RAPPORTEUR

United States - Mexico Transboundary Groundwater Conference
Innovation and Creativity: Strategies for Unprecedented Challenges
October 14-15, 2020

OBJECTIVE: To explore and analyze innovative perspectives of transboundary groundwater resources management between Mexico and the United States and identify strategies to assess current and future transboundary conditions from a legal, technical, environmental and managerial perspective.

Opening remarks. Rosario Sanchez (TWRI, Texas A&M), John Tracy (TWRI, Texas A&M), Adrian Pedrozo (IMTA) y Jayne Harkins (IBWC).

The current situation of transboundary groundwater resources faces legal and institutional limitations, but also lack of trust and institutional leadership. The limits of sustainability of groundwater resources are being exceeded due to limited attention, regulation and information. 20 percent of the world's aquifers are overexploited. In the northern part of Mexico and the southern part of the United States, there is a special challenge due to the arid conditions of the border and the dependence of border communities on groundwater to meet their drinking water needs.

It is imperative to work together, to develop open and inclusive spaces to generate scientific research and share knowledge in order to find binational strategies to help provide solutions to shared challenges.

There is a current political opportunity in Mexico with the creation of a new General Water Law

Keynote lecture: Climate change and transboundary groundwater systems. Christopher Milly (USGS).

It is important to integrate the diversity of physical data related to climate and environment such as temperature, reflectivity, irradiance, snow cover, precipitation, evaporation, etc., in dynamic models to generate information that allow us to understand how atmospheric warming affects runoff in the Upper Colorado River Basin. At the same time, these data has to be developed in a way that can be used by water managers, therefore avoiding the "black box" of the models, as well as possible errors in the statistics.

Although there is high variability over time in the flow values of the Upper Colorado River Basin, studies indicate that overall atmospheric temperature is decreasing runoff.

The eight CMIP5 climate models used, incorporated a series of temperature and precipitation data from 1913 to 2017 to achieve projections for 2036-2075, show scenarios in the decrease of runoff in the Upper Colorado River Basin of between 5 to 40%.

Due to higher temperatures recorded during the same period, there is greater evotranspiration, which influences a lower degree of runoff. Likewise, there is uncertainty regarding changes in rainfall, although projections also indicate that it will generally decrease.

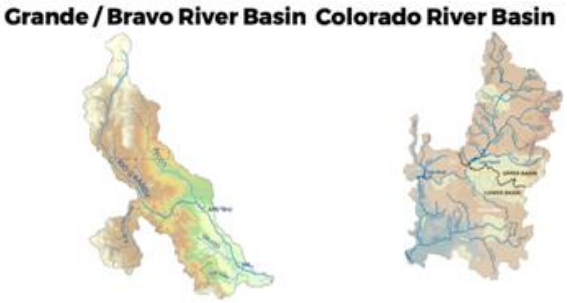
One problem identified is that there is little dissemination about the results of the studies carried out.

Discussion Panel I: Groundwater depletion and water security in the Rio Grande Basin vs Colorado River Basin. Julio Soriano (IMTA), Sharon Megdal (Univ of Arizona) y Antonio Hernández-Espriú (UNAM).

1. How does climate variability impact groundwater availability (Rio Bravo/Grande river basin vs Rio Colorado basin)?

For both, the Rio Grande Basin and the Colorado River Basin, using data from 2002 to 2020, the results indicate:

- Increase in temperature
- Decrease in precipitation, in volumes of snow cover (snowpack) and in the decrease in current flows
- Early snowmelt and runoff



As a common result, both basins experience losses in groundwater availability, largely caused by climate change and anthropogenic activities. Similarly, the monitoring of dams show a significant decrease in reservoir levels, which implies greater pressure on transboundary groundwater, mainly during times of drought.

It is noteworthy for the Mexican side, during the period 2010-2013 there were precipitation anomalies as well as an extreme drought between 2011-2013, which influence the recharge of dams and aquifers. In particular, in the middle part of the Rio Bravo / Grande Basin there is the greatest impact on natural availability, where it is expected that by 2030, the average annual precipitation will decrease ~ 2% and the average annual temperature will increase between 0,7 and 1,7 °C, while

for 2050, the average annual runoff is expected to decrease between 7,3 and 14,4%.

As there are aquifer systems with different depths in the basins, the shallowest ones, such as unconfined alluvial / karstic ones, are the most likely to be affected by climate change. It is worrisome that in Mexico the impacts on this type of aquifers are little studied, as they are the main source for domestic and productive consumption in the area, and at the same time there are experiencing more frequent droughts.

2. Does the US and Mexico need novel hydro-diplomacy and governance tools under the expected climate change scenarios (any differences between basins Colorado/Rio Grande)?

