VOLUME:4 | ISSUE:2 | DATE: DECEMBER 11 2023 | EDITOR: ALFONSO RIVERA | COORDINATION: MARIE-AMÉLIE PÉTRÉ & CHRISTINA FRASER | DESIGN: ROSARIO SANCHEZ

NEWSLETTER

International Association of Hydrogeologists

IAH TRANSBOUNDARY AQUIFERS COMMISSION

EDITOR'S MESSAGE

Alfonso Rivera
Chair, TBA Commission

As we approach the end of 2023, we reflect on the so many events, congresses, workshops, webinars, and many other types of happenings on groundwater, which have occurred this year at national and international scales.

Once gain, groundwater was in the news and a good chunk of this was related to sharing aquifers or transboundary groundwater.

In this newsletter, we summarize the events with news and information on what we believe are most relevant in relation to transboundary groundwater and aquifers. We try to balance between scientific, social, and policy-related information on this increasingly growing domain.

We have our usual sections on ISARM networks, events, people in the news, knowledge capsules and recent TBA publications.

We are proud to mention that the IAH Transboundary Aquifers Commission actively participated in many of those events throughout the year.

We had a very successful year and 2024 promises to be even more exciting.

The TBA Commission's team wishes you a very happy and successful 2024.

Good reading!

WHAT'S INSIDE THIS ISSUE:

Global workshop "Conjunctive Management of Surface Water and Groundwater: National to Transboundary Level" (16 – 17 October 2023, Geneva and online)

By Alfonso Rivera

The Transboundary Aquifer Commission was invited to partner with UNECE in the organization of the Global Workshop on conjunctive management of SW and GW from national to transboundary level. This event organized under the leadership of the Ministry of Climate of Estonia, the Ministry of Natural Resources and Spatial Planning of the Republic of Slovenia; other partners included:
UNESCO, the United Nations Economic and Social Commission for Western Asia (UNESCWA), the International Atomic Energy Agency (IAEA), the Finnish Environment Institute (SYKE), the International Groundwater Resources Assessment Centre (IGRAC), the Regional Centre for Groundwater Management in Latin America and the Caribbean (CeReGAS), the Sahara and Sahel Observatory (OSS), the Environment Agency Austria (UBA), GEF IW:LEARN and other organizations. The Global Workshop WAs funded by the governments of Finland, Sweden and Switzerland as well as GEF IW:LEARN.

Questions addressed during the workshop included:
▪ Why is conjunctive management of surface water and groundwater useful and what are possible benefits and challenges in its implementation?
▪ How can conjunctive management be implemented in transboundary settings? How can it foster and advance transboundary water cooperation?
▪ What are the success stories and lessons learned in implementing conjunctive water management practices in national and transboundary settings?

Some members of our commission participated in person, others online.
The photo shows members of the TBA commission and other IAH members. The IAH was acknowledged by the two co-chairs of the workshop and by the UNECE secretariat for “the great support provided in preparing the programme of the workshop and for providing valuable presentations and for the working-groups coordination during the workshop.

The Permanent Forum of Bination Waters (PFBW) launched a Transboundary Aquifers Pilot Program along the USA/Mexican border

By Rosario Sanchez and Afonso Rivera

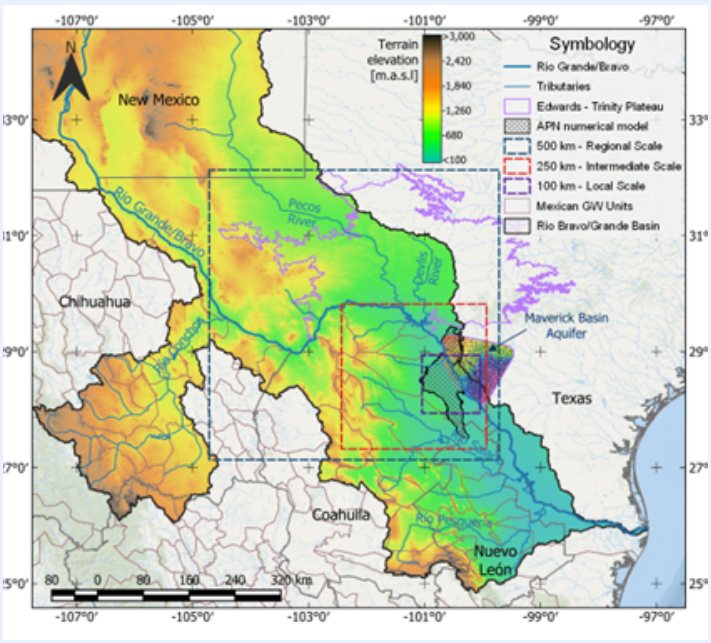
The 21st century sees the U.S.-Mexico borderlands facing an emerging array of water-resources management challenges. These challenges range from the increasing demand of water due to urbanization, industrialization, and agricultural expansion. This growing demand strains the capacity of limited water supplies to deal with a host of social, legal, and environmental issues threatening surface and groundwater quality and security. Droughts across the region, already decades-long, are likely to continue and intensify, and constrain even further the ability of the parties to meet water delivery obligations in the Colorado and Rio Grande rivers (Coronado et al. 2021, Renteria et al. 2022).

It has become very clear that meaningful collaboration on transboundary waters is required of both countries.

The need to regulate groundwater between Mexico and the United States requires information and research. **The Transboundary Aquifer Pilot Program** offers an alternative and an opportunity to improve our shared

knowledge on transboundary groundwater resources, but also to engage stakeholders in the research process. This effort will initiate work at the Allende-Piedras Negras transboundary aquifer and aims to develop a community-based model that will expand from the physical and numerical analysis to the social, economic and transboundary implications.

