

A Joint Management of Transboundary Aquifers: From Asymmetries to Environmental Protection*

Hacia una gestión conjunta de los acuíferos transfronterizos: De las asimetrías a la protección ambiental

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ABSTRACT

Mexico lacks a public policy for the management of its transboundary aquifers. Based on the guidelines and international instruments developed for this purpose and considering the asymmetries that characterize the management of transboundary groundwater between Mexico and the United States, this work examines an academic proposal for the joint management of those international watercourses and seeks ways to protect and conserve this water, using the principles of sovereignty, territorial integrity, and sustainable development. The study finds that there is a relative ignorance and lack of interest in the subject among the various sectors dealing with the issue in Mexico.

Keywords: 1. transboundary aquifers, 2. sovereignty, 3. asymmetries, 4. Mexico, 5. United States.

RESUMEN

México carece de una política pública para la gestión de sus acuíferos transfronterizos. Con base en las directrices e instrumentos internacionales desarrollados para tal fin, y considerando las asimetrías que caracterizan la regulación de las aguas subterráneas transfronterizas entre México y Estados Unidos, este trabajo examina una propuesta académica para la gestión conjunta de esas aguas internacionales, misma que tiene por objetivo su protección y conservación, a partir de los principios de soberanía, integridad territorial y desarrollo sustentable. El análisis final refleja que en México prevalece un relativo desconocimiento y desinterés por el tema entre los diversos sectores involucrados.

Palabras clave: 1. acuíferos transfronterizos, 2. soberanía, 3. asimetrías, 4. México, 5. Estados Unidos.

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INTRODUCTION

In the debate about the world water crisis, the perspective of the Dublin Conference (1992) has gained ground for sectors that defend market intervention in water management, in contrast with those who claim water as a common good, and the absence of concrete policies for joint management and protection of transboundary aquifers is evident. In this sense, the approach to and study of transboundary groundwaters that flow through these aquifers require an analysis that reflects the intrinsic relationship of three linked dimensions: the scientific, the technical, and the political, which are only examined in a fragmented way in the specialized literature. This possibly obeys, among other things, the *a priori* nature of groundwater; it is conferred a condition of *social invisibility* and, consequently, there is a scarcity of scientific production of an interdisciplinary nature about groundwater.

In 2015, the International Groundwater Resources Assessment Centre (IGRAC) and UNESCO identified in Mexico 18 transboundary aquifers, 11 situated on the northern border (San Diego-Tijuana, Lower Basin of the Colorado River, Sonoyta-Papagos, Nogales, Santa Cruz, San Pedro, Conejos Médanos/Mesilla Bolson, Hueco Bolson, Edwards-Trinity-El Burro, Lower Basin of the Río Bravo/Grande, and Los Mimbres-Palmas) and seven on the southern border with Guatemala and Belize (Soconusco-Suchiate/Coatán, Chicomuselo-Cuilco/Selegua, Ocosingo-Usamacinta-Pocóm-Ixcán, Márquez de Comillas-Chixoy/Xaclbal, Boca del Cerro/San Pedro, Trinitaria-Nenton, and Península de Yucatán-Candelaria-Hondo). In step with this process of physical stocktaking, supranational organizations such as the United Nations, the U.N. Economic Commission for Europe (UNECE), and the U.N. International Law Commission designed international guidelines and instruments (some with binding effects) for the joint management and political water allocation of these watercourses between the states that share them.

For its part, the United States concluded in December 2016 a federal program of binational characterization and assessment of four transboundary aquifers (Santa Cruz, San Pedro, Mesilla/Conejos Médanos, and Hueco Bolson) between that country and Mexico. The results, although they reflect intense work on both sides and a mutual interest for scientific knowledge about those hydrological reservoirs, show that significant legal, financial, and institutional asymmetries still underlie the management of groundwater in each of the two countries, a situation that ultimately impedes the formulation of a general accord on the issue similar to the 1944 Water Treaty (Water Treaty, 1944).

This study analyzes the opinions received involving an academic proposal that a group of researchers of the National Autonomous University of Mexico (UNAM) developed for the regulation of groundwater in Mexico; the proposal has a section dealing with transboundary aquifers, developed based on the four international principles that should guide their management: the equitable and reasonable use of water, the obligation not to cause significant damage, the obligation to notify and exchange standardized information, and the obligation to cooperate.

THE INVISIBILITY OF GROUNDWATER

In 2012, the World Bank and other institutions carried out a global consultation to promote the *governance of groundwater* after identifying the process that would define the management of groundwater. For Latin America, the diagnostic was distressing: There was little systemic knowledge, unclear registries of the users and utilization of the groundwater, low levels of investment for groundwater management, and a lack of qualified personnel to evaluate it under the highest scientific standards. Finally, national legislation in the region on groundwater was seen as marginal or absent.