The two basins are going through a complex situation, where:

- The allocation of water exceeds the figures of the average flows of the main rivers
- There is greater extraction and demand of groundwater on the border (both from the agricultural sector and domestic use)
- There is a lack of water allocation for environmental use
- There has been no water recovery since the severe drought of the 90´s.
- Deforestation and land use change continues in the area
- There is no broad bilateral agreement on the management and use of transboundary groundwater
- Climate change offers historical records in terms of increased temperatures and less precipitation (which directly affect compliance with the 1944 treaty)

In the last 12 years, governments and social organizations have been working to achieve dialogue on transboundary waters. However, given the scenario described above, new governance tools are needed to promote regulation of this resource, so with a novel water diplomacy the following should be considered:

- Inclusion of all stakeholders in cooperation processes
- The joint monitoring, evaluation and follow-up of water uses and its cycle variables, as well as better understanding of the extent, depletion rates and quality of aquifers
- Efficiency to meet priorities
- An adaptive collaboration management
- Negotiate mutual and equitable benefits
- Make decisions with a technical and scientific basis, which implies supporting more research on the subject, including climate change factors
- Thinking of generating new Minutes within the 1944 Treaty

Likewise, existing institutions such as IBWC should try to make the most of the current minutes, such as 242 and 323, to find better opportunities for cooperation between both countries.

3. What is the role of the water-energy-food nexus in transboundary waters?

About 40% of the population lives in transboundary basins and aquifers.

Research suggests that excessive extraction of groundwater can also affect surface water availability.

Surface water plays an important role for hydroelectric power generation in the Rio Grande Basin, but groundwater is the main source of water for unconventional oil / gas energy. Especially the use of fracking requires significant amounts of water. The existence of shales in the border area intensifies the use of groundwater, particularly in Texas, where shale gas production is increasing. If Mexico decides to implement fracking, it poses a huge risk to the availability of water within the territory of the Rio Grande Basin.

Therefore, it is necessary to understand systemically the relationship between the different interests and interdependencies of the water, energy and food sectors to develop comprehensive policies that generate synergies to guarantee water protection and allow the development of the region.

4. What would you say are the key challenges when it comes to water security in the border region as a whole?

Although there is no single formula to guarantee the availability of water in the future, the courses of action would have to be focused to:

- Achieve equitable household supply, in quantity and quality, while ensuring adequate volumes in ecosystems to protect their environmental services
- Proactively manage risks to adapt to global changes, such as climate change and water scarcity
- Promote a comprehensive management model for transboundary aquifers, which involves improving governance, planning, allocation, efficient use, as well as technical-scientific coordination
- Education for transboundary water governance and cooperation, which implies the urgent awareness of both decision makers and various stakeholders (social sector, private sector, NGOs)
- Design and implementation of innovative tools for participation, awareness and conflict resolution, as well as for water supply and pollution control

- Develop more multidisciplinary studies to better understand the current conditions, as well as communication and organization among the scientific community
- Data availability such as water levels, quality, extraction rates, hydraulic parameters for evaluation
- Recognize and understand in detail the relationship that exists between the flows of shallow aquifers with deeper aquifers
- Study the feasibility of using water desalination as an alternative option
- Ensure sufficient funds for project implementation

In the case of the US, groundwater rights are managed as private property, therefore it constitutes a challenge to generate awareness about the consequences of an unsustainable use. In Mexico, complete aquifer systems must be incorporated into the management unit (transboundary connectivity), and not just under administrative political limits. At the same time, the development of more basic data on the resource, such as snow water and quality, should be strengthened.

Presentation: "Transboundary groundwater resources and potential funding opportunities". Fernando Barrera (North American Development Bank).

Financial support for water and sewage has been distributed to the infrastructure area, as shown below:

- Water supply, treatment and distribution
- Collection, treatment and reuse of wastewater
- Water conservation
- Storm drain
- Flood control

Of the main services and programs offered by the North American Development Bank are:

- Project certification. Verification of technical and financial viability, as well as its sustainability and environmental / health impacts
- Loans and financial services: Competitive rates, with terms of up to 30 years. Includes technical support, coordination and structuring services
- Subsidies:
    - Community Assistance Program (CAP): Grants of up to US $ 500,000 for public sector projects in low-income communities with priority for water and sanitation
    - Border Environmental Infrastructure Fund (BEIF): EPA-funded grants for priority water and sanitation projects within 100 km of both sides of the border
- Technical assistance. Development of institutional capacity and projects in the areas of sustainability, climate change and green infrastructure

Eligible projects must be located within 62 miles north and 186 miles south of the US-Mexico border.

Likewise, programs are needed to finance scientific research projects.

Theme lecture: The human right to water in a transboundary context. Carolina Escobar (IMTA) y Edith Kauffer (CIESAS-Sureste).

