AN ABSTRACT OF THE THESIS OF

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Title: Exploring Educational Tools to Improve Transboundary Groundwater Management

Abstract approved: Aaron T. Wolf

Abstract:

Groundwater tables are dropping quickly in many regions of the world. Central Asia is an arid region where groundwater abstraction rates often exceed recharge rates. The Pretashkent Aquifer is a crucial transboundary groundwater resource for the Republics of Kazakhstan and Uzbekistan. Both countries rely on the aquifer as a primary source of drinking water, which is contributing to its depletion. With rapid drawdown comes risks of contamination from brackish water in aquifers above. Since surface water bodies in the region do not meet drinking water standards, further depletion and/or pollution of the Pretashkent Aquifer could lead to conflict. For this reason, the Pretashkent Aquifer is a focus of UNESCO's Governance of Groundwater Resources in Transboundary Aquifers (GGRETA) Project. My contribution to GGRETA is to provide a chapter that outlines educational tools that may improve the hydro-diplomacy skills, bilateral relations, and technical groundwater knowledge shared between Kazakhstan and Uzbekistan. Assessment of each tool is based on: its ability to address one of the key transboundary groundwater management challenges, its adaptability to international groups, its alignment with experiential learning principles and styles, and its satisfaction of one of the core human needs. The compilation of tools constitutes my chapter of the GGRETA Groundwater Hydro-diplomacy Toolkit, which will be provided as a foundation for dialogue and learning to support transboundary groundwater cooperation.

Exploring Educational Tools to Improve Transboundary Groundwater Management

by

Melissa Skye Steritz

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I understand that my thesis will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my thesis to any reader upon request.

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Melissa Skye Steritz, Author

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Section A. Research Questions

Primary Research Question:

- What challenges are associated with managing transboundary groundwater resources, and how can they be successfully addressed through education and training?

Sub-questions:

- How can currently limited groundwater education be improved to address transboundary management challenges?
- What role will technology and other tools play in addressing transboundary groundwater management challenges?

Section B. Global Groundwater Trends

Figure 1: People in rural Northern India rely heavily on groundwater for household use and irrigation *(*Source: *Hindustan Times, 2018).*

In the past several decades, many regions have increased their reliance on groundwater for all uses, but especially: drinking water (as seen in Figure 1), municipal water, and agricultural production (Famiglietti, 2014). Water resource management experts Llamas and Martinez-Santos (2005) explain that modern groundwater abstraction is a way out of poverty for millions of modest farmers, who have moved from growing low-value crops to cash crops. Additionally, these experts argue that "groundwater is [perhaps] the cheapest and fastest way to achieve UN Millennium Declaration goal of halving the number of people without affordable drinking water", and to meet the Sustainable Development goals of poverty and malnutrition eradication (Llamas & Martinez-Santos, 2005, p. 337). In other words, groundwater is enhancing the quality of life of some of the poorest people on the planet. Consequently, rural farmers are drilling into aquifers deeper and faster than ever.

In many arid and semi-arid regions, pumping rates are far surpassing recharge rates (Jarvis, 2014). Scholars have named the race to the pumps "the silent revolution", often resulting in competitive well-drilling and pumping (Jarvis, 2014). This problem has been increasing in severity for at least the last sixty years, as a variety of stakeholders, especially independent farmers, pursue the benefits associated with groundwater development (Conti, 2014; Jarvis, 2014). Unfortunately, these new developments occur with minimal governmental management, planning, control, or intervention.