Academics have found the same issues. Groundwater goes unnoticed in the designs that are commonly used to represent the natural water cycle, a tradition rooted since its conception by Robert E. Horton in 1931. This, from the perspective of Linton (2010), facilitated the abstraction of the modern study of hydrology, that is, water in infinite circulation through various phases. Water flows in the cycle to a certain point, but it is in the filtration phase where it is represented in a static form to later *emerge* at the surface via springs. The hydrologists Tóth (1970) and Freeze and Cherry (1979), among others, using a base of scientific evidence, showed the connection and the lateral and continual hydraulic movement of water through the varying porosity of the rocks (aquifers) of the subsoil in three dimensions: local, intermediate, and regional. These contributions have only been minimally incorporated into the traditional configuration of the water cycle and, with respect to the social sciences field, they continue to be at the margins and little valued. This occurs even though groundwater constitutes the main reservoir of *physically available* fresh water, 30.28 percent compared with the 0.31 percent of surface water (lakes, ponds, rivers, streams, and dams, among others (Table 1).

TABLE 1. Quantities (x 10⁶) of physically accessible fresh water in the world (2008)

Glaciers, perpetual snows, and permafrost	27 760 km ³	69.40 %
Groundwater	12 112 km ³	30.28 %
Surface waters	128 km ³	0.31 %
<i>Total world fresh water</i>	<i>40 000 km³</i>	<i>100 %</i>

Source: Author's compilation based on Rivera (2008).

The hydrologists Nalęcz and Puri (2012) say aquifers supply 175 million people in Latin America. In Mexico, the Comisión Nacional del Agua, or Conagua, [National Water Commission], says 70 percent of Mexicans depend on that source of supply (Conagua, 2016). In terms of transboundary groundwaters, the International Groundwater Resources Assessment Centre (2015) inventoried 592 transboundary aquifers in the world. According to Rivera (2015), 60 percent of the world's freshwater (surface and underground) is crossed by international borders; however, only 40 percent of the international basins are governed by some sort of agreement.

When it comes to the implications of the process of political water allocation of transboundary groundwaters, it is indispensable to approach the issue from an interdisciplinary perspective that overcomes the binary traditions of the modern study of nature, as Swyngedouw (2009) says. The *social invisibility* of groundwater can be overcome, not only illustrating its varying flows in space and time through the porosities of the subsoil in the water cycle, but incorporating it as part of the hybrid totality. Water is a kind of lubricant that articulates social relations as a whole, but as Linton (2010) and Perrault (2013) say, there is no multiscale social process that disregards water for its functioning. In this sense, Swyngedouw (2009) understands that the movement of water, in its natural cycle, goes far beyond the natural conditions and phases that physical studies give it, as water's journey in different parts of the world is a source of multiscale conflict that has a direct relationship with the processes involved in its social appropriation, use, allocation, and organization; at the same time it reveals the form in which power is distributed in a given society (Swyngedouw, 2009; Linton, 2010; Perrault, 2013). Based on the above, the *hydro-social cycle* category shows that the importance of groundwater

lies in the combination not only of its natural geographic conditions but of its legal-political agreements, which reflect the technical-social and historic system that places it as the source of dispute and political intervention where social actors decide where this liquid flows (Boelens & Arroyo, 2013).

THE PROBLEM OF THE EXERCISE OF POLITICAL SOVEREIGNTY IN TRANSBOUNDARY AQUIFERS

One of the political problems that shackle transboundary groundwaters is the type of sovereignty states must exercise over these shared watercourses. The controversy results from a lack of accurate knowledge about the subject in dispute, because groundwater must be inventoried, characterized, and undergo a socio-technical evaluation to give states the information that allows them to adopt a policy in accordance with the nature of transboundary groundwater.

Villar (2015) says the debate about sovereignty has to do with the lack of clarity about the correct formulation of the concepts that should be employed for this issue. The definition of “transboundary aquifer” in draft Article 2 of United Nations General Assembly Resolution 63/124 (2008), *The law of transboundary aquifers*, refers to a “permeable water bearing geological formation underlain by a less permeable layer and the water contained in the saturated zone of the formation.” This geological formation also can be hydraulically tied into other aquifers, forming in this way a transboundary aquifer system, which, because of its geological extension, can have different parts situated in different states, as Rivera (2015) and UNESCO (2015) point out. There are two essential elements: on the one hand the aquifer as the *basic management unit*, and on the other hand, the groundwater flows as fundamental components of the system in three dimensions (Tóth, 1970).

However, in the international instruments that have binding effects, vague ideas prevail about groundwater. Thus, the *Convention on the Protection and Use of Transboundary Watercourses and International Lakes* (Helsinki Water Convention, 1992) recognizes that groundwater can have transboundary status as long as it can be verified that it is crossed by an international border. For its part, U.N. Resolution 51/229 dealing with the *Convention on the law of the non-navigational uses of international watercourses* (New York Convention, 1997) says an international watercourse “is a system of surface waters and groundwaters constituting by virtue of their physical relationship a unitary whole,” and that transboundary aquifers for

the convention are only those of an unconfined nature,¹ excluding those that are confined and semi-confined (Rivera, 2015).

On the other hand, in the case of the Helsinki Water Convention (1992), UNECE took a long time to publish the *Guidelines on Monitoring and Assessment of Transboundary Groundwaters* (UNECE, 2000) and the *Model Provisions on Transboundary Groundwaters* (UNECE, 2014), which substantially remedy the issues of management of transboundary groundwater. Still, authors such as Movilla (2016) say both documents lack binding effects because they are not treaties, as they do not invoke international responsibilities in case of non-compliance, leaving everything in the sphere of cooperation.