Key partners in this specific research have been gathered into a core group, which provides support, endorsement and guidance on how to assess both the physical technical endeavours as well as the policy and social science analysis. Most of the organizations in the core group address the restoration and conservation of the environment, through interdisciplinary research, and the sustainable use of water resources shared by the United States and Mexico; they are allies of the Permanent Forum of Binational Waters.



ISARM Africa
TBA News

Contributed by Kevin Pietersen

SADC-GMI completed the Khakhea/Bray Dolomite Transboundary Aquifer Biodiversity

The Khakhea/Bray Dolomite Transboundary Aquifer (TBA), shared between Botswana and South Africa, is experiencing increased abstraction for agriculture and domestic use. The study, funded by the JRS Biodiversity Foundation, sought to provide cause-effect relationships between changes in groundwater quality and groundwater levels and the changes in the biodiversity of the groundwater-dependent ecosystems (GDEs) in the TBA. The study identified and delineated GDEs' spatial extent using Sentinel-2 MSI-derived spectral indices and the analytical hierarchy process (AHP) in the GIS environment in Khakhea–Bray Dolomite TBA. This method integrated a multicriteria process based on expert opinion, GIS techniques, remote sensing and fieldwork. Additionally, it included geospatial information, including land-use and landcover (LULC), topographical parameters such as topographic wetness index (TWI), slope, curvature and flow accumulation, multispectral indices such as normalised difference vegetation Index (NDVI) and modified normalised difference water index (MNDWI). The method to delineate GDEs is transferable to other arid and semi-arid environments.

The study provided scientific insights into the evolution of the pans (figure). Theoretical consideration and field observations show that the pans are typical landforms in the karst environment formed mainly on the dolomite outcrops from the dissolution of carbonate minerals. The study team concluded that most of the pans' formation or occurrence is unrelated to the groundwater discharge process. However, some pans appear to occur in the groundwater discharge zone as controlled by geology. Most of the pans are located above the confined dolomite aquifer and could be sources of groundwater recharge where preferential flow paths exist. The study team derived these findings from the hydro-geophysical investigation encompassing desktop study, field observations, electric potential difference – audio magnetotelluric (EPD – AMT) surface geophysical survey, and stable isotope analysis.

Pan wetlands in the Khakhea/Bray Dolomite TBA

ISARM Americas TBA News

Contributed by Lucia Samaniego

ISARM Americas Program Meeting

From September 10 to 13, the meeting of the UNESCO ISARM Americas Program was held in Rio Quente, State of Goiás, Brazil, where representatives from 17 countries participated.
Each participating country made a presentation of their Transboundary Aquifer Systems and exchanged ideas on future actions.

The member countries of the UNESCO ISARM Americas program working group, 20 years after its launch in the region, emphasized the strategic and critical importance of groundwater for sustainable development and the urgency of guaranteeing its adequate management and governance, particularly under the current context of climate change.

Likewise, they reaffirmed their willingness to cooperate to understand transboundary underground water resources; and support the preparation and publication of the synthesis of knowledge of Transboundary Aquifer Systems in favor of sustainable management, adopting policies and practices that preserve the quality and quantity of water, as well as its capacity for natural regeneration.

Finally, they confirmed the interest in collaborating with education, dissemination and public awareness about the importance of transboundary aquifer systems and the challenges they face.

OPINION – THE WATER CRISIS IN GAZA IS NOT NEW

Contributed by Alfonso Rivera

For sure, the current crisis between Israel and Palestinians exacerbates the water crises in the Gaza strip. But war crises or not, the water crisis is not new in the Gaza strip.
It is a combination of physical water scarcity with transboundary cooperation, or lack of.

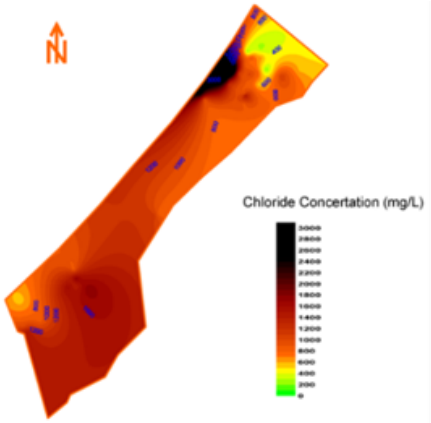
The UN says approximately 2 million people in Gaza may soon run out of water because Israel has shut off supplies. After attacks by Hamas militants, Israel has cut off water and electricity to the region for more than a week, exacerbating a water crisis years in the making.

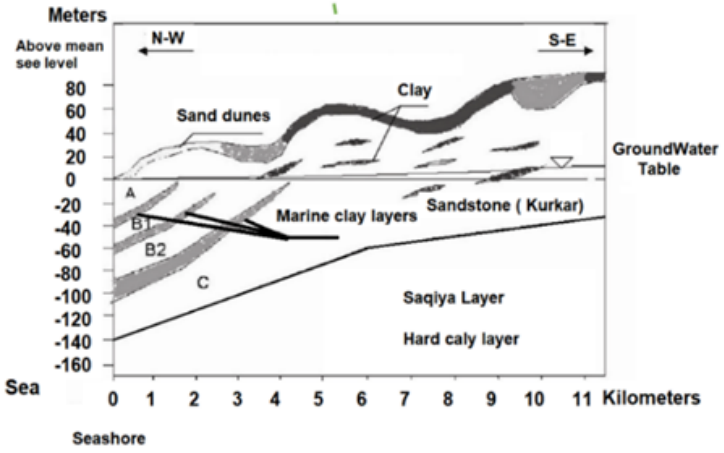
In fact, Gaza has struggled with a water crisis for decades. The region – one of the most densely populated in the world – has no reliable source of surface water. Its only main freshwater supply is a shallow aquifer. Over-pumping from Gaza and surrounding countries, including Israel, has severely depleted the aquifer in recent years, increasing its salinity. Seawater intrusion, wastewater and agricultural run-off have also contaminated it. The UN says that 97 per cent of the aquifer's groundwater doesn't meet World Health Organization water quality standards. As a result, most of Gaza's population relies on private water tankers and small-scale desalination plants to supply drinking water.