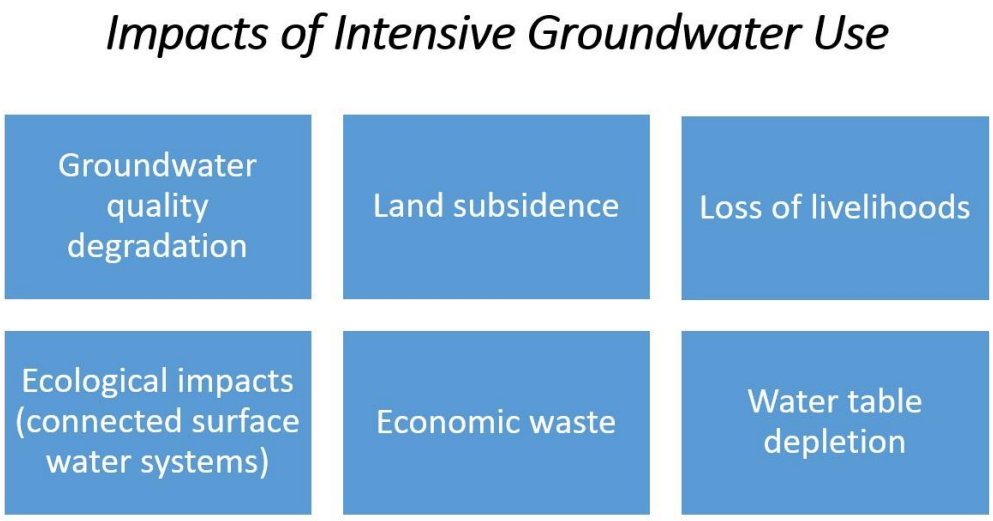


Figure 2: Overuse of groundwater may result in negatively impacted economies, environmental degradation and decreased quality of life for human populations (Steritz, 2019).

If the current trend of intensive groundwater abstraction continues, serious problems may arise in the next few generations (as outlined in Figure 2). Among these are: "water table depletion, groundwater quality degradation, land subsidence, or ecological impacts on aquatic ecosystems" resulting from reduced flow into connected surface water systems (Llamas & Martinez-Santos, 2005, p. 339). Jarvis (2014) also explains how economic waste and loss of livelihoods may result from the overexploitation of groundwater resources. Each of these consequences justifies further exploration of groundwater management solutions. Together, they provide a compelling case for research that explores both the challenges of groundwater management, and the potential solutions that may mitigate groundwater problems. Specifically, research that investigates tools for transboundary groundwater management is vital to improving institutional decision making regarding long-term aquifer sustainability.

Section C. Necessity and Challenges of Transboundary Management

Experts have found that more than 64% of countries contain a portion of at least one transboundary aquifer (IGRAC, 2016). Many countries rely on groundwater for both water and

food security. Collaborative management of aquifers and groundwater resources is increasingly crucial as billions of people around the world become more dependent on transboundary groundwater sources. Neighboring nations, known as "aquifer states", can increase the long-term sustainability of aquifer use and reduce the risks of conflict by beginning conversations about how to collaboratively manage shared groundwater resources (Conti, 2014).

In analyzing a plethora of case studies involving countries with shared aquifers, Conti (2014) found that "most aquifer states have peaceful or neutral interactions with each other with respect to water resources management", and most intend to begin managing groundwater resources collaboratively (p. 40). However, even with this intention, progress is slow and intermittent due to a number of complex challenges.

Firstly, since large-scale groundwater abstraction is a relatively new problem, there is no overarching, international, legal framework in place for groundwater developments (Eckstein, 2017). Adding to the confusion, most countries lack unified and coherent groundwater abstraction laws and policies, at the national level. Thus, groundwater governance and management is fairly undeveloped across the globe, and many governments lack effective regulatory mechanisms (Shah, 2009). Since groundwater governance is truly nascent, it can be difficult to prevent unsustainable drawdown. For these reasons, scholars like Shah (2009) refer to modern groundwater development as 'anarchy'.

Missing information, the absence of mutually-accepted models, inaccurate data, divergent ways of knowing, and different methods for data collection and analysis further complicate groundwater management at the transboundary scale (Wade, 2004). In short, neighboring countries often have contrary understandings of how their shared groundwater bodies function. Some groundwater experts, like Dr. Todd Jarvis (2014), view groundwater governance as a

quintessentially wicked problem due to the fact that there are many possible explanations for groundwater problems and no simple solutions. Due to the ambiguity of international groundwater governance, aquifer states seeking to co-manage resources may lack a common understanding of their shared aquifer, as well as how to collaborate.

Experts from neighboring aquifer states at times disagree on numerous aquifer characteristics, including: the areas of recharge and discharge, the geologic boundaries, and the degree of connectivity to surface water (Welch, 2017). Furthermore, there is a prevalence of folk beliefs associated with groundwater (Jarvis, 2014). These beliefs are not easily changed, nor are they easily reconcilable with scientific understandings. Differing perspectives can make coming to a consensus extremely difficult. Ultimately, achieving a common accord on an aquifer's dynamics may be a prerequisite for collaborative management. It may be challenging to reach a harmonious, scientific understanding of groundwater dynamics, while also respecting long-standing and deep-seated beliefs related to groundwater.