Since 2010, the UN has recognized access to water and sanitation as a human right. Likewise, this right is linked to the guarantee of other rights and to the fulfillment of the Sustainable Development Goals. Therefore, the integrated management of water resources must have this very important approach for the dignity and well-being of the transboundary population.

The 1944 treaty does not recognize the human right to water and sanitation. By including this perspective, it would imply:

- Duties of States: Respect it, protect it, promote it, guarantee it
- Regulatory criteria: Regarding the availability, quality, acceptability, accessibility and affordability of water
- Principles: Equality, non-discrimination; accountability; sustainability; participation, access to information and transparency

SDG 6 'Clean Water and Sanitation' establishes that to guarantee universal access to safe and affordable drinking water by 2030, sufficient investment in infrastructure is required, and hygiene is promoted at all levels. Likewise, the protection and restoration of ecosystems related to water, such as forests, mountains, wetlands and rivers, is needed. Greater international cooperation is also needed to achieve water efficiency and support treatment technologies in developing countries.

A bilateral hydro-diplomacy based on human rights would have to consider the prevention of conflicts, the closing of gaps between urban and rural areas, the inclusion of different actors in the different decision-making processes, as well as a basin approach.

Therefore, a binational regulatory framework is required that allows cooperation for transboundary water security with a human rights approach, which would imply the shared responsibility of prioritizing domestic and environmental use, in order to achieve regional water justice.

Theme lecture: Transboundary water ethics/tribal rights. David Groenfeldt (Water Culture Institute y University of New Mexico).

Values shape human behavior, and ethics is a basic part of the law, as it is a fundamental part of the criteria of justice. Currently the laws are no longer sufficient to achieve better management of water resources.

To change water management, social and political behavior must also do so. It is a negotiation and mediation process to achieve consensus among stakeholders on the values to follow and to implement them at multiple levels (municipal, basin, national, global), ensuring they are consistent, sustainable, inclusive and fair. This translates into a process that is born from ideas and beliefs, which end up being reflected in rules (normativity, regulations) and preferences, and applied on how water should be managed. The process of incorporating the values must also include their respective monitoring as well as resolving intrinsic conflicts.

A good example of new values to include is those addressed within water integrity, such as Transparency, Participation and Accountability. Another example of values are those included within the human right to water and sanitation.

Below are the five categories of water values:

- Environmental. Biodiversity and ecosystems health
- Economic. Employment, efficiency in its use, water sanitation
- Social. Water justice, human rights, recreation and well-being
- Cultural. Identities, meanings, relationships, heritage
- Governance. Transparency, Participation and Accountability

Ethics can guide decisions in watershed management, to achieve responsible and sustainable administration. Being groundwater an invisible resource, we must find a way to make it visible so that it can be valued. It will be a challenge to apply new ethical values in the management of transboundary waters, due to the multiple interests that exist in each country, but there may be common values that allow the development of long-term agreements and projects. Decentralization can help apply values in water management, as the local communities have the ability to make the decisions. Although assigning a price to water can allow a more rational use, this can cause the vital liquid to only be looked at from an economic perspective, omitting its social, environmental and cultural value.

Discussion Panel II: Groundwater and Surface water interactions: the case of the Colorado River Basin vs Rio Bravo Basin. Leopoldo Isaac Alaniz (UNAM), Jude Benavides (UT-RGV), Samuel Sandoval (UC-Davis) y Anita Milman (Univ of Massachusetts).

1. What are the most salient characteristics of these processes (physical, political, institutional, environmental, etc) in each international basin?

Physical:

- Less infiltration caused by the lining of the All-American Canal
- Increase in temperature due to climate change. For the Colorado basin, an increase of between 1-2 C is expected by 2050
- Reduction in freshwater and domestic flows
- Uncertain and largely unknown impact on groundwater availability
- Increased extraction from both agricultural and municipal sources
- Lack of knowledge of the flows and interactions between groundwater and surface waters

Political / institutional:

- There is a variety of aquifer regulation in both countries. In the US it is polycentric (each state has its regulations and water can be private) and in Mexico it is centralized (the federal government manages it and the water belongs to the nation)
- Groundwater is managed without considering transboundary flows
- Greater need for international cooperation in research studies with local participation and contributions

Environmental:

- Arid and semi-arid soils
- Deltas especially damaged by anthropogenic activities
- High dependency on water stored upstream (snow cover, mountain precipitation, etc.)
- Concentration of dissolved solids in Colorado river deliveries
- Deficient sanitation in the Tijuana and Bravo rivers

2. Which events were relevant to the historical evolution of these processes?

One of the first historical events that influenced both countries was the Treaty of Peace, Friendship, Limits and Settlements of 1848 (known as the Treaty of Guadalupe-Victoria), when there was the reconfiguration of the binational territories. Two events that occurred later were related to the use of binational waters, where two doctrines emerged. First, the Mexican, known as Gamboa-Vallarta in 1890, proposed a proportional use of international waters, in equal parts, while the one from the United States, in 1895, called the Harmon Doctrine, privileged sovereignty and the development of the nation to freely take advantage of the natural resource.