Prior conflicts with Israel have also severely damaged Gaza's water system. In recent years, Israel and Egypt have also restricted the import of equipment needed to maintain water infrastructure, including water pumps. This, along with a lack of investment, has prevented Gaza from making repairs meaning the region's water system was outdated and incapable of meeting demand even before the current crisis. According to Peter Gleick (Pacific Institute), "The conflict is disrupting already unreliable water availability in Gaza for millions of people."
Thus, physical water scarcity, political conflicts, and lack of transboundary support/cooperation are the reasons why the region is so vulnerable to water crises.

Water is vital for survival, but it may become a powerful weapon to control peoples too.

Sources:
Newscientist, October 2023
Seyman et al., Water 2020, 12(8), 2218; https://doi.org/10.3390/w12082218
U.N., 2019
Water Global Practice, 2018





OPINION – Out of sight, out of mind, out of water
Contributed by Gabriel Eckstein
(extracted from its original publication by Reforma Mexico Today)

As climatic changes continue to grip the American Southwest and precipitation declines, communities across the U.S. Mexico border are not looking to the skies. Rather, they are turning their eyes to the ground below them, specifically to the numerous aquifers that cross the frontier. Unfortunately, a dearth of information, lack of monitoring, and near absence of cross-border cooperation make it unlikely that the region's last vestige of native water will quench their growing thirst.

Hidden all across the frontier, from Baja to the Gulf, more than seventy subsurface formations holding precious groundwater crisscross the Mexico-US border. For many border communities like Ciudad Juarez in Chihuahua, Ciudad Acuna in Coahuila, Del Rio in Texas, Nogales in Sonora and Arizona, and a dozen others-the water in these transboundary aquifers is the only reason they continue to survive the parched frontier.

Despite this heavy reliance, information about these resources is desperately lacking. Few aquifers have been explored or monitored, and scant information is available on the origins of the water, as well as their recharge rates, the extent of withdrawals, chemistry, flow rates, direction, dependent ecosystems, and much more. What is known is that many of the aquifers along the frontier are being overexploited as populations and industries expand, with little regard for sustainability or cross border consequences. Moreover, many are polluted due to poorly regulated-orunregulated agricultural land municipal runoff, industrial waste, and mining activities.

More troubling, though, is the reality that the two nations have yet to ink an agreement addressing how these underground resources might be managed, shared, exploited, or protected. In fact, groundwater has long been n neglected Mexico-US political relations. Transboundary aquifers are excluded from the existing treaty regime, rarely appearon the binational agenda, and have only sporadically received the focus of federally funded research. Without cooperation, these resources are doomed to dwindle, jeopardizing the viability of the region's communities, economic growth, and environment.

As temperatures continue to rise and droughts become more widespread, there is an urgent need for action on the region’s transboundary aquifers. Information on the borderregion's groundwater is desperately needed, especially for those aquifers underlying cities and communities that depend on the subsurface resources for their survival.

That information must also be sharedand exchanged between the two neighbors, especially among stakeholders, local and regional leaders, and academics.

In addition, where rivers do traverse the frontier-such as the Rio Grande, Colorado River, Tijuana River, San Pedro River, and Mimbres River-information on the hydrological relationship that those rivers have with surrounding aquifers must be exploredto better understand how they influence each other.

The two countries and the borderstates should also come to terms with administering these shared resources, especially their allocation, and protection. Ideally, becauseevery subsurface formation tends to function differently, Mexico and the U.S. should develop aquifer-specific rules, policies, and procedures for the most critical aquiferson the border. If that is not possible, at the very least, they should developprinciples and priorities to guide them in managingthese critical freshwater resourcesunder drought conditions.

Lastly, the two nations should facilitate public participation in the decision-makingprocess, especially from local and regional stakeholders. Groundwater use is a local activity. Local institutions and communities may not always have the resources or technical knowledge to address broad and scientifically complex transboundary challenges, yet they are typically betterinformed about localcross-border needs and challenges. They are also likelyto be more responsive and adaptable to evolving environmental and economic circumstances.

Relying on the Rio Grande, Colorado River, and the other rivers that cross the Mexico-US frontier is no longer an option. Overallocation and climate change-driven droughts have madeit a foregone conclusion. If theborder region is to havea future, it lies underground in its aquifers.