In effect, both the Helsinki Water Convention (1992) and the New York Convention (1997) are the binding instruments with the greatest reach for transboundary groundwaters; while the most advanced document involving the issue is United Nations General Assembly Resolution 63/124 (2008), its current status is a draft.² Sánchez (2015) says the issue of sovereignty, in effect, is an impediment to a change in status for this resolution, as the controversy constantly comes from Article 3, “Sovereignty of aquifer States,” which says a state has sovereignty over the portion of a transboundary aquifer located within its territory and shall exercise its sovereignty in accordance with international law, based on United Nations General Assembly Resolution 1803 (XVII) (1962), *Permanent Sovereignty over Natural Resources*. What is worrying, the author says, is that the states initially began to apply exclusive territorial sovereignty over aquifers, which would de facto mean that states would not be obligated to formulate joint plans for the aquifers’ management. Without a doubt, this type of sovereignty is incompatible with the true nature of transboundary groundwater, as modern hydrology warns that the water flows slowly without recognizing any political border (Tóth, 1970; Rivera, 2015).³

¹ That is to say those whose waters discharge in bodies of surface water.

² Eckstein and Sindico (2014) say that that in the future, this document could take some of the following forms: provisions with a binding character, an independent international treaty, a declaration of principles, or a protocol. That depends on the interests of and negotiations between the nations involved in the issue.

³ In Mexico in 2016, Conagua and UNECE, among others, convened the Taller Regional sobre los Principios Generales de la Cooperación en Aguas Transfronterizas [regional Workshop on the General Principles of Transboundary Water Cooperation]. Its objective was to promote the benefits of adhering to one of the instruments referred to. The author participated in this event and spoke about how the lack of agreements in this rubric is explained by latent water conflicts, accentuated by the prevailing asymmetries between Latin American countries.

In contrast, United Nations General Assembly Resolution 3129 (XXVIII) (1973), *Co-operation in the field of the Environment concerning Natural Resources Shared by Two or More States*, appeals, from an environmental protection standpoint, for the effective cooperation for the conservation of aquifers and the establishment of systems of consultation, so that states can manage the water in accordance with their interests but without forgetting their commitments that come from international law (Sánchez, 2015). Thus, it is hoped that the states recognize that, in terms of the waters in question, there should not be absolute sovereignty in accordance with the goal of preserving peace, ecological equilibrium, and the harmonious use of water between riparian states.

Also, various specialists (Brooks & Linton, 2011; Eckstein & Sindico, 2014; Sánchez, 2015; Rivera, 2015; Movilla, 2016) coincide in that the four essential principles that should guide whatever international management plan for these waters are: 1) its equitable and reasonable use; 2) the obligation not to cause significant damage; 3) the obligation to notify and exchange standardized information, and 4) the obligation to cooperate. For Brooks and Linton (2011) and Rivera (2015), the principle that must always prevail is the one to *not cause significant damage* as the unreasonable extraction of water irreversibly alters the nature of the system, provoking damage in its quality, flow, volume, and recharge capacity, impeding its essential functioning in sustaining biodiversity, and, consequently, fighting climate change.

On the other hand, what is certain is that over time, United Nations General Assembly Resolution 63/124 (2008) keeps having a greater influence as a guide for nations that want to establish *ad hoc agreements*⁴ on the matter. At least the *Acuerdo del Acuífero Guaraní* [Agreement on the Guaraní Aquifer] (2010), pending ratification between Argentina, Brazil, Paraguay, and Uruguay, and the *Memorandum of Understanding relating to the setting up of a Consultative Mechanism for the management of the Iullemeden Aquifer System, Taoudeni/Tanezrouft Aquifer Systems* (2014) between Algeria, Benin, Burkina Faso, Mali, Mauritania, and Nigeria, are examples of the influence of Resolution 63/124 (Fox, 2014).

On the other hand, the recent UNESCO (2015) publication *Estrategia regional para la evaluación y gestión de los Sistemas Acuíferos Transfronterizos en las Américas* [Regional Strategy for the Management of the Transboundary Aquifer Systems in the

⁴ As there is still no binding convention in force, all the agreements that exist about the issue are of that nature. They are by aquifer and can be considered to be pilot management plans between the signing riparian states.

Americas], says the presence of national states in the coordination and execution of the models of transboundary groundwater management is critical, above all in areas such as hydrological characterization and assessment, the identification of the number of inhabitants who depend on the aquifer, and projected economic activities, among others. These elements must be considered for the design of a sovereign—but at the same time interdependent—policy that establishes the responsibilities acquired by the riparian states that share these waters (UNESCO, 2015; Rivera, 2015).

THE PREVAILING ASYMMETRIES IN THE MEXICO-U.S. CASE

The Water Treaty (1944) is an important landmark between both Mexico and the United States because it has to do with benchmark agreements in the political water allocation of three main shared watersheds: the Río Bravo [Río Grande], the Colorado River, and the Tijuana River. Its reach does not include transboundary groundwater, but the treaty has functioned as a corollary for the formulation, still pending, of a general agreement in this rubric, as set out in Acta/Minute 242 of the Comisión Internacional de Límites y Aguas, whose English name is the International Boundary and Water Commission (Comisión Internacional de Límites y Aguas, 1973).⁵ The above appears directed toward two problems: on the one hand, the dichotomies that characterize the domestic management of groundwater in both countries, and on the other hand, the weight of the prevailing legal, institutional, and financial asymmetries involving the issue.