Both perspectives, coupled with a significant drought event during the 1930s, gave the guidelines to generate the current Treaty on the Distribution of International Waters of 1944, where minutes 242, 316, 319, 323 emerged years later, which added new binational provisions.

More recently, two influencing events were the 1994 North American Free Trade Agreement (NAFTA), and its reconfiguration, the 2020 T-MEC. Also other instruments that have impacted watershed management are the environmental flow laws and the lists of endangered species and lawsuits. Similarly, the Gravity Recovery and Climate Experiment (GRACE) mission has been generating accessible satellite data on groundwater since 2003.

Finally, at the river level, some events that had an impact on their management are listed below:

Colorado

- Hoover Dam (1931-1936)
- All American Canal (1934)
- Glen Canyon Dam (1956-1966)
- Contingency plan for drought (2019)

Bravo River

- Falcon Dam (1953)
- Amistad Dam (1969)
- Minute 289

Tijuana River

- Construction of pressure line for wastewater
- San Diego International Wastewater Treatment Plant (1997)

3. <u>What has been the U.S. and Mexican governments' role concerning these processes (policy prescriptions, agreements, projects, etc.)?</u>

The relationship between the US and Mexico has generally respected the agreements and the minutes. Institutions such as the International Boundary and Water Commission (IBWC) have been created, and others such as the North American Development Bank (NADB) and the Border Environmental Cooperation Commission (BECC) have been promoted.

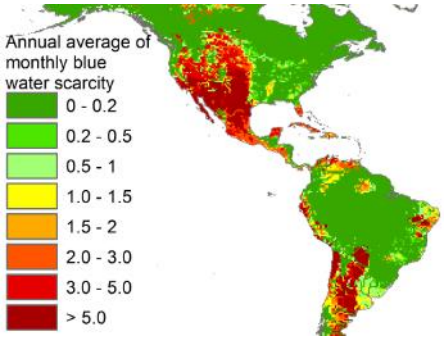
Currently, work has been done mainly on drought management, groundwater storage, application of downstream adaptation measures, and urban infrastructure projects. Both nations share the challenge of obtaining funding to implement management improvements and, on the other hand, environmental justice, since the necessary flows do not exist to fully satisfy the water demand of ecosystems and the population.

4. What actions or policies at the national or binational level could improve outcomes related to groundwater and surface water interactions in either or both basins?

- Produce more information (with emphasis on the local and downstream sections of the rivers) and its respective exchange and standardization (homologation), to improve decision-making at all levels
- Study the interaction between aquifers and surface waters
- Generate estimates of future demand in the area, incorporating climate change criteria
- Improve the measurement and monitoring of groundwater
- Promote water efficiency in irrigation (although this might increase the agricultural frontier)
- Strengthen leadership, participation, communication and understanding between both countries
- Promote a binational holistic management, both territorially and disciplinary, and promote adaptive measures
- Review and adapt current legal frameworks (propose binational / interstate regulation, establish new incentives), prioritizing shared interests
- Increase the budget for binational projects (support and integrate local projects / initiatives)
- Work towards water security and sustainability

Keynote lecture: The role of financial institutions in sustainable transboundary water management. Rick Hogeboom (Universidad de Twente)

The border region between Mexico and the United States constitutes an area of the highest pressure and scarcity. In particular, Mexico is one of the main countries that consume water at a global level and is a large importer of the liquid (virtual water), making it one of the nations with the highest average international water footprint.



Because the productive sector can be affected by water problems, which translates into investment risks, companies are increasingly showing greater interest in investing in the water sector. Therefore, it is an opportunity to finance projects related to water security. The water sustainability criteria that must be analyzed for investment

decisions, which ensure a sustainable supply, are:

- Water use efficiency (technology)
- Environmental sustainability (reforestation, pollution)
- Social equity (access and local infrastructure)
- Water accounting (status and trends of supply, demand and use)
- Public policies (implemented in the country, states)

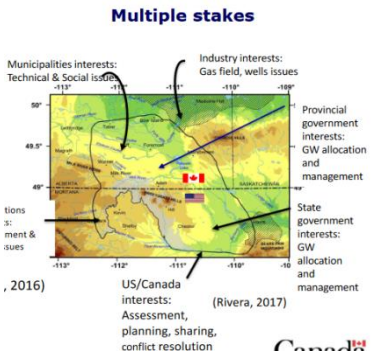
Despite the existence of good intentions, what has affected the investment process is related to the inefficiency and fragmentation of the water sector policies, which has resulted in limited understanding between the public and private sectors, and therefore, affected infrastructure development and public services that companies require to reduce their investment risks.