Special session on groundwater governance and management in Transboundary Aquifers; IAH 50th World Congress Cape Town

by Kevin Pietersen

The Congress theme for IAH 50 was Groundwater: A Matter of Scale, exploring the connectedness of groundwater to the earth and human system. The participants discussed groundwater issues, techniques and solutions to improve access to safe and sufficient water and sustainably manage groundwater. In addition to plenary and invited speaker presentations, there were poster presentations, exhibition booths, special sessions including a session for young professionals, and scientific presentations covering every aspect of hydrogeological sciences. We had various Commission and Networking meetings taking place. The participants benefitted from interacting with colleagues from around the world. There were 500 delegates from 53 counties. A special session on groundwater governance and management in Transboundary Aquifers was held, including presentations and panel discussions. The programme was as follows:

Presentations:
- J Sauramba., G Mundondwa., B Gwangwawa., K Pietersen: Inculcating TBA governance in SADC – The SADC-GMI experience
- A Rivera., M Pétré., C Fraser., J Petersen Perlman., R Sanchez., L Movilla., K Pietersen: Why do we need to care about transboundary aquifers, and how do we solve their issues?
- G de los Cobos: Radical evolution of the Geneva transboundary aquifer agreement: an example for the sustainability of TBA governance
- B Gwangwawa., J Sauramba., K Pietersen., G Mundondwa: The current policy, legal and institutional framework for groundwater governance in SADC

Panel discussion:
- D Mndzebele., SADC-Water Division., G de los Cobos., GESDEC-DT - Canton of Geneva, Switzerland., B Gwangwawa., Environmental and Social Management Specialist, SADC-GMI., J Sauramba, Executive Director, SADC-GMI

Audience discussion

Challenges of transboundary aquifers in the XXI century, UACH

by Alfonso Rivera

The University of the State of Chihuahua, Mexico (UACH) organized a workshop on the Challenges of Transboundary Aquifers of the XXI Century. Alfonso Rivera was invited to deliver a lecture and a workshop to the Faculty of Engineering UACH. It was a hybrid event, in presential and via Zoom.

The talks were given in Spanish, but most of the slides were written in English.

On the first day, I delivered a 60-min conference on: ""State of affairs and knowledge of the transboundary aquifers at the global scale and in North America: the Canada-United States experience"

On the second day, I combined a workshop and a dialogue including quantitative exercises, with theme: "Status and Knowledge of Transboundary Aquifers in North America: challenges along the U.S.-Mexico Border"

My lectures had a great success judged by the number of participants. Both my keynote speech and lecture/workshop attracted more than 200 people, students, professors, and public at large. Circa 50 other people joined by Zoom from various parts of Mexico, Canada, USA, Chile, Uruguay, Afghanistan... It seems that the issue of transboundary waters attracts a lot of attention.

PEOPLE IN THE NEWS
by A. Rivera

Professor Emilio Custodio – Rest in Peace

My HOMAGE to EMILIO CUSTODIO

Emilio Custodio was a pioneer in hydrogeology in the Spanish-speaking world. He was highly recognized across the globe for his multiple contributions to groundwater sciences in at least three languages, Spanish, English and French.

His 1976 two-book compendium, which he wrote with another big (the late Ramon Llamas), was and still is a reference in the Spanish-speaking world.

Un gran hombre y un gran amigo. QEPD.

Sharon B. Megdal
Ph.D. is Director of The Water Resources Research Center (WRRC), The University of Arizona.
Other primary titles are Professor and Specialist in the Department of Environmental Science, C.W. & Modene Neely Endowed Professor, and Distinguished Outreach Professor.

Sharon Megdal aims to bridge the academic, practitioner, and civil society communities through water policy and management research, education, and engagement programs. The geographic scope of Dr. Megdal's work ranges from local to international. Applied research projects include analysis of water management, policy, and governance in water-scarce regions, groundwater recharge, and transboundary aquifer assessment.

She is the lead editor of the book, Shared Borders, Shared Waters: Israeli-Palestinian and Colorado River Basin Water Challenges. She has guest edited several special journal issues, the most recent entitled Advances in Transboundary Aquifer Assessment. Dr. Megdal teaches the graduate course "Water Policy in Arizona and Semi-arid Regions". In 2020, she was awarded the Warren A. Hall Medal for lifetime achievement in water resources research and education by the Universities Council on Water Resources.

New faces in the TBA Commission

The TBA Commission welcomes two new members in its team, increasing the commission members to 17 individuals from four continents. Welcome Constanza Mass and Alice Aureli!

Constanza Maass Morales

Constanza is a PhD candidate at the IHE Delft Institute for Water Education and Delft University of Technology (TU Delft). Her research interests include Transboundary Aquifers (TBAs), cross-border groundwater impacts, and hydrogeological tools (numerical modelling and GIS-risk index) to support Water Diplomacy.

Alice Aureli

Alice holds a Ph.D. in Hydrogeology. She has worked in the secretariat of the UNESCO Intergovernmental Hydrological Programme since 1989. She recently retired from UNESCO where she occupied the position as Chief of the UNESCO Groundwater Sustainability and Water Cooperation Section.

She was in charge of the coordination and implementation of the ISARM UNESCO activities. From 2002 to 2010 she led the UNESCO experts' group that advised the UN International Law Commission in the preparation of the Draft Articles on the Law of Transboundary Aquifers. An important aspect of her work has been on scientific and policy-related issues surrounding groundwater governance. Alice is the author of a large number of publications and has also served as editor of various international journals.

The TBA commission warmly welcomes Alice!

TAAP USGS 5-year plan by Rosario Sanchez

The Transboundary Aquifer Assessment Program Act where the states of Arizona, New Mexico and Texas commit to keep working together on the assessment of transboundary aquifers between Mexico and the United States, has been develop and submitted as part of the reauthorization of the program by the United States Congress in 2023. The plan expands by large its original purpose: to assess four main priority aquifers in the (US-Mexico border region: San Pedro and Santa Cruz between Arizona and Sonora, and La Mesilla and Hueco-Bolson between Texas, New Mexico and Chihuahua.