To illustrate this, in the United States the management of groundwater is the responsibility of each political entity that makes up the country; these entities exercise sovereignty over natural resources in differing ways.⁶ In Mexico, it is the federal

⁵ Point 5 says, “Pending the conclusion by the Governments of the United States and Mexico of a comprehensive agreement on groundwater in the border areas, each country shall limit pumping of groundwaters in its territory within five miles (eight kilometers) of the Arizona-Sonora boundary near San Luis to 160,000 acre-feet (197 358 000 cubic meters) annually.” This is only one way to agree on a restrictive access to groundwater in just one very small portion of the Mexico-U.S. border.

⁶ For instance, in Texas, the *doctrine of absolute ownership* recognizes the right of owners to everything found underneath their property. In contrast, in New Mexico, the *doctrine of prior appropriation* gives that state the authority over all watercourses, but they can be subject to concession for the use of third parties.

executive that exercises the constitutional stewardship of groundwater.⁷ This means that there is quite a contrast between these regulatory frameworks. This takes on differing dimensions in the management of groundwater shared by both countries, considering that the U.S. federal government is hampered from presenting a general agreement on the issue because of its lack of powers in this area. In Mexico, something similar occurs, because although the Constitution says subsoil waters are the property of the nation, in reality these are the subject of non-regulated extraction, and first and foremost are in the private domain.⁸ Also, the lack of effective management over the water,⁹ weak financial capacity,¹⁰ a lack of qualified personnel, and the limited powers that municipalities and states have in matters of management of transboundary groundwater prevent Mexico from proposing a bilateral agreement on the matter, at least with the United States.¹¹ Despite everything, both countries began to identify those shared aquifers that are under pressure because of the quantity of groundwater they provide, meaning that the issue now has a precedent.

The CILA signed with its U.S. twin, the International Boundary and Water Commission (IBWC), two binational coordination agreements for the study of four transboundary aquifers inside the framework of Acta/Minute 242. In the case of the 2009 agreement,¹²

⁷ Article 27 empowers the federal executive to establish regulations that regulate groundwater extraction or suspend non-regulated extraction for reasons of utility or the public interest.

⁸ Article 933 of the federal civil code says that that on plots where there is a natural or artificial spring, there is a right to use that water; but if these go from one property to another, its utilization is considered to be for public use. As Simental Franco (2015) says, this technically means the transmission to private use of national waters, and, ergo, they are already privatized.

⁹ A meticulous review of the official reports on six border aquifers located in Coahuila shows that in at least half of them, it is not known who uses the water, how it is utilized, and how many concessions there are; there are no indicators of the quality of the water, nor are the recharge/discharge zones of the aquifers defined.

¹⁰ For the World Bank consultation in 2012, U.S. 4.4 million was spent. In the case of the *United States-Mexico Transboundary Aquifer Assessment Act* of 2006, which called for a U.S. study of transboundary aquifers with Mexico over 10 years, U.S. 50 million was budgeted (only 10 % was spent). In California, the *Sustainable Groundwater Management Act* (2014) was approved with the idea that 100 million would be spent up to the year 2050. In Mexico, in 2017, Conagua's budget was reduced 72 %.

¹¹ To illustrate, the Instituto Mexicano de Tecnología del Agua [Mexican Institute of Water Technology] does not list any researcher who studies transboundary aquifers.

¹² Before this agreement, there had already been two joint binational studies, the Transboundary Aquifers and Binational Ground-Water Database for the City of El Paso/Ciudad Juárez Area in 1998 for the Hueco Bolson aquifer, and the Binational Nogales Wash United States/Mexico Groundwater Monitoring Program in 2001.

this came from U.S. Public Law 109-448, the *United States-Mexico Transboundary Aquifer Assessment Act* (2006), which in its Point D, Section 4, seeks active cooperation with Mexico for the characterization of the Hueco Bolson and Mesilla aquifers in the Paso del Norte region and the San Pedro and Santa Cruz River Valley aquifers in Arizona and Sonora states. For this, a federal program was created, the *Transboundary Aquifer Assessment Program* (TAAP), which had as its objective 1) to develop and share databases on the quality and quantity of groundwater; 2) evaluate the affordability and the movement of water and its interaction with bodies of surface water; 3) develop and improve information related to the groundwater flow systems to facilitate an agreement and planning; and 4) provide useful information to institutional decision-makers (Alley, 2013).

The results of this program are of a public character; standing out, for example, is the publication of the *San Pedro River Aquifer Binational Report* (Callegary et al., 2016), which has the results of the hydrological assessment and the updating of its conceptual model. Put together, reports' results present substantial advances in the creation of databases and critical indicators of groundwater. In light of these reports, it is possible to consider the TAAP as an important precedent in the matter, not only for the quantity of financial, technical, institutional, and human resources involved, but also for the abundant information generated. However, the absence of public policies for aquifers is worrying, because, as Milman and Scott (2010) say, the program did not establish the creation of a plan for binational management of the assessed aquifers. Even in the 2009 "Joint Report of the Principal Engineers Regarding the Joint Cooperative Process United States-Mexico for the Transboundary Aquifer Assessment Program" there was a tacit agreement not to address issues about water rights or the binational management of aquifers.

