that groundwater, at least in part, would be addressed by the UN's Treaty on the Non-Navigational Uses of International Watercourses.[58]

The principles of the Draft Treaty may be distilled into five essential tenets. First, it draws a connection between the customary international law on surface waters and that on groundwaters. Second, it links the supply and quality of groundwater, and balances the emphasis on allocation with an emphasis on water quality management and public health. Third, it emphasizes that the twin goals of (1) "optimum utilization and conservation" and (2) "the need to protect the underground environment" must be balanced on "an equitable and reasonable basis." Fourth, it emphasizes the need for the parties "to develop and maintain reliable data and information concerning transboundary aquifers and their waters." Finally, the Draft Treaty emphasizes the value of establishing transboundary groundwater conservation areas and conservation management plans.

While these five tenets do not fully represent the substance of the Bellagio Draft Treaty, they are important in several respects. Most significantly, they are carefully drafted so as to stimulate consensus building in international law. As they gain greater acceptance, they gain greater legal force and, in turn, become a useful guide or model for international agreements on joint management of transboundary groundwater basins. These five principles also build on the wisdom of experience with water management on the Mexico–U.S. border and the global study of water dispute resolution. For example, in recognition that there is a greater likelihood of reaching agreement where common interests may be identified, the Draft Treaty balances public health concerns with water allocation and utilization concerns. Moreover, these principles embrace the need to be flexible and fair in advancing solutions to transboundary groundwater disputes, stressing the importance of weighing and adjusting competing values in water management and the need to approach these questions on an equitable and reasonable basis.

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57. *Id.* at 669.

58. *See* G.A. Res. 51/229, U.N. GAOR, 51st Sess., United Nations Convention on the Law of the Non-Navigational Uses of International Watercourses (1997), *reprinted in* 36 I.L.M. 700-20 [hereinafter United Nations Convention].

Finally, they point to certain practical instruments that may be deployed to implement these guidelines.

While some of these principles remain controversial within the international legal community, particularly the question of whether the principle of "equitable utilization" should prevail over a party's obligation to cause "no significant harm," the Draft Treaty provides a credible and adaptable template for sustainable management of transboundary groundwater that links commonly accepted principles of customary international law to the varied hydrographic, socio-economic, and political circumstances found in relation to these aquifers. The Draft Treaty also may be drawn upon by scholars and policy makers interested in thinking through the range of issues and approaches that might be adopted by governments seeking solutions to transboundary groundwater problems. Indeed, it may have indirectly contributed to ILC work in the 1990s aimed at developing an international treaty on the non-navigational uses of international watercourses.[59]

In 1994, the ILC produced Draft Articles on the topic that were used by the UN in negotiating the Convention on the Law of Non-navigational Uses of International Watercourses, adopted by the UN General Assembly May 21, 1997.[60] As the first set of guiding principles on the non-navigational uses of international watercourses to be adopted by the global body, these rules are significant precursors to an international water courses regime. Surely, this will carry weight in the voluntary design of international solutions to transboundary groundwater disputes as well as proffer solutions—arbitration and adjudication—to these problems. While this Convention, following the ILC Draft Articles, addresses only those watercourse that are hydrologically connected to surface streams, its recommendations will likely influence future agreement on transboundary groundwaters.

The Convention on the Law of the Non-Navigational Uses of International Watercourses moves the international community closer to a set of principles that will contribute to the settlement of these increasingly critical disputes. It incorporates both the principles of "equitable utilization" and "no significant harm" while giving slightly greater preference to the latter in settling international watercourse disputes.[61] These principles guide international negotiations and provide a substantial

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59. *See generally* Stephen S. McCaffrey, *An Assessment of the Work of the International Law Commission*, 36 NAT. RESOURCES J. 297 (1996).

60. *See id. See also* United Nations Convention, *supra* note 58.