In sum, there are a multitude of factors that create challenges for modern groundwater management, and that complicate transboundary cooperation over groundwater resources. A few of these are:

1. the economic value of groundwater pumping,
2. the lack of bilateral and multilateral agreements regarding the management of shared aquifers,
3. the lack of regulations and policies at the national level,
4. the invisible nature of groundwater,
5. the problem of missing or inaccurate data,
6. the lack of bilateral or multilateral dialogue regarding groundwater,

7. the lack of mutually-accepted models, and
8. the pervasiveness of folk beliefs about groundwater.

As a result of these difficulties, there are only five international groundwater treaties and agreements in existence (Eckstein, 2017; McCracken, 2019). Due to these complicated and diverse factors, aquifer states should stay open to all types of collaborative management – with or without treaties. Transboundary water cooperation often occurs for a number of years without any formal legal mechanism in place, and treaties are frequently "the result of ongoing cooperation, rather than the catalyst for it" (Conti, 2014, p.42). With that in mind, it is increasingly important to help parties initiate and meaningfully participate in dialogue, and to provide resources that may enhance cooperation without expecting any particular outcome, such as a treaty.

Section D. Background on the GGRETA Project

The motivation for this research is to contribute to the ongoing Groundwater Resources Governance in Transboundary Aquifers (GGRETA) Project. GGRETA's primary goal is to build technical, institutional, and hydro-diplomacy skills that facilitate collaborative management of transboundary aquifers. Therefore, the primary purpose of this research is to understand how people can effectively learn about complex groundwater dynamics, improve intercultural relations, and integrate a set of cooperative tools to enhance their decision making about groundwater. This research will determine how I structure and what I choose to include, in the GGRETA Groundwater Hydro-diplomacy Toolkit. This toolkit will be the main deliverable for the second phase of the GGRETA Project in Central Asia which is being implemented jointly by the United Nations Educational, Scientific and Cultural Organization (UNESCO) and Oregon State University (OSU).

A prominent goal of this toolkit is to enhance the knowledge of the stakeholders who share a common aquifer. The International Groundwater Resources Assessment Center, or IGRAC, recommends that even if one aquifer state feels like they already have sufficient capacity, "Water management institutions [should] seek to increase their level of capacity for groundwater resources management through education and partnerships" (Conti, 2013, p. 43). Today, there is an imperative need for enhanced education and partnerships because of the current, global groundwater trends.

The water ministries of the Republics of Kazakhstan and Uzbekistan are the target audiences for the GGRETA Hydro-diplomacy Toolkit. Their shared Pretashkent Aquifer is currently facing rapid depletion and increasing pressure from industries (IGRAC, 2018). This artesian aquifer is practically non-renewable due to negligible recharge and is of utmost importance as a drinking water source for both countries since surface water bodies fail to meet drinking water standards (IGRAC, 2018). Therefore, promoting joint management of the Pretashkent Aquifer may help prevent future water conflicts. The following section will briefly explain the history that led to the complex hydropolitical situation between Kazakhstan and Uzbekistan.

Section E. Background on Kazakhstan and Uzbekistan

While the geopolitical history of the region stretches back much further, I will begin with the collapse of the Soviet Union, in 1991. With this event, fifteen independent nations were created overnight. Unfortunately, the water distribution and irrigation systems had been poorly maintained during the Soviet Era. For example, under Soviet control, large stretches of land were transformed into agricultural regions, and intensive irrigation led to groundwater tables becoming increasingly shallow and saline. The nascent Central Asian nations inherited the responsibility of handling these

water issues immediately following their independence. However, a lack of funds to address these problems led to further deterioration and increased tensions over both surface water (seen in Figure 3) and groundwater in the arid region (O'Hara, 2000).

According to studies by Lee et al. (2018), several transboundary aquifers in the Central Asia region are being "aggressively exploited [which is] leading to increased aquifer vulnerability and unsustainable aquifer management conditions"; this is largely due to degradation of surface water quality (p. 107). Due to the mounting pressures on groundwater resources in Central Asia, the United Nations Educational, Scientific, and Cultural Organization (UNESCO) selected the region to be one of three focus areas for the Groundwater Resources Governance in Transboundary Aquifers (GGRETA) Project.