While the TAAP laid the foundation for a much more effective assessment of the cited aquifers, it is worrying that aspects such as the issue of water rights (concessionaires, private parties with water rights, among others) and their management have been marginalized; the matter was left practically subsumed to technical and engineering rationales. While the results were not disregarded, the political dimension was left at the margins of the cooperation process. Also, the TAAP program, which had high financial resources and numerous personnel, places Mexico in a context of disadvantage in the management of transboundary groundwater. The political backdrop of the TAAP was to acquire a much more realistic sense about the type, quantity, and volume of the principal water reserve situated on both sides of the border; this situation no doubt strengthens the United States in the construction of its water

security, understood as the capacity of a population to safeguard sustainable access to water of a suitable quality for socioeconomic development, assure protection against pollution, and preserve ecosystems in a climate of peace and political stability (United Nations Water, 2013). In that framework, studies such as that of Sánchez, López, and Eckstein (2016), which maps all the transboundary Mexico-U.S. aquifers, shows the interest of the United States in the issue.¹³

Finally, the importance of these bodies of water will be shown with the intensification of the extraction of shale gas, as it is projected that Mexico will become one of the main world producers of the gas after 2030; it is expected that the fracking of shale gas will provide more than 75 percent of Mexican natural gas production in 2040 (U.S. Energy Information Administration, 2016). In Coahuila-Nuevo León, the secretary of energy estimated an initial area of 1 023.9 square kilometers, a volume of the prospective resource of 500.5 million barrels of crude oil equivalent; this technique demands enormous quantities of groundwater. The principal fields of this gas are transboundary and are located in the Burgos Basin (Texas, Coahuila, and Tamaulipas) overlapping with the *Eagle Ford* formation that, according to Rahm (2011), is the fourth biggest field of shale gas in the United States, producing at least 3.335 billion cubic feet/day in September 2016. The principal water source for the fracking is the groundwater in the Edwards-Trinity-El Burro transboundary aquifer system in Coahuila and south-central Texas.¹⁴ This is possible thanks to the modification made to Article 81 of the *Ley de Aguas Nacionales* [National Waters Law], which came out of the energy reform,¹⁵ in which the unreasonable delivery of groundwater for the production of energy products is allowed, even though unreasonable extraction will produce, because of its hydraulic connectivity, irreversible alterations to aquifers. This leaves the question: How will Mexico deal with the transboundary environmental damage caused by fracking?

¹³ In Mexico there is a complete omission when it comes to the issue; a good example is that the *Nuevo Atlas Nacional de México* [New National Atlas of Mexico] (Instituto de Geografía de la UNAM, 2007) and the *Estadísticas del Agua en México* [Water Statistics in Mexico] (Comisión Nacional del Agua, 2016), in which there is not a single reference to transboundary aquifers.

¹⁴ In the Milk River Aquifer (U.S.-Canada), environmental damages have been recorded as a result of the intensive extraction of water for fracking, according to Rivera (2015).

¹⁵ The article says that if the studies show that the geothermic hydrothermal deposit and the aquifers above the fields do not have a direct hydraulic connection, the granting of a water concession from CONAGUA will not be subject to the availability of water or presidential decrees that prohibit the extraction of groundwater (Diario Oficial de la Federación, 2014).

THE REGULATION PROPOSAL FOR THE MEXICAN TRANSBOUNDARY AQUIFERS

An important forerunner to the development of international instruments to regulate transboundary aquifers was “Transboundary Groundwaters: The Bellagio Draft Treaty,” formulated in 1989 by R. D. Hayton and Albert Utton in the framework of what was stipulated under Acta/Minute 242 (Hayton & Utton, 1991). The document tried to become a *model* instrument for the resolution of conflicts in the matter, beginning with the particulars of the Mexico-U.S. border; Nevertheless, it ran aground due to Utton’s death in 1998. It is a landmark because it presented ways of protecting transboundary groundwater and formulated an initial framework for multilevel management.

As discussed above, the controversy surrounding the drafting of Resolution 63/124, and the limitations of the Helsinki Water Convention (1992) and the New York Convention (1997) prompted the exploration of other means to arrive at agreements related to the protection and equitable use of transboundary groundwater. In effect, one of them is the strengthening of domestic frameworks in terms of groundwater, which in many cases are nonexistent; however, Milman and Scott (2010) say that it is at the national or local level where transboundary groundwater can be better managed. In the United States there is the *Sustainable Groundwater Management Act* (2014) in California, approved as an emergency measure because of the damage done by drought over five years; it mandated the creation of county groundwater sustainability agencies. It has a regulatory framework similar to that of Texas, whose Texas Groundwater Protection Committee works with groundwater districts, with the most emblematic one being the Edwards Aquifer Authority, which controls the extraction of water in San Antonio. While these do not make reference to transboundary aquifers, they are important precedents for their history and closeness with Mexico.