The 2023-2027 strategic plan covers five main tasks:
1) Stakeholder Engagement and Capacity Building, 2) Socio-Economic Context, Governance, and Policy, 3) Binational Groundwater Atlas (Data Management, Mapping, and Visualization), 4) Aquifer prioritization and vulnerability assessment: prioritization of transboundary aquifers for study, and 5) Hydrologic Studies to Understand Water Availability Challenges Facing Transboundary Aquifers – Stressors from Population, Industry, Agriculture, Drought, and Climate Variability.
According to the new TAAP overarching framework, a more ambitious and interdisciplinary research work is expected.

Case Study Informal cooperation on the hydrogeological assessment of the Milk River Transboundary Aquifer by Marie-Amélie Pétré and Alfonso Rivera

A new publication on good practices and lessons learned in transboundary data exchange is currently being prepared by the Convention on the Protection and Use of Transboundary Watercourses and International Lakes (UN Water Convention). The publication will be a collection of cases accompanied by text that highlights the lessons learned with reference to good practices on the data and information exchange as collected in the cases.
The IAH Transboundary Aquifers Commission was invited by the Water Convention to submit a case about current practices on transboundary data exchange using a predesigned template and contribute to the development of the publication. Our commission submitted one case using data and information of the Binational Groundwater Task Force (BGTF) of the Permanent Forum of Binational Waters, as presented in the previous Newsletter.
A second case was recently submitted by Marie-Amélie Pétré and Alfonso Rivera on the Informal cooperation on the hydrogeological assessment of the Milk River Transboundary Aquifer shared by Canada and the USA. If interested, a copy of this new template may be obtained by a simple request to Alfonso Rivera at aguasub7@gmail.com.
All the data and models of this case are publicly available through two open file reports, a PhD thesis, four scientific publications and a project website. This hydrogeological assessment constitutes a common scientific knowledge base of the aquifer across the Canada-U.S. border, a prerequisite towards joint management plans. The project on the aquifer assessment has ended, but its legacy is well alive for a number of stakeholders. Even in the absence of formal agreements, conversations and data exchange continue towards a shared management of the aquifer.

10th SADC River Basin Organisations / Shared Watercourse Institutions (RBOs/SWIs) Workshop held in Maputo, Mozambique, October 2023

The SADC RBOs/SWIs Workshop is a biennial platform organised to engage RBOs as a vehicle for strengthening regional integration and cooperation. SADC-GMI hosted a session at the workshop entitled "Enhancing conjunctive water resources planning, development, and management through integrating groundwater governance in RBO/SWI structures. The modality of the workshop included presentations and panel discussions. The presentations focussed on the institutional strengthening of RBOs in TBA governance and lessons learned from the SADC-GMI experience. The workshop allowed for implementation agreements with the Komati Water Basin Authority and the Incomati and Maputo Watercourse Commission.

TBA Commission website (by Arnaud Sterckx)

Since June 2023, the TBA Commission operates its own website: https://tba.iah.org/. News and events are published there, as well as the newsletters and the knowledge capsules on transboundary aquifers. Should you have material for the website, contact the administrators: Marie-Amélie Pétré (marieamelie.petre@gmail.com), Alfonso Rivera (aguasub7@gmail.com) and Arnaud Sterckx (arnaud.sterckx@un-igrac.org).

KNOWLEDGE CAPSULES ON TBA
by A. Rivera

In previous issues of the Newsletter, we have defined various terms as they are used and applied in the domain of transboundary aquifers; you may find these in the link below this section.

In this issue, we add two other terms to narrow the scope of our main goal on the knowledge of TBA: aquifer classification, and groundwater / surface water interactions.

Aquifer classification (readapted from Rivera et al., 2018)

Aquifers can be classified in many different ways, including size, depth, geographic setting, water yield, rock or sediment type; as well as hydrologic characteristics such as groundwater flow and pressure conditions.

The material the aquifer consists of is most commonly used to group aquifers. In its simplest form, this provides three broad categories: sedimentary rock, igneous and metamorphic rocks, and Quaternary sediments. We can further simplify the classification on two categories by grouping sedimentary and igneous and metamorphic rocks into “consolidated”, thus the aquifer categories would be unconsolidated or consolidated.

This broad classification of categories of aquifers is based on geological conditions; however, in addition to the rock (reservoir) an aquifer also contains a fluid (groundwater); thus, we propose to further classify aquifers using hydraulic conditions (physics, flow systems) by using and important variable: hydraulic pressure (p), or hydraulic head (h), as a function of

space and time. This second classification will be very helpful in supporting the definition of groundwater flow systems in future works, in particular, when defining zones of shared management of TBA.

For a rock formation to be considered an aquifer the water in it is every bit as essential as the rock. Thus, the classification we propose herewith is twofold; as a first step, the geological conditions and the hydraulic conditions are separated conceptually in order to organize knowledge and knowledge gaps of aquifers and groundwater.

The complexity of the geological conditions is simplified as a first attempt into a general overview using categories and sub-categories:

Categories:
· Unconsolidated
· Consolidated

Sub-categories:

- Unconsolidated:
  - Alluvial sediments (valleys and plains, deltaic and littoral sediments)
  - Glaciofluvial sediments (eskers, fans, plains and terraces)
  - Glacial deposits
- Consolidated:
  - Clastic (Sandstone-dominated)
  - Carbonate (Limestone-dominated)
  - Shale interbedded with clastic or carbonate
  - Interbedded lithologies
  - Fractured Crystalline-Volcanic

Furthermore, hydrogeologists generally recognize four basic types of aquifers based upon de the groundwater's relationship to the surface environment.