Solutions must be joint and long-term, accompanied by awareness-raising processes to understand the challenges and impacts of water sustainability (such as the continuity of productive operations), establish objectives and greater water accounting to help in decision-making.

Discussion Panel III: Potential Models of Transboundary Groundwater Management. Alfonso Rivera (GSC Canada), Francesco Sindico (Univ of Strathclyde Glasgow), Gonzalo Hatch Kuri (UNAM) y Deborah Van Nijnatten (Wilfrid Laurier University).

1. Transboundary groundwater resources are often complex formations that can better be described as transboundary aquifer systems. What should be the unit of management in a transboundary context? Individual formations, hydraulically related formations, the entire border, some other unit? And why?

One of the lessons learned from ISARM (Internationally Shared Aquifer Resources Management) is that it is not mandatory to integrate the entire transboundary groundwater unit to make shared decisions, since flow systems help to analyze the existence and flows of aquifers along its limits. The central point of the management unit should be the scale, due to the various factors and multi-sectorial interests.



Taking into account the temporal and financial limitations, decision makers must prioritize border sites where problems (hot spots) such as quality or quantity in the aquifers may occur.

On the other hand, there are different definitions of aquifers, of which of them seem to be different (lack of conceptual clarity). There is no standardized definition in the laws of these concepts between cross-border territories.

Management based on the hydrological system should be at the local or regional level, which includes informal mechanisms. Given the existence of fragmentation in the management of the basin, a polycentric management could be promoted. For this purpose, it will be necessary to identify the interactions between the parties within the system, integrate them in a coordinated manner and connect the different scales at the binational level. Also, it would be helpful to consider the common application of the OECD governance indicators.

2. What institutional framework(s) is/are critical to achieve a successful transboundary groundwater management regime? And at what level of governance should that framework operate – specific aquifer, local community, state, national – in order to be most successful? And why?

The framework should start from local governance for specific aquifers, with the support of both countries, including:

- Scientific knowledge for decision making
- Social participation to achieve common agreements
- Implementation of norms and policies that reinforces shared work

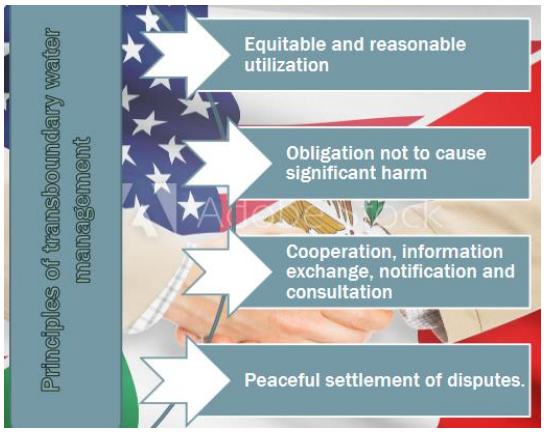
The existence of a joint authority would help in the management of transboundary groundwater, which is open / inclusive (possibility of participation), transparent (access to information) and at the most local scale possible, but with the presence of the central government.

The institutional framework must start from defining the transboundary groundwater management unit. For this it is necessary to evaluate the movement of water (recharge areas, discharge, etc.) within the system with flow models. But the challenge is to agree on which institutions will be in charge of the studies and the valid recognition of the results, the universities, the IBWC? What can be worked on in the short term is to generate an approved communication channel on groundwater (both information and laws).

Due to the political situation, innovation and the creation of new institutions is difficult. We need to work with what we have. What can be worked on is to achieve the binational scientific agreement to disseminate the situation especially for decision makers, since there is still a limitation and fragmentation of binational data. What to think about is: How to disseminate knowledge? What communication strategies should be considered? To change the system, we must inform those who are in the system. Encourage participation and involvement in management processes, and form institutional architectures that allow long-term action.

3. What regulatory mechanism should be incorporated into a management framework for transboundary groundwater resources, and how should they be implemented and enforced in the transboundary con-text?

Regulatory mechanisms for transboundary groundwater should be designed to protect water and identify and support opportunities for social and economic benefits, balancing international and multi-jurisdictional interests. The main challenge in the design and implementation of a regulatory mechanism is to make it compatible with the existing legal and institutional instruments in each nation.