61. *See* United Nations Convention, *supra* note 58, at arts. 5-7. For a discussion of the principle of "no significant harm," see Albert E. Utton, *Which Rule Should Prevail in International Water Disputes: That of Reasonableness or that of No Harm?*, 36 NAT. RESOURCES J. 635 (1996).

basis for addressing international water quality issues in transboundary groundwater basins and allocation and utilization of groundwater. This Convention also contains a process for addressing proposed changes to a water course system by one or more of the watercourse states.[62] The recommended procedural rule requires states to provide prior notice of any intended alteration of a watercourse and allows the affected state(s) up to six months to respond before a project may be undertaken. If one or more of the affected states objects to the project, implementation must be suspended for another six months while consultations on a solution proceed. In its other provisions, the Convention provides explicit support for the preservation of ecosystems,[63] identifies a range of "harmful conditions" which states must prevent or mitigate if harmful to other states,[64] and provides private citizens extraterritorial access to the judicial systems of other countries to seek relief for damages incurred by a state's water-course related actions.[65]

It is important to note, however, that this Convention does not explicitly address or directly apply to confined transboundary groundwater. In this regard the Convention reflects the unresolvable differences regarding the proper status of confined transboundary groundwater. In fact, the ILC addressed this question in a separate vague resolution that "[c]ommends States to be guided by the principles contained in the Draft Articles" for the purpose of resolving disputes related to confined transboundary groundwater.[66]

Despite this limitation, these recent developments in customary international law strengthen the capacity of nations to seek solutions to groundwater disputes by utilizing pre-existing diplomatic architecture for international dispute resolution at the regional and global level. In this regard they complement the developments on the institutional level that affect water management on the Mexico–U.S. border. Though not sufficient in and of themselves, these agreements help to draw Mexico and the United States to the negotiating table. In the 25 years since Minute 242 was adopted, the necessary institutional mechanisms have gradually developed, bringing these two nations closer to addressing and resolving the transboundary groundwater dispute.

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62. *See* United Nations Convention, *supra* note 58, at arts. 13-15.
63. *See id.* at art. 20.
64. *Id.* at art. 27.
65. *See id.* at art. 32.
66. *See* McCaffrey, *supra* note 59, at 317.

IV. MOVING BEYOND MINUTE 242 IN MANAGING BORDER GROUNDWATER

What lessons can be drawn from this review of the Mexico–U.S. transboundary groundwater situation that may contribute to the realization of Minute 242's mandates? In my view, a number of suggestions arise. First, although progress has been made, we still need to strengthen our technical knowledge of groundwater along the border. Additionally, great cross-border dissemination of this knowledge needs to occur. This means supporting the efforts of the IBWC, BECC, EPA, SEMARNAP, Water Working Group, and other agencies to build up the stock of information on groundwater aquifers straddling the border.

Additionally, at the diplomatic level we must strive for incremental, case-by-case solutions to Mexico–U.S. transboundary groundwater problems, building up a common base of principles, experiences, and practices that will provide solutions for those remaining problems. Our aim should be the strengthening of the basis for "mutuality." According to Ostrom, this is the key to further cooperative efforts in dealing with these problems.

Moreover, as a point of departure, we should center our attention on the tractability of these problems, particularly the social construction of these problems, as they are distributed through the border zone. We must better understand how these problems vary in terms of their potential for engaging the affected communities in cooperative efforts aimed at the sustainable management of these resources. We must identify cases where institutional density is greatest, where the problem of resource management is less divisible, and where there is greater prospect of building consensus on shared values. The preceding review, for instance, suggests that tackling problems where water quality is a prominent local concern may lead more directly to binational cooperation than those cases where the issue has surfaced as a distributive or allocation concern. Along these same lines, we should explore a variety of incentives—drawing on various market-based options as well as regulatory devices—to strengthen all of the stakeholders' interests in cooperative solutions to these problems.