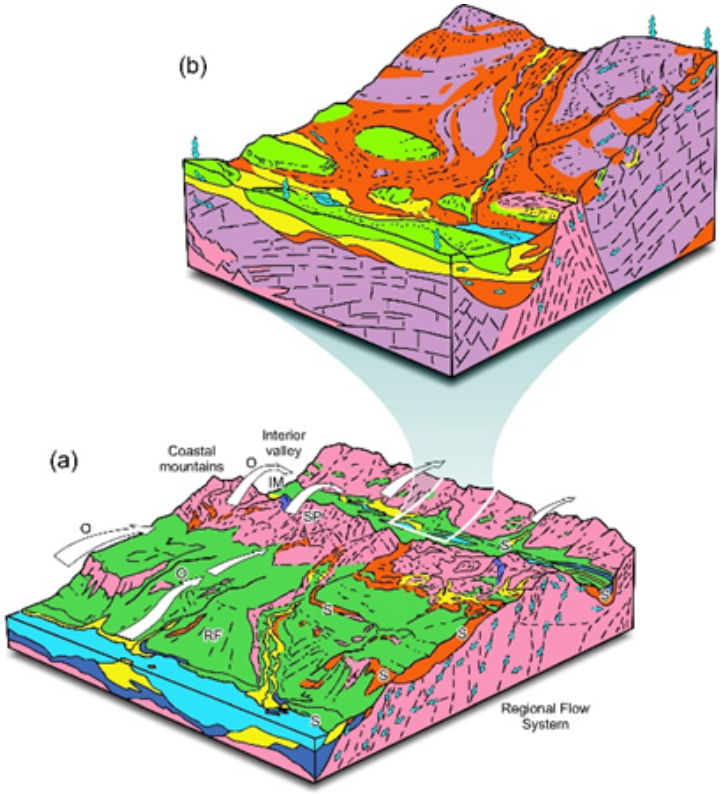
Types: Confined, semi-confined, perched, unconfined, and a mixture of these.

Similarly, *hydraulic conditions* can be clustered along five criteria, which will be useful to defining conceptual groundwater flow systems; these are: scales (hydrogeological region, aquifer system, aquifer unit), groundwater flow systems, usefulness, and response time.

For instance, the schematic figure below represents a hydrogeological region (thousand of square kilometers) with some Canadian conditions. In such a region, the flow of groundwater may cross the boundaries of various aquifer systems, watersheds (surface water) and/or jurisdictions (TBA).

Classification of aquifers based on the hydraulic conditions above will be discussed in a future newsletter.

Source: Rivera, A., Temgoua, A.G.T. and Aucoin, F., 2018. Principal Bedrock Aquifers of Canada: Potential Aquifers, Aquifer Systems and Aquifer Extents. Geological Survey of Canada, unpublished Open File.



Cordillera hydrogeological region (Sharpe et al., 2014)

Groundwater and surface water interactions

Why do rivers carry water even in desert environments during periods when there is no rainfall? This was a key question that motivated the study of groundwater centuries ago.

In school, I was taught that the water in rivers depended on rainfall, snowmelt or a combination of both, but they didn't tell me about their dependence on aquifers.

Although the use of groundwater dates back several centuries, the study of hydrogeology is relatively new and was motivated by questions such as this.

Some philosophers from the 4th and 5th centuries BC, observed the Balkan peninsula where they lived and concluded that rivers came from a series of underground conduits, including huge caverns, which were recirculated with seawater. In that region, there is an abundance of limestone formations and karst flow is common, so it quickly dissipates rain. This led the thinkers of the time to assume that the rivers emerged from those rock formations (see first figure below). It was believed that the driving forces were the pressure differences exerted by the wind or the weight of the rocks, while the suction was by vacuum. Desalination was attributed to filtration.

It was not until the seventeenth century when observations led to the troublesome proposition that surface runoff in rivers, outside the rainy season, was sustained by contributions from the ground, which acted as a reservoir of water, releasing it slowly and constituting the base flow. A few French scientists made measurements of precipitation, infiltration and evaporation in the Seine basin, Paris, confirming the plausibility of these ideas through detailed water balances.

The later consolidation of these ideas went hand in hand with the development of geology as a discipline in the late eighteenth century, whose principles provided the framework for the properties and structure of sediments and rocks, including the role of fractures, joints, and weathering horizons. With this, concepts were understood about the layers that store and transmit water and those that restrict it. The application of the physical laws that describe flow in aquifers was developed largely by engineers. Although the best-known name is Henry Darcy, his findings of 1856 were preceded by several works by his French colleagues, as well as other Europeans.

We have come a long way since the works of those scientists; today, we know and understand the dynamics of interactions between the two water resources, surface water and groundwater, or rivers and aquifers (see second figure below).

Because of these interactions, some scientists go even farther suggesting to consider only ONE water. It is an interesting recommendation; however, it becomes difficult to manage both resources at the same time because of the very different time- and space-scales. Furthermore, if a river and an aquifer are hydraulically connected and both are transboundary, the management as a single resource shared by two or more jurisdictions becomes even more problematic.

Efforts are underway to promote conjunctive management in transboundary contexts (Water Convention, 2023). Conjunctive Water Management is an approach to water resources management in which surface water, groundwater and other components of the water cycle are considered as one single resource, and therefore are managed in closest possible coordination, in order to maximize overall benefits from water at the short and at the long term (UNESCO, 2020).