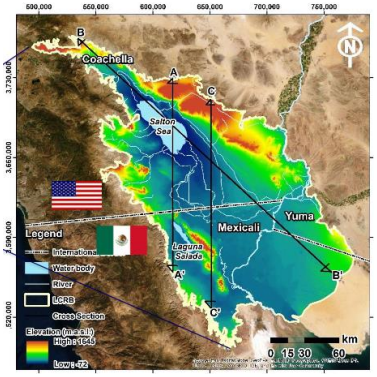


Although it could be proposed to create a bi-national institution in charge, this would have to ensure a budget and human capital to meet the assigned responsibilities. The bases of international law could serve to give the rules of operation.

On the other hand, there are already institutions that started from 1944, which could be strengthened instead of thinking of creating new ones. In Mexico, give more powers to CILA (IBWC): execute programs and plans to manage transboundary groundwater (such as research projects, validation, homologation and dissemination of knowledge), identify financial resources as well as open local spaces for participation. Open technical and legal spaces to achieve the conservation of water resources.

4. <u>Consider a specific case example of transboundary aquifers anywhere in the world, and identify the greatest challenge and opportunity to achieving binational (or multinational) cooperation among the aquifer riparians of that cross-border scenario.</u>

According to the experience in the Lower Colorado River Basin, one of the greatest challenges is the diversity of jurisdiction and practices that exist in each country. There may be an opportunity for cooperation and collaboration between science and policies for management, through the IBWC Treaty of 1944, and Acts 318 and 319, despite the lack of coverage of groundwater. Current scientific efforts include a model that integrates the interactions of aquifers with surface waters, as a first step for a joint assessment, which represents the basis for future binational cooperation.



On the case of the Agreement on the Guaraní Aquifer where Argentina, Brazil, Paraguay and Uruguay participate, began to be negotiated in 2004, and it was signed in 2010 but has not yet entered into force. Despite being considered an international example, due to the political and scientific

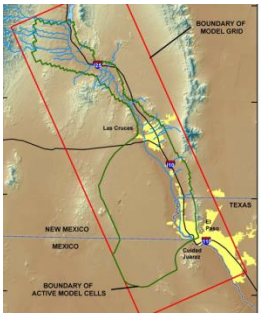
interest among all nations, it is a project that remains on paper.

Analyzing critically the example of the San Pedro River in Mexico, it is necessary to strengthen the systemic conceptualization of groundwater (which implies changing the teaching paradigm), at the same time it is necessary to promote academic programs, such as undergraduate or postgraduate degrees for the study of this matter, in order to have human capital to produce sufficient information. It is also important to strengthen the monitoring infrastructure as well as the regulations for the collection and management of information, including data banks.

Finally, the case of groundwater from the Danube River, where there is a specialized group, which generates, shares and standardizes information in networks, monitoring and reporting on the status of aquifers in the basins, as well as the implementation of strategies and goals agreed within the International Committee for the Protection of the Danube River (ICPDR).

Discussion Panel IV: Transboundary groundwater and the state of current numerical models. Alex Mayer (UTEP), James Callegary (Arizona USGS) y Randall Hanson (One-Water Hydrologic).

1. Hydrogeological numerical models are built using geological, physical or chemical boundaries; can they integrate jurisdictional boundaries too? If yes, how? If not, why not?



Although it is a challenge, the models of integrated hydrological systems can include jurisdictional limits, where restrictions are applied depending on the regulatory frameworks of each area, because across the basins there are cities, industry, commerce, tourism, national parks, etc. One of these models is the One-Watercan that works with different layers of analysis that allow including budget data.

Because borders are dynamic, they can change over time as land use, supply and demand, or jurisdictional boundaries change. Therefore, these limits could be treated as changing variables.

In the Rio Bravo for example, the RGTIHM (Rio Grande Transboundary Integrated Hydrologic Model) is used. It is managed with various 71 sub-regions including irrigation districts and wells in agricultural areas, where 80 landowners have been traced, and they understand the use and exploitation of water. Knowledge of finite water balances within models could be used in shared management practices.

2. Name the top challenges encountered in building a numerical model of an aquifer shared by two or more countries.

- Initially define a cross-border conceptual framework
- Manage asymmetries, fidelity and publication times of the information to be able to standardize the data in the different regions
- Review the methodologies, protocols and formats for the exchange and capture of information (such as automatic update models)
- Regarding information transparency policy, the ways in which institutions handle information.
- Include future demand, climatic variables, and policy changes in predictions
- Incorporate cultural and historical factors that affect in one way or another
- Being a binational challenge, the language has to be considered for the various activities and processes
- Reduce the gap of accessible information related to land use and geochemistry (halogens, stable and unstable isotopes, etc.)
- Have sufficient infrastructure equipment to operate the models

3. What physical-chemical processes should be modeled that are specific to transboundary aquifers and useful for shared management?