In Latin America, only one province, Córdoba in Argentina, regulates groundwater (*Código de Aguas para la Provincia de Córdoba*, 1996). It controls the perforation, extraction, and utilization of water and dictates measures for its protection and environmental conservation. On the other hand, UNESCO (2016) warns about the increase in the dependence on groundwater in nine Asian cities, of which five (Bandung, Bangkok, Ho Chi Minh City, Hyderabad, and Tokyo) created specific regulations for that water. Bandung approved a framework that regulates the number of extractions and water fees; Bangkok’s groundwater law dates to 1977, with modifications in 1992 and 2003; Tokyo saw excessive extraction of groundwater,

which caused ground subsidence, and as a result the city created the *Law Concerning the Regulation of Pumping-Up of Groundwater for Use in Buildings*.

As a result of this, an interdisciplinary academic group attached to UNAM came up with an academic proposal to regulate groundwater in Mexico within the context of Article 4 of the Constitution; the Constitution's third transitory provision also calls for the Mexican Congress to expedite a general water law (Carmona, Carrillo, Hatch, Huizar, & Ortega, 2017). The general objective of *Ley del Agua Subterránea: Una propuesta* [Groundwater Law: A Proposal] is the protection, preservation, and control of the extraction of groundwater, through the systemic functions of the groundwater flows. Out of a total of 98 articles, two headings, 11 chapters, and eight transitory provisions, standing out is Chapter 7, "De los Acuíferos Transfronterizos" ["Of the transboundary Aquifers"], because it has a regulatory framework for those bodies. Its objective is the protection, preservation, and management of groundwater, considering these as the hydrogeological transboundary management unit,¹⁶ for which measures are established for the control of its extraction, allocation, and utilization, through equitable and reasonable use, attending to the principles of sovereignty, territorial integrity, and sustainable development, as well as elevating to the maximum the mutual benefits derived from the use of this resource, in accordance with the international instruments and the opinion of specialists.

To carry out the above, the chapter suggests the coordination between a technical-administrative Servicio Hidrogeológico Nacional [National Hydrogeological Service] and the CILA to effect the following: 1) define and assess the contribution flow systems; 2) find out the volumes of natural recharge and discharge of each aquifer; 3) evaluate the sustainable performance of groundwater; 4) supervise the allocation and sharing of water, that is, establish a precise register of the concessions on the Mexico side and create a trustworthy database that could be exchanged with neighboring nations; 5) propose water flows; 6) permanently monitor the quality of the extracted water; 7) establish early warning procedures; 8) reduce pollution coming from both point sources and diffuse sources; 9) serve as a binational forum for the diplomatic exchange of information about existing and prevailing uses of

¹⁶ The concept of transboundary aquifer of this proposal, found in Article 3 of Chapter 1, is in concordance with the definition in the draft of U.N. Resolution 63/124. It should be emphasized that in Mexico's National Waters Law, there is no definition whatsoever for this concept.

groundwater and about facilities' activities that can have a transboundary impact; 10) store, safeguard, define, validate, and approve all the facts and information that are the object of diplomatic exchange through criteria accessibility, transparency, and accountability; 11) calculate and make transparent present and future requirements of groundwater.

Similarly, the obligatory delivery of a quarterly report to the Mexican Congress is under consideration; this would show the advances in the management of the transboundary aquifers that Mexico and its neighboring nations must conduct, considering the following aspects: 1) The applicable transboundary legal framework; 2) the plans, programs, and any other instrument of sectoral, regional, and border planning, applicable in each country; 3) the identification of those responsible in each country; 4) the identification of economic and financial resources for the execution of each program; 5) the mechanisms for the standardization, comparison, validation, and exchange of information; and 6) the forms, mechanisms, and procedures for public participation in the development of the plan, its evaluation, monitoring, follow-up, and social accountability. It should be mentioned that if Mexican cannot obligate neighboring nations to cooperate with the rubric, the TAAP has already set a precedent of cooperation with the United States. The implications of this policy with relation to Guatemala and Belize are yet to be examined.

Finally, to execute the above, the powers of the CILA would be broadened in coordination with the National Hydrogeological Service to facilitate the operation of a suitable management plan for each shared aquifer. The chapter is based on the four principles cited earlier that should guide any international management plan for transboundary aquifers.

THE PROCESS OF CONSULTATION, ASSESSMENT, AND OPINIONS ABOUT THE PROPOSAL

The formulation of *Ley del Agua Subterránea: Una propuesta* took around a year and upon completion, a copy was delivered to those sectors involved and interested in the issue (public sector, private sector, academia, civil associations, and non-governmental organizations) and views or opinions were sought with the goal of gathering the comments and suggestions in order to use them to make adjustments to the proposal, with the idea that this could provide a much more enriched version that would be more worthy of a work submitted to the federal legislature.

Although it would be helpful to list all the comments received about the proposal, for the purposes of this study only those comments and suggestions specifically dealing with Chapter 7, “De los Acuíferos Transfronterizos,” were selected. Table 2 shows the number, type of actor, name, and date in which the document was delivered with its view or opinion, as well as the particular points addressed, which arrived up to the point this article was completed.