Fourth, we should support those efforts at the binational, trinational, regional, and global levels that deepen the commitments of both nations to binational cooperation. This includes strengthening our understanding of transboundary groundwater problems and our capacity to solve them, not just at the geophysical or hydrological level, but at the environmental, public health, socio-economic, and institutional levels as well. In this regard, we should support the work of the IBWC and the Water Working Group in developing binational databases on the hydrology of transboundary aquifers. Additionally, the CEC's transboundary environmental impact study initiative contributes to this

process of building institutional commitments to a cooperative process, as does the work of the ILC and the UN Convention on the Law of the Non-navigational Uses of International Watercourses. Further, joint efforts in air shed management in EPJAZ have experiential benefits for local communities striving to cooperatively solve a range of important shared resources problems.

Finally, following the lead of visionaries in the international environmental legal community, we should support those prescriptive solutions that balance values and emphasize equity as well as place protection of environmental values on the docket along with human health and material well being. In this regard it is reasonable to suggest that statesmen on both sides of the border take another look at the Bellagio Draft Treaty for guidance on balancing competing values in transboundary groundwater management as well as institutional design. In the persistent tradition established by Al Utton, we should continue to identify potential solutions, advance designs, offer suggestions, and persuade appropriate agencies on state, federal, and binational levels to address these issues.

In sum, there is much that we can and should do to build on the developments that have occurred over the past 25 years, for they hold promise for advancing cooperative solutions to our common groundwater problems. As we all recognize, the solutions to this particular class of transboundary resource problems are the critical components in the sustainable future for all of the border communities.

TABLE 1. TRANSBOUNDARY GROUNDWATER ALONG THE MEXICO-U.S. BORDER: LOCATION, ALLOCATION, UTILIZATION, PROBLEMS*

Aquifer	Location	Allocation	Utilization	Problems
Tijuana River Basin (Pacific Basin Subarea)	Spans the border at Tijuana–San Diego, draining 1,750 square miles total.	No bilateral agreement. No tacit cooperation, coordinate management, or conjuctive management practice. No information sharing.	Currently, most groundwater withdrawn is taken on the U.S. side in agriculture in the lower reach of river near or in the estuary.	Water quality due to sewage contamination has been cited as the principal problem.
Tecate (Pacific Basin Subarea)	Basin straddles border 40 miles east of the Pacific coast.	No bilateral agreement. No tacit, coordinate, or conjunctive management in place. No information sharing.	Well water used for municipal and industrial purposes in Tecate, Baja Calif. Norte.	Unknown.

* *See generally* Stephen P. Mumme, Groundwater Management on the Mexico–United States Border (Dec. 1996) (unpublished report submitted to the Commission on Environmental Cooperation, Montreal, Quebec, Canada, as part of the Mexico-United States-Canada Transboundary Inland Water Project, on file with author).

TABLE 1 (CONTINUED)

Aquifer	Location	Allocation	Utilization	Problems
Colorado River Aquifer (Colorado River–Sea of Cortez Subarea)	Underlies the Mexicali and Imperial valleys, stretching north under the Imperial Valley's East Mesa and south under Mexicali Valley.	No bilateral agreement on allocation.	Groundwater is primarily used in agriculture with some urban uses, principally on the Mexican side of the border.	Groundwater in the Mexicali Valley is presently being mined at an estimated rate of 100,000 acre-feet annually. U.S. decision to line the All American Canal with concrete promises to diminish an important source of recharge. Salinization of surface and groundwater occurring. New River surface water is severely contaminated with adverse effects on groundwater in vicinity of watercourse. Withdrawals not presently monitored on U.S. side (California).