The factors to be included in a model depend on the objectives in transboundary water management, which should be agreed binationally, and adapted to each management unit studied. But the main ones studied are:

- Salinity. Fresh and brackish water hydrostratigraphy; flow and transport patterns in response to pumping and recharging
- Pumping. Know the magnitudes and directions of the transboundary flow that imply the depletion of the aquifer
- Interaction between aquifers and surface waters. Understand aspects such as infiltration and its impacts
- Chemical transport, such as infiltrated metals or pH variables
- Flows. From the saturated zone, from water with variable density or from fractured and karst aquifers
- Water sources. Both pluvial, superficial, groundwater, recycled
- Climate change. Temperature, precipitation, drought, fires, etc.
- Infrastructure. Dams, wells, irrigation, drainage
- Demand and supply

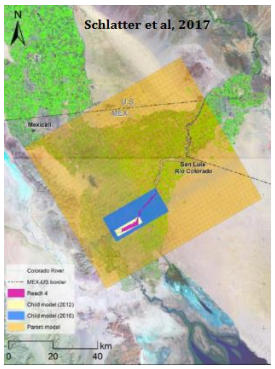
In conclusion and clearly, the state of the numerical models built in the transboundary context is far from ideal for the multiple existing factors and where

great collaborative efforts are required. However, numerical models are perhaps the best tools to support shared management of transboundary groundwater.

4. Provide a real example of a transboundary aquifer model anywhere in the world that has been successful as a management tool, an information tool, or a data-integration and harmonization tool. Or all of the above.

The model of the Genovese Transboundary Aquifer between Switzerland and France shows the respective payments that have to be made to each nation, for example, in terms of groundwater recharge. Various factors are included such as infrastructure operating costs, depreciation costs, pumping, fees, among others.

Similarly, a study carried out in the Colorado River Delta to determine the riparian spatial extension in Mexico that can be sustained by groundwater in various altered water scenarios is noteworthy. For this, a modeling of the depth of groundwater was carried out, considering environmental flows, agricultural return flows, upstream subsoil inputs and evapotranspiration. One of the results was that groundwater is vulnerable to decisions made in irrigation districts.



Likewise, the Rio Grande Transboundary Integrated Hydrologic Model (RGTIHM) already addressed in this conference, has been able to contribute with the analysis of the impacts of climate change in the area, as well as the evolution of water demand, especially in the agricultural sector. Finally, this tool can also help to simulate the reuse of water, as well as the deliveries that have to be made to Mexico derived from the 1944 treaty.

Final remarks

The current situation of transboundary groundwater resources faces legal and institutional imitations, but also a lack of trust and lack of leadership.

There is no broad bilateral agreement on the management and use of border groundwater.

It is extremely important to strengthen open spaces to analyze these types of issues and disseminate scientific information.

The sustainability limits of groundwater resources are being exceeded. Its attention is urgent based on scientific knowledge, but with social and political consensus.

Monitoring of reservoirs shows a significant decrease in storage levels (there are precipitation anomalies), which implies greater pressure on transboundary groundwater, primarily in times of drought, which now are longer and more intense.

Climate change is affecting the availability of water and setting historical records, therefore it is an incentive to reformulate the management of transboundary waters. It also implies a challenge for data collection.

The shallowest aquifers, such as unconfined alluvial, are the most likely to be affected by climate change, and are currently being used as sources of supply at the border.

The natural recharge and availability of aquifers decreases. Can desalination be a viable alternative?

The climatic trends and water availability in the area are not favorable. Moreover, increase in population and demand due to economic activities driven by the agricultural and energy sectors (many supported by agreements such as NAFTA, or the T-MEC), put additional pressure on the available resources for future use.

The resilience of hydrological systems is highly dependent on regional groundwater systems and their response to climate variability.

While approaching watersheds as a system can be important, working at each scale is essential to address the diversity of problems, interests, resources, and jurisdictions.

Understanding the relationship between water, energy and food is crucial for a new hydro-diplomacy and for generating appropriate policies (finding synergies and using economic treaties).

Both agriculture and fracking especially in the US, puts great pressure on aquifers (look for alternatives in the area). It implies a revision on current regulations and its environmental impacts in the region.

The governance of transboundary aquifers could be worked under adaptive cooperation to current conditions, using existing institutions and laws to find opportunities and negotiate mutual and equitable benefits for the preservation of the resource (agree on acceptable limits of the water footprint).

Despite the diversity of water regulation among both countries, it is crucial to improve planning, allocation, efficient use, as well as technical-scientific coordination of transboundary water management.

Promote urgent awareness on the subject at all level and scales. Managing potential risks on time can prevent the appearance of conflicts that affect the region economically and politically.