TABLE 2. Comments received from interested and involved actors in Chapter 7, “De los Acuíferos Transfronterizos,” from the Ley del Agua Subterránea: Una propuesta

<i>No.</i>	<i>Type</i>	<i>Name</i>	<i>Date of receipt</i>	<i>Comment</i>
1	Governmental	Mexican Supreme Court of Justice (Office of Minister Franco González Salas)	February 2017	It is useful to examine the North American Free Trade Agreement, as this pact brought about the Commission for Environmental Cooperation; while it contains provisions related to climatic change and precursor pollutants in general, it also could provide some rules in terms of groundwater. Furthermore, to also review UNESCO'S <i>Regional Strategy for the Management of the Transboundary Aquifer Systems in the Americas</i> , even though it deals with recommendations and is not legally binding.
2	Governmental	Instituto Mexicano de Tecnología del Agua (management)	February 2017	It is recommended that a technical-legal study be carried out to determine that there is no duplication or inconsistency in the matter of the management of transboundary waters, as there are legal frameworks such as the 1944 Water Treaty and the Helsinki Water Convention (1992) and the New York Convention (1997).
3	Civil association	Mexican chapter of the International Association of Hydrogeologists (Scientific outreach committee)	February 2017	No comment in particular.

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<i>No.</i>	<i>Type</i>	<i>Name</i>	<i>Date of receipt</i>	<i>Comment</i>
4	Civil association	Asociación Nacional de Empresas de Agua y Saneamiento de México [National Association of Water and Sanitation Utilities of Mexico] (legal office)	March 2017	Contributes a clarity of concepts and mechanisms that serve for the suitable management of transboundary groundwater, for which they must encourage the legislative branch to modify the Constitution and reform the National Waters Law, in order to resolve the problem of the intensive exploitation of aquifers that has caused a severe environmental impact, the mining of the groundwater reserve.
5	Academia	Centro de Investigaciones en Geografía Ambiental [Center for Environmental Geography Research], UNAM (Opinion of three scholars)	February 2017	No comment in general
6	Nongovernmental organization	OXFAM México (Water Project leadership)	February 2017	No comment in particular.
7	Nongovernmental organization	Agua para Todos, Agua para la Vida [Water for All, Water for Life] (national management)	April 2017	It is suggested that the management of transboundary groundwater be done through strict monitoring involving the sovereignty of these international watercourses, through the creation of citizen-governmental binational watershed councils.

Source: Author's compilation based on opinions received

The common denominator in the comments is that there is some degree of a relative misunderstanding about the issue. The above is seen in the suggestions that the specialized literature and the international instruments be consulted. In this regard, the *North American Boundary and Transboundary Inland Water Management Report* (Commission for Environmental Cooperation, 2001) refers to cooperation agreements on transboundary waters between Canada and the United States and

mentions the U.S.-Mexico case, but makes no mention whatsoever on specific procedures for the regulation of transboundary aquifers. In that sense, the 1983 *Agreement Between the United States of America and the United Mexican States on Cooperation for the Protection and Improvement of the Environment in the Border Area*, known as the La Paz Agreement, has brought about programs such as the current *Border 2020* [Programa Frontera 2020], whose second objective, *Improve access to clean and safe water*, could have to do with transboundary groundwaters, although its plan of action is restricted to improving conditions involving water and health infrastructure of the main border cities. Certainly, the management framework for transboundary aquifers from UNESCO (2015) is the text that offers the most information for the design of joint management plans; it should be noted that the proposal presented here reasserts its guidelines and principles.

Thus, it is important to carry out a technical study on legal requirements involving groundwater in relation to the 1944 Water Treaty. However, as this work has tried to make clear, the treaty is completely devoid of them, and this has been a concern for both countries, which has brought them to the point where institutions such as the CILA and the IBWC, despite their lack of powers, take part in the issue, without strictly exceeding what is stipulated in the treaty. In the case of the Helsinki Water Convention (1992), although this was modified in February 2013 for it to acquire a *global* character open to the participation of all U.N. member states, neither Mexico, the United Nations, Guatemala, nor Belize have acceded to it; the same situation exists with the New York Convention (1997). Therefore, both instruments barely function as a kind of guide for making agreements in the issue studied here. In this regard, it must be emphasized that an important set of recommendations in the *Guidelines on Monitoring and Assessment of Transboundary Groundwaters*, a document that resulted from the Helsinki Water Convention (1992), is embodied in Chapter 7 of *Ley del Agua Subterránea: Una propuesta*.

Finally, there is the proposal about the creation of binational watershed councils. They have an important presence of citizens in co-participation with governmental authorities. In the Paso del Norte region, a council has brought together water users, academics, the private sector, and government in relation to the management of the Río Bravo/Grande, in a form parallel to the watershed councils that operate in Mexico under the National Waters Law. It is of a binational character, founded under the name *Paso del Norte Watershed Council; Aqua XXI* and *Paso del Norte Water Force* (Bustillos, 2009) also are landmark organizations in the participative management of this basin. Brown and Mumme (2000) say the Binational

Watershed Advisory Council for the Tijuana River Watershed began to incorporate the participation of private and governmental actors to jointly decide about the use and allocation of these waters, which demonstrated an active participation between the binational water agencies and users, despite the existing institutional and financial asymmetries. In that sense, the recommendation of Agua para Todos, Agua para la Vida [Water for All, Water for Living], can be read in the incorporation of those social movements that are in conflict over the use and allocation of water at the border, such as in Mexicali, where there is a group against the establishment of the Constellation Brands brewery, which, no doubt, should be opposed. Nevertheless, in the case of the transboundary aquifers, it is desirable, in the first place, that the necessary conditions be created for the generation of hydrological and social information about the portion of the aquifer in Mexico, so that this information can be used to build the binational management plan for each shared aquifer. This proposal envisages that citizen participation be done through the technical groundwater councils.