TABLE 1 (CONTINUED)

Aquifer	Location	Allocation	Utilization	Problems
Yuma Mesa (Sonoran Desert Subarea)	Lies on the east bank of the Colorado River. Includes 35,000 acre Yuma Mesa project area and rich agricultural zone south of San Luis Rio Colorado.	No formal binational agreement on allocation. Minute 242 limits groundwater withdrawals in immediate border vicinity to 160,000 acre-feet annually. Arizona's groundwater management plan limits total state withdrawals and aims at sustainable uses. Lower Colorado River currently defined as a planning zone with some withdrawal monitoring, but presently not subject to regulation as Active Management Area or Irrigation Non-Expansion Zone.	Agriculture is the principal user on both sides of the border, but the city of San Luis Rio Colorado depends entirely on groundwater for its municipal and domestic uses.	Groundwater continues to be mined at rates exceeding recharge. Groundwater salinity is an ongoing problem within the Walden–Mohawk and Yuma Mesa Irrigation Units.

TABLE 1 (CONTINUED)

Aquifer	Location	Allocation	Utilization	Problems
Sonoyta–Organ Pipe National Monument** (Sonoran Desert Subarea)	Basin originates in Organ Pipe National Monument and runs in a southwesterly direction across the border near Lukeville, AZ, and passes through Sonoyta, Sonora, continuing on through El Pinacate federal reserve before reaching the Gulf of California.	No formal allocation has been made. No tacit, collaborative or conjunctive management of the basins surface and groundwaters.	Groundwater is drawn for wells in Lukeville and Organ Pipe National Monument. Intensive use of groundwater for municipal, agricultural, and ranching purposes on the Mexican side.	Current withdrawals 2.5 times in excess of known rates of recharge. Systematic monitoring of wells on Mexican side has been suspended in recent years.

** Information on Sonoyta–Organ Pipe is taken from the article in this volume by Maria Murgia de Lourdes Ruiz, *El Agua de la Reserva de la Biosfera El Pinacate y Gran Desierto de Altar, Sonora, Mexico*

TABLE 1 (CONTINUED)

Aquifer	Location	Allocation	Utilization	Problems
Rio Santa Cruz–Ambos Nogales (Sonoran Desert Subarea)	From headwaters in Arizona's San Rafael Valley, this basin loops some 35 miles through Mexico before doubling back into the U.S., passing just east of Ambos Nogales. Nogales Wash passes through both cities and drains into the Rio Santa Cruz just south of Nogales, AZ.	No binational allocation. Arizona Dept. of Water, spearheading effort to model groundwater dynamics in Santa Cruz River aquifer, has exchanged information with Mexico's CNA aimed at linking ADWRs effort with Mexican studies. The IBWC, Arizona Dept. of Environmental Quality, EPA, CNA, and Sonora's COAPAES are currently monitoring and exchanging information on groundwater quality for the Nogales Wash aquifer. ADEQ, EPA, CNA, and the city of Nogales, Arizona are also working on well-head protection strategies to protect the Nogales Wash and Santa Cruz River aquifers from sources of contamination.	Agricultural and urban on both sides of the border. Increasing urban demand for groundwater in Ambos Nogales. Nogales, AZ, draws on the Santa Cruz River for 50% of its current needs, taking the rest from an aquifer from Potrero Creek, northwest of the city. Nogales, Sonora, relies on the Santa Cruz for 40% of its current utilization, with remainder drawn from aquifers in Los Alisos creek (to the south) and Nogales Wash. On U.S. side, withdrawals are regulated by the AZ Dept. of Water Resources; Santa Cruz Active Management Area oversees rural and municipal water withdrawals and is currently meeting "safe yield" consumption targets. The Santa Cruz AMA is one of just two regions in Arizona where withdrawals are actively regulated.	Under state and federal plans with BECC sponsorship, Nogales, Sonora, until recently had planned to significantly augment Rio Santa Cruz groundwater withdrawals in the near future as part of its new Aquaferico project. Sonora's COAPAES has recently decided to put those plans on the backburner and turn instead to sources in Los Alisos creek south of Nogales, Sonora, to augment local supplies. Contamination of Nogales Wash groundwater is occurring from wastewater and industrial waste generated in Nogales, Sonora, and industrial waste from facilities on both sides of the border. High nitrate levels in certain wells on the U.S. side occur due to the use of septic systems in the area.