There is an important information gap (such as knowledge of the flows and interactions between groundwater and surface waters) and fragmentation of data and studies. The current dissemination that exists on the results of the various scientific studies is insufficient; therefore, it does not have the impact to generate the necessary changes.

In the same way, it would help to standardize the concept of groundwater, define management units (knowing their flows comprehensively and systemically) and generate estimates of future demand in the area.

Hydrological systems models can be one of the best tools for water management, but it faces information limitations (the use of the black box must be avoided as much as possible). It also faces challenges related to the incorporation of other changing factors such as legal, institutional, social, historical and political variables to achieve a holistic and flexible analysis, and serve as a decision tool at different time scales.

Securing funding for transboundary water research and projects is still a challenge, due to insufficient interest - or ignorance of the problem - from the political and private sectors.

The economic sector is one of the main consumers of water, it must work together to generate investment projects in terms of water security, how to include them and hold them accountable?

There remains a double challenge for the academic sector: Share and standardize multidisciplinary information on transboundary groundwater (coordination); make knowledge known to society in general and decision makers (communication).

It is necessary to have a common language between the academia, the political and social sectors. Citizenship and scientific participation should be promoted to form innovative architectures that allow long-term action including informal mechanisms.

Transboundary wter management must include a foundation on the human rights to water and sanitation, which is in part a new management ethic and administrative and political culture to promote water justice at the border.

More educational programs should be supported in academic centers that address the problem of transboundary basins that integrate both surface and groundwater. It will help to promote shared indicators of governance of transboundary waters.

The main challenge in the design and implementation of a regulatory mechanism is to make it compatible with the existing legal and institutional instruments in each nation.

Binational management can possibly be initiated at critical points (hot spots), where there may be conflicts or where the greatest environmental damage is identified.

Although an update of the 1944 treaty, its existing laws and policies may be desirable, the feasibility of this to happen is limited and would possibly require the creation of new institutions. Therefore, in the short term, it is necessary to work with institutional experience. Strengthen and give new powers to the current institutions involved, such as the International Boundary and Water Commission (IBWC), and the North American Development Bank (NADB).

Questions for the Scientific Community

Many questions remain to be answered, but undoubtedly, there is a great opportunity to strengthen the binational management of our transboundary waters, to achieve the justice and water security that is needed in these times of climate and political uncertainty. This enormous challenge can be a great door to foster the friendly relationship between Mexico and the United States, and to set a democratic example in global hydro-diplomacy.

After the analysis during the two days of the conference, ideas and proposals for transboundary groundwater management emerge, but at the same time, questions also arise that the scientific community has to reflect on before proposing strategies for the future.

Some of the questions that should be answered in this collective exercise of both reflection and action are:

1. Is there currently enough scientific leadership to push the issue of transboundary groundwater on the political agenda of both countries?

2. Has the scientific community established a balance between the ideal and the possible, considering the budgetary / institutional / legal limitations as well as the current political interests?

3. Are scientists using a common, accessible and strategic language with decision makers?

4. Is the scientific community clearly communicating the political and economic benefits that would arise from the implementation of the technical / scientific solutions that are being proposed?

5. Are communication campaigns being developed with local / regional populations and organizations, as well as with the private sector, the media and with sub-national governments?

6. Are scientists training in lobbying, public policy advocacy, or effective communication strategies?

These questions can lead us to new possibilities and at the same time pose new challenges. For example, getting out of the academic spaces and achieving greater territorial impact, through communication and awareness directed to local socio-environmental organizations, as well as to municipal governments along with the private sector and the media. The push on the issue of border waters requires reaching high levels of decision, to achieve equity and binational water security.

Along this path, academics and experts must agree on priorities and be willing to negotiate and compromise, between what is possible in a given context, and what is ideal or desirable. Scientific proposals could have a greater scope to the extent that they also have some kind of political, economic or social benefit, that is, positive results that governments can show and that contribute to their legitimate interests and in their development plans. In this way, greater communication and support for science will be promoted in favor of decision-making in the matter of water.

Our proposal

The Permanent Forum of Binational Waters proposes the creation, promotion and development of the Binational Groundwater Task Force whose mission is to define the objectives and priorities of the Forum and the scientific community in general in matters of transboundary groundwater, both in research and social scope, institutional and communication to the different sectors of society.

Its general objectives will be based on the definition and configuration of the values that govern shared groundwater water resources:

1. Define the values of the basin, what do we assign a value to?

2. What are the threats to those values?

3. What are the priorities and the order of those priorities?

The specific objectives will be defined by the TBA-TF according to the mission and redefinition of priorities.

At the same time, the Forum will convene interested moderators and panelists to be part of the scientific publication planned by the organizing binational institutions and that will integrate both the results and the reflection questions. The overall objective is to raise awareness from a binational perspective to the border community on the importance and attention to our shared groundwater resources.