On the other hand, a proposal of this nature requires, initially, a rigorous academic and institutional debate that includes all interested voices in the management and regulation of these transboundary groundwaters, both in Mexico and in those bordering countries. The case of the Mexico-U.S. border shows that population growth and the constant pressure on the sources of water supply, which have been seen more frequently since NAFTA entered into effect, can open the possibility for an important number of users and those interested in this issue to be involved in a much more horizontal process of discussion and debate. This can occur through academic or public forums on the issue where the voices of those with expertise and traditional forms of management are incorporated in addition to those with grievances about the unequal allocation of groundwater at the border. At the same time, it is also advisable to disclose the interests of those behind the actual political water allocation of groundwater. No doubt, the dialogue and the construction of a consensus between the various prevailing interests could be one of the paths that can help a public policy, such as the one that has been suggested here, be successful.

In sum, the set of comments and views analyzed help bring about an initial framework of reflection for the goals of this proposal; this will continue to occur as long as more opinions on the matter are received. For now, we await those of Conagua, the Red del Agua de la UNAM [UNAM Water Network] and the Centro

de Docencia e Investigación Económica [Center for Teaching and Economic Research], among others.

CONCLUSIONS

In the academic approach to groundwater, piecemeal methods that favor the technical and engineering perspective are the rule, bypassing other dimensions such as the political and cultural ones. Therefore, the study of groundwater requires an interdisciplinary approach, such as in the discussion framework involving the development of the *hydro-social cycle*, because it allows a timely analysis of the multiple aspects that converge in the processes of the political water allocation of international watercourses. In the case of transboundary groundwaters, as was evident throughout this work, it requires the presence of at least three closely linked conditions, which are the production of scientific knowledge, the establishment of an independent sovereign policy, and the conservation of this vital liquid.

The history of the issues that have characterized the complex Mexico-US bilateral relationship, at least during the 20th century, is marked by the negotiation and entrance into force of the 1944 Water Treaty, which establishes the political water allocation of the three shared watersheds. Also, it was possible to observe a greater interest on the part of the United States in the issue, because of the importance of the use and supply of transboundary groundwater in a context where the northern border is one of the geographic spaces that record the greatest levels of economic integration, and where that water has a leading role in that process. Nevertheless, the processes of bilateral negotiation between Mexico and the United States have not been exempt from controversy and there are frank differences in the interests underlying the form of managing these international watercourses. Indeed, Sánchez (2004) shows that in the conflict involving the All-American Canal, there has been a unilateral exercise of sovereignty of the United States in the management of transboundary groundwater from a perspective of national security; this disregards and belittles the fact that these watercourses, while scarcely visible due to their physical nature, must be considered as shared, transboundary resources, where bad water management negatively impacts one of the parties involved. This situation has brought about a still-unresolved dispute between both countries.

Surely, in the present century the political dimension of groundwater will be reassessed, not only in North America, but in the entire world because of the growing rate of dependence on it that has been documented. This means that transboundary

groundwater undoubtedly will occupy an important space on international agendas, but it will be difficult for it to be enshrined in treaties or general agreements because, as mentioned, the issue over the kind of sovereignty that must be exercised over these waters is a significant impediment for dealing with the matter.

Although the binding international instruments call on member states to come to peaceful accords in relation to their shared watercourses, neither Mexico nor any other neighboring countries adhere to these instruments. In that sense, General Assembly Resolution 63/124, *The law of transboundary aquifers*, can be an excellent guide so that Mexico can pursue bilateral agreements with respect to the issue, but it will be difficult to do so without strong domestic legislation on groundwater that would help provide the state with the necessary information for the later establishment of joint management plans of its transboundary aquifers, as was evident in the objectives the U.S. TAAP program pursued.

That is why Chapter 7, “De los Acuíferos Transfronterizos” from *Ley del Agua Subterránea: Una propuesta*, seeks the incorporation of a regulatory framework for transboundary groundwater with international watercourses shared by Mexico and neighboring countries. As seen throughout this work, the socio-hydrological characterization of these bodies, using a modern methodology such as the groundwater flow systems perspective and a suitable social analysis, must be the standard providing information so that the state can later present a comprehensive plan of binational management for each shared aquifer. In the current legal framework for national waters, such a situation is not taken into account; therefore, to achieve this constitutional change, Mexico could set an international precedent in this rubric if it strengthens the laws that govern national water.

Similarly, such actions could help strengthen the institutional capacities in Mexico in terms of the control and good governance of this water, a situation that could reduce the dismay over the prevailing asymmetries in the current management of groundwater in the country, at least in relation to the United States. At the same time, this plan provides the minimum elements necessary for the care, protection, and environmental conservation of groundwater, an element vulnerable to small changes that come from unreasonable and excessive extraction, avoiding with it transboundary conflicts that come from predatory activities that unfold in the alteration of the flows, ground subsidence, and chemical pollution, such as occurs with fracking, among other things.

Finally, also strengthening this proposal are the dynamics involving the reception of views and opinions whose valuable input allowed this study to receive feedback,

as there are plans to deliver a much more enriched version to the Mexican Congress, whose legislators could make it into a law or a chapter inserted as a constitution change to the existing National Waters Law.

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