TABLE 1 (CONTINUED)

Aquifer	Location	Allocation	Utilization	Problems
San Pedro River (Sonoran Desert Subarea)	Headwaters near Cananea, Sonora. Crosses the border between Sierra Vista and Naco, AZ, just east of the Huachuca range, passing near Bisbee, Sierra Vista, St. David and Benson, AZ, before joining the Gila River near Winkleman, AZ.	No binational agreement on allocation.	Agricultural and municipal uses on both sides of the border. Upstream, Cananea, Sonora, mining center is the principal industrial and municipal user, while downstream, Sierra Vista and adjacent Fort Huachuca, AZ, meet virtually all municipal water needs from this basin.	Upstream, water levels at Cananea are declining. Downstream, water levels in the San Pedro River floodplain aquifer appear to be stable, but rapidly growing municipal uses downstream in Arizona may affect water balance, adversely affecting regional fauna and flora. Contamination from tailing pond spillage at Cananea has been a problem in the past and may reoccur.

TABLE 1 (CONTINUED)

Aquifer	Location	Allocation	Utilization	Problems
Naco–Bisbee (Sonoran Desert Subarea)	Ambos Naco is a binational community located on the border roughly 20 miles east of the San Pedro River. Bisbee is located 5 miles north. Theses cities share part of the San Pedro River regional aquifer.	No binational agreement on transboundary allocation. Aquifer water quality monitoring has been undertaken in 1997-1998 by CNA, ADEQ, and EPA under the auspices of the International City and County Management Association.	Municipal consumption with some industrial applications near Bisbee and a small amount of agriculture and livestock.	Supply is not presently a serious local concern. Contamination from sulfates related to now defunct copper mining operations in Bisbee threatens municipal wells. Sewage spillage at Naco, Sonora, is a potential threat to wells there, as well as to those in the Greenbush Draw area used by Naco, AZ, and Bisbee.

TABLE 1 (CONTINUED)

Aquifer	Location	Allocation	Utilization	Problems
Douglas Basin–Rio Agua Prieta (Sonoran Desert Subarea)	Situated roughly 25 miles east of Ambos Naco where it underlies the contiguous border cities of Agua Prieta, Sonora, and Douglas, AZ. Rio Agua Prieta (Whitewater Draw in the U.S.) drains southward along the western perimeters of the two cities.	No binational agreement on allocation. ADWR has designated the Sulphur Springs Valley as an Irrigation Non-Expansion area.	Both Douglas and Aqua Prieta rely exclusively on the basin's groundwater for their municipal and industrial needs. Agriculture in Arizona's Sulphur Springs Valley also utilizes the resource for irrigated farming and livestock operations.	Both cities overdraft groundwater, with declines in the Douglas area in excess of 20 feet recorded for 1966-1978. Overdrafts could pose binational problems. Discharge of treated sewage to the Rio Agua Prieta at Mexican drainage a potential threat.

TABLE 1 (CONTINUED)

Aquifer	Location	Allocation	Utilization	Problems
San Luis-Playas–Hacita Basins (Sonoran Desert Subarea)	East of the Chirachua Mountains, along the Chihuahua-New Mexico border. Several groundwater basins cross the international border in this area.	No binational agreement. These aquifers are among those designated for study in a binational project to characterize the trans-international boundary aquifers of southwest New Mexico and northern Mexico. Project involves the IBWC, CILA, USGS, NM Environment Dept., and EPA.	Primary and sole source of water besides catchment ponds for ranches and their livestock.	Unknown.