Characterizing surface-water/groundwater interactions is an important component of the physical assessment of TBAs, raising additional shared management and governance challenges. For example, surface waters interacting with a TBA might already be managed by a transboundary agreement that does not include groundwater. Furthermore, the extent of a TBA can greatly differ from the extent of the watershed(s) with which it interacts, suggesting that different stakeholders might be involved.
(Rivera et al., 2023).

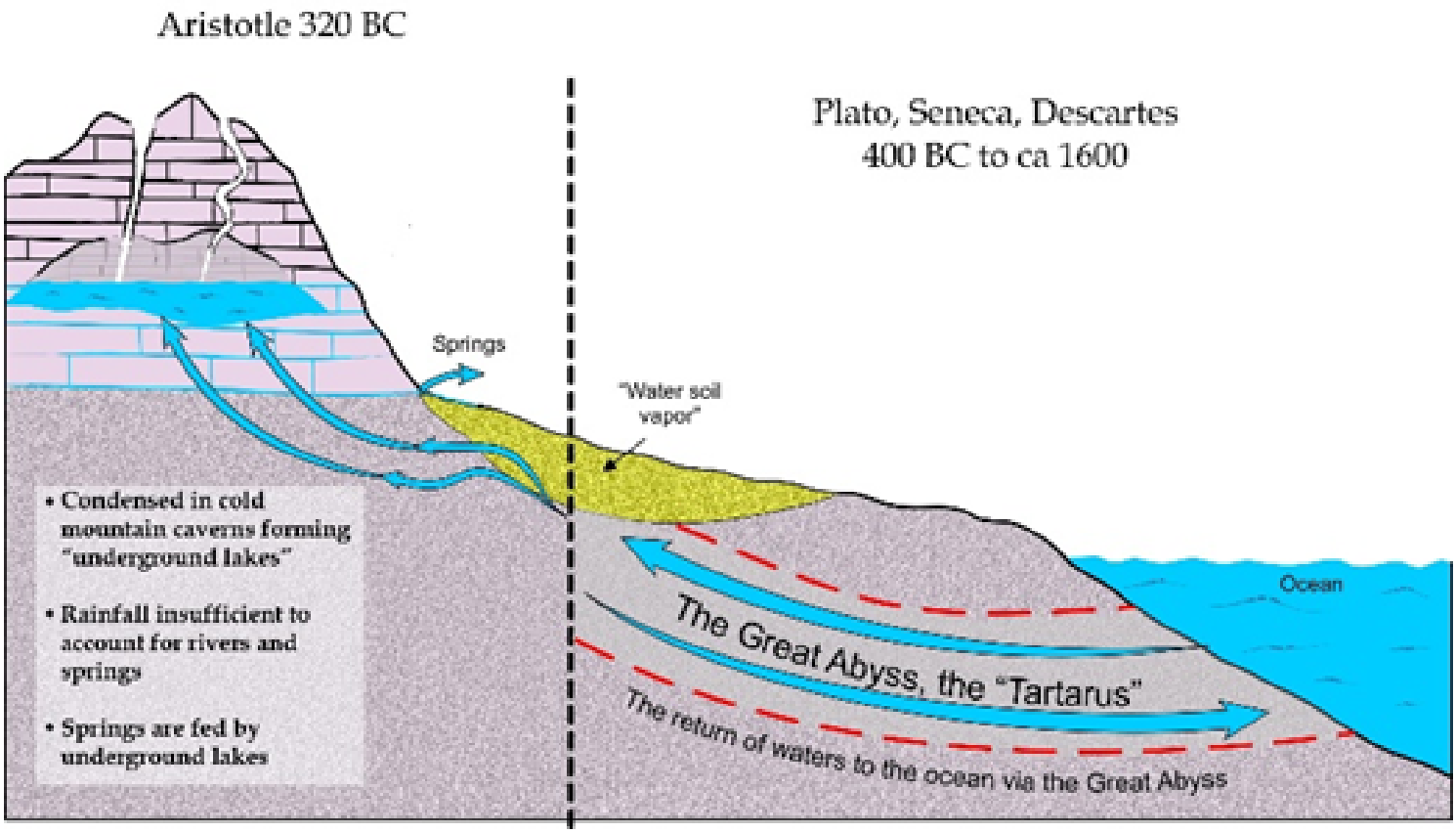
Sources:

Hinton, M., 2014. Groundwater-surface water interactions in Canada. In Rivera (ed) Canada's Groundwater Resources ISBN 978-1-55455-292-4 (HC), Fitzhenry & Whiteside Ltd, 824 pages.