TABLE 1 (CONTINUED)

Aquifer	Location	Allocation	Utilization	Problems
Mimbres Aquifer (Mimbres–Animas Basin Subarea)	Associated with Mimbres River draining from headwaters in New Mexico's Black Range and crossing border southwest of Deming at Columbus, NM–Las Palomas, Chihuahua, thought to extend 35 miles south to its terminus in Laguna de Guzman.	No binational agreement. Designated for study in the binational effort to characterize the trans-international boundary aquifers of southwest New Mexico and northern Mexico.	Upstream, industrial and municipal uses; downstream, municipal water supply. Agriculture on U.S. side accounts for 95% of all withdrawals.	Substantial overdrafts at Columbus–La Palomas resulting in water level decline of 140 feet east of Columbus between 1950 and 1970. Withdrawals generally exceed recharge rates throughout the Mimbres basin, posing possible binational problem.

TABLE 1 (CONTINUED)

Aquifer	Location	Allocation	Utilization	Problems
Mesilla Bolson (Upper Rio Grande Basin Subarea)	West of El Paso, extending north to New Mexico and south into Mexico just west of Cd. Juarez.	No formal binational agreement.	Municipal and agricultural. Most Texas portion used municipally by city of El Paso. New Mexican use predominantly agricultural. Cd. Juarez, Chihuahua has inaugurated a 25-well project and anticipates drawing heavily on this aquifer.	Substantial overdraft has caused minor land surface subsidence and directions and flow change. Increasing abstraction for the municipal-industrial needs of El Paso and Cd. Juarez expected to contribute to binational competition.

TABLE 1 (CONTINUED)

Aquifer	Location	Allocation	Utilization	Problems
Hueco Bolson, El Paso and Cd. Juarez (Upper Rio Grande Basin Subarea)	Straddles Rio Grande between Franklin Mountains of El Paso and Hueco Mountains southeast of Cd. Juarez. Underlies much of both municipal areas. Joins the Mesilla Bolson just north of the border, extending northward into New Mexico.	No binational agreement. Municipal planners in both cities are exchanging information on use and conservation and have undertaken informal talks on joint planning. In 1998, the IBWS-CILA published a *Transboundary Aquifers and Binational Ground-Water Data Base of the El Paso–Cd. Juarez Area*, in which the EPA, CNA, the Texas Water Development Board, the NM Water Research Inst., and the Cd. Juarez *Junta Municipal de Agua y Saneamiento* also participated. El Paso Water Utilities and U.S. Army currently simulating pumpage effects on U.S. part of the Bolson and monitoring groundwater quality there.	Industrial and municipal uses in El Paso and Cd. Juarez. Meets 60% of El Paso municipal needs. Cd. Juarez' water consumption grew 60% between 1985 and 1995, leading to 1.7 meters annually.	Overdrafting, followed by the threat of salinization and contamination. Studies in 1988 and 1990 established a draw-down rate of 1-4 feet annually, predicting depletion of aquifer by 2030. Cd. Juarez' disposal of untreated sewage in the Rio Grade main stem a potential threat.

TABLE 1 (CONTINUED)

Aquifer	Location	Allocation	Utilization	Problems
The Minor Bolsons (Upper Rio Grande Subarea)	Several located southeast of El Paso and Cd. Juarez along the Rio Grande; principal ones: Red Light Draw, the Green River Valley Bolson, and the Presidio-Redford Bolson.	No binational agreement.	Agriculture and ranching; though several tiny municipalities also use the resource.	No supply problems reported, though withdrawal rates are known to exceed recharge in some parts of these bolsons.
The Edwards–Trinity Plateau Aquifer (Rio Grande, Rio Conchos to Amistad Dam Subarea)	Underlies the Edwards Plateau in central Texas and Coahuila.	No binational agreement on allocation. The IBWC-CILA in partnership with the Texas Water Development Board and the CNA is presently conducting a study to characterize the transboundary aquifers in the Del Rio–Cd. Acuna region of the border.	In the U.S., agriculture accounts for 70% of all withdrawals. Municipal pumpage accounts for 15% of withdrawals. Del Rio, TX, relies on groundwater wells and springs for all of its municipal water supply. In Mexico, use is largely agricultural, though Cd. Acuna and Cd. Jimenez rely on the aquifer for most municipal needs.	In the U.S., groundwater levels have not registered declines more than 20 feet since 1980. Texas water authorities project Del Rio has reliable stocks to accommodate development until 2040. Reports were unavailable on the situation on the Mexican side of the border.

TABLE 1 (CONTINUED)

Aquifer	Location	Allocation	Utilization	Problems
Carrizo Wilcox Aquifer (Rio Grande, Amistad to Falcon Dam Subarea)	Stretches from the northern reaches of Coahuila and Nuevo Leon through south Texas and into Arkansas and Louisiana.	No binational allocation. The IBWC-CILA in partnerships with the Texas Water Development Board is currently conducting a study of aquifers in the Eagle Pass–Piedras Negras section of the border.	Irrigation accounts for 51% of withdrawals in Texas, with municipal, industrial, and ranching accounting for the remainder. Nuevo Laredo and several other Mexican municipalities are outside the reach of the aquifer. Data on Mexican agricultural reliance was unavailable.	Groundwater supplies in the Winter Garden area are diminishing. Binational ramifications of the drop in water levels in this region are not known. Water quality is the principal problem in the area. In the Winter Garden, brine infiltration from oil wells and adjacent formations has contaminated groundwater wells. Irrigation also contributes to groundwater degradation. *Colonias* along the Rio Grande on both sides of the border are potential sources of contamination from latrines and other unregulated practices. Sewage disposal by Mexican cities in the Rio Grande main stem may also contribute to groundwater contamination.

TABLE 1 (CONTINUED)

Aquifer	Location	Allocation	Utilization	Problems
Gulf Coast Aquifer (Lower Rio Grande Valley Subarea)	Extends across a wide expanse around the perimeter of the Gulf of Mexico, hydrologically linking Florida to Mexico.	No binational allocation.	Water source for 54 Texas counties and the coastal zone of Tamaulipas. In the Rio Grande section, irrigated agriculture is by far the principal user as urban areas take their water from the Rio Grande main stem. Various *colonias* scattered on both sides of the river do, however, draw water from shallow wells.	In Rio Grande section, water contamination. South of the San Antonio River into Mexico, water quality declines. In Texas' Star and Hidalgo counties, over 50% of wells exceed national drinking standards for nitrates. Salinization of area soils has also resulted from factors contributing to rising water tables (including irrigation and the mesquite tree eradication), necessitating major drainage projects to protect crops. Illegal disposal of toxic industrial wastes in Mexico by *maquilas* and other industries near Matamoros has contributed to locally degraded groundwater; problems of salinity are also in evidence.

TABLE 2. TYPES OF MEXICO–U.S. GROUNDWATER PROBLEMS GROUPED BY DOMINANT ISSUE TYPE AND DEMOGRAPHIC SETTING*

DEMOGRAPHY	DOMINANT ISSUE TYPE		
	Allocation	**Water Quality**	**Both**
Predominant Urban	El Paso-Cd. Juárez Douglas-Agua Prieta		Ambos Nogales Ambos Naco Hueco Bolson
Predominant Rural	Yuma Mesa-SLRC S.Luis/Playas/Hachita Minor Bolsons	New River	Imperial- Mexicali
Mixed/hard to classify	Sonoyta-Organ Pipe San Pedro River Mimbres Aquifer Edwards-Trinity	Tijuana Basin Carrizo-Wilcox Gulf Coast	Mesilla Bolson

* *See generally* Stephen P. Mumme, Groundwater Management on the Mexico–United States Border (Dec. 1996) (unpublished report submitted to the Commission on Environmental Cooperation, Montreal, Quebec, Canada, as part of the Mexico–United States–Canada Transboundary Inland Water Project, on file with author).