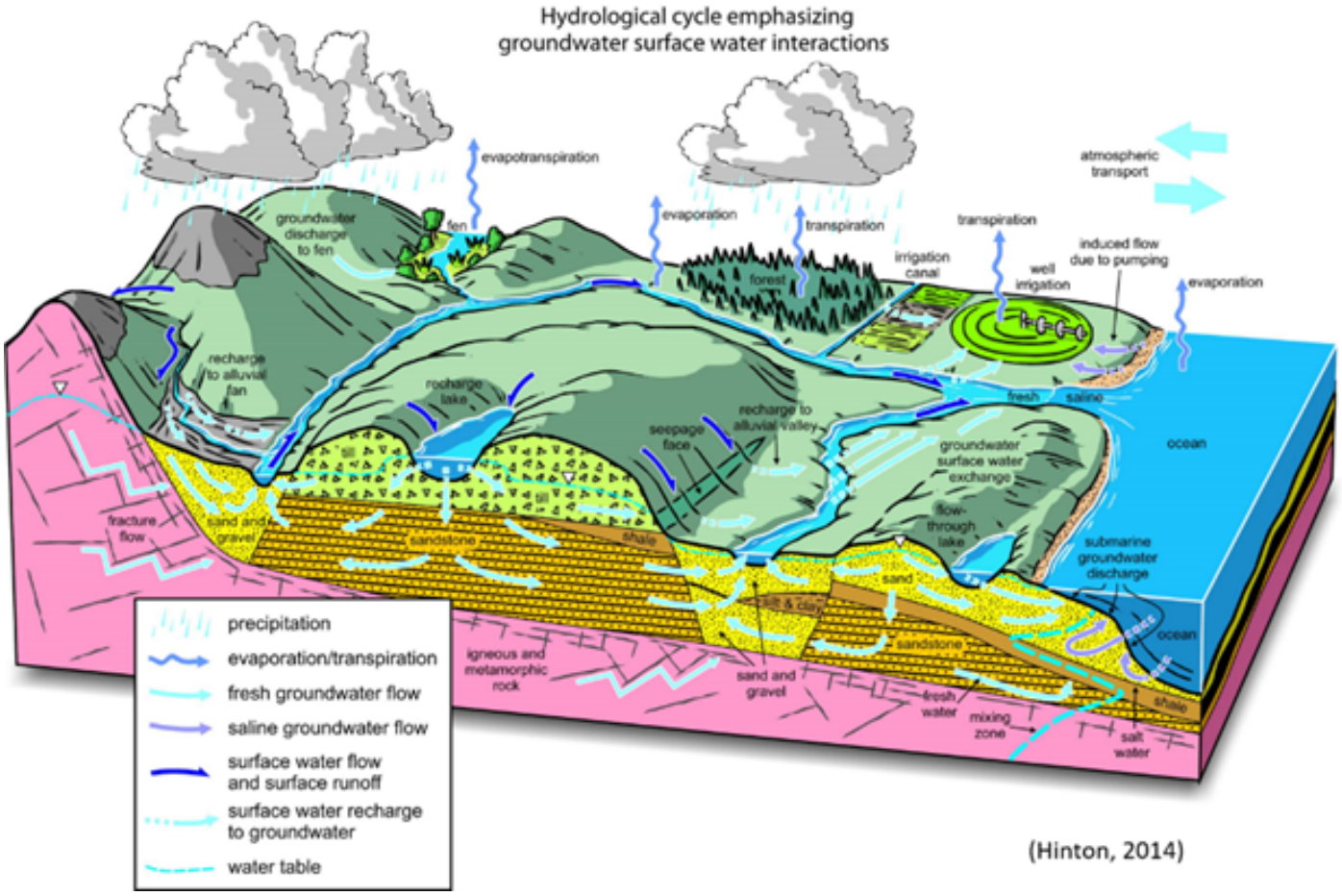
Rivera, A., 2014. Kainai Environmental Education and Awareness Summit 2014 -WATER

Rivera, Pétré, Fraser, Petersen-Perlman, Sanchez, Movilla, and Pietersen, 2023. Why do we need to care about transboundary aquifers and how do we solve their issues? Hydrogeol J 31, 27–30 (2023). https://doi.org/10.1007/s10040-022-02552-y.

Sharpe, D., et al., 2014. Hydrogeological regions of Canada. In Rivera (ed) Canada's Groundwater Resources ISBN 978-1-55455-292-4 (HC), Fitzhenry & Whiteside Ltd, 824 pages.



The water cycle perceived from 300 BC to the Renaissance (Rivera, 2014)



Hydrological cycle emphasizing groundwater-surface water interactions (Hinton, 2014)

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RECENT TBA-related PUBLICATIONS

Alistair S. Rieu-Clarke, Francesca Bernardini, Sarah Tiefenauer-Linardon, and Alice Aureli, 2022. Advances in monitoring transboundary water cooperation? Reflecting on the development and implementation of SDG indicator 6.5.2 March 9, 2022 Water International.

Book "Advances in Transboundary Aquifer Assessment" 2023. Editors Anne-Marie Matherne and Sharon B Megdal.

Flema, B., Bukovskab, I., Demidkob, J., Gundersena, P., Klosc, V., Kolosd, H., Marandie, A., Raidlae, V., Stalsbergf, L., Wyszomierski, M., 2023. Bridging gaps in groundwater management in International River Basin Districts (IRBDs) – through harmonized monitoring and data sharing https://doi.org/10.1016/j.ejrh.2023.101540. Dec 2023 Journal of Hydrology Regional Studies, Volume 50, December 2023, 101540

Fraser, C.M., Kukuric, N., Dmitrievab, T., and Dumont, A., 2023. Transboundary water cooperation under SDG indicator 6.5.2: disaggregating data to provide additional insights at the aquifer level. CMF, 0000-0003-0282-5770. DOI https://doi.org/10.2166/wp.2023.026

Good Practices and Lessons Learned in Transboundary Data-sharing (Second draft); a new publication being prepared in the framework of the Water Convention. UNECE Water Convention, 2023.

Puri, S., Villholth, K., Aureli, A., Rivera, A.' and Dumont, A., 2023. Conjunctive Management of Water Resources Technical Note. Global Workshop on Conjunctive Management of Surface Water and Groundwater: National to Transboundary Level 16–17 October 2023, Geneva and online.