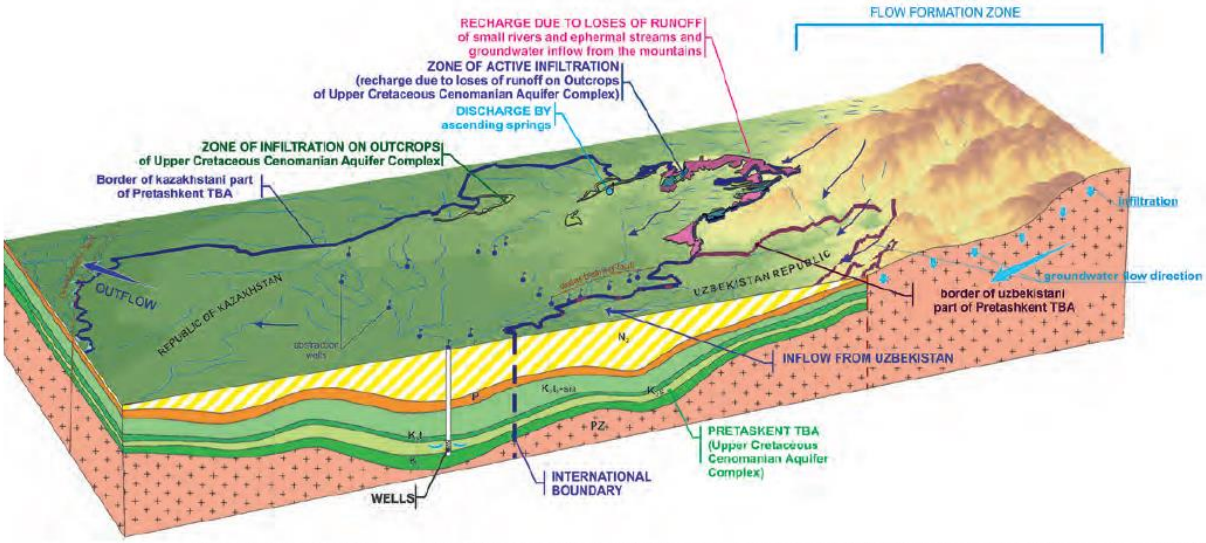
Figure 3: Map showing shared surface water resources in the Central Asia, which have been a source of tension along with shared aquifers (Zolotova, 2018).

Within Central Asia, Uzbekistan shares more transboundary watercourses than any other nation. In total, Uzbekistan shares 31 transboundary basins with other Asian countries. Uzbeks share multiple transboundary aquifers with their neighbors in Kazakhstan, including two significant sources of drinking water: the Syr Darya Aquifer and the Pretashkent Aquifer. Both Kazakhstan and Uzbekistan rely heavily on the Pretashkent Aquifer, which exemplifies a medium-sized, artesian aquifer buried deep underground. Its recharge zones are particularly small, which contributes to the negligible amount of recharge in recent years (IGRAC, 2018).

The aquifer lies underneath an area of land approximately 17,000km^2. Approximately 10,340 km^2 of that land is within Kazakhstan's borders. In Kazakhstan, "99% of the water withdrawn [from the Pretashkent Aquifer] is used for agriculture", while the remaining percent contributes to domestic and public supply (IGRAC, 2018). In Uzbekistan, water from the aquifer is used for drinking, irrigating and completing important industrial activities, such as metallurgy (IGRAC, 2018).

In terms of their shared Pretashkent Aquifer, the intense depletion of groundwater storage evidenced by a "constant lowering of groundwater heads" is the primary concern (IGRAC, 2018). Since the main sources of surface water in Southern Kazakhstan and Northwest Uzbekistan do not meet drinking water quality standards, the Pretashkent Aquifer is an important source of drinking water for the people of both countries. IGRAC (2018) states that it is the most important groundwater body in the area because of its contributions to both Kazakhstan's and Uzbekistan's populations. Thus, degradation of water quality is a major concern. With groundwater levels dropping quickly, there is a chance that brackish water may begin seeping in from overlying strata. The rapid drawdown of the Pretashkent (modeled in Figure 4) and accompanying fears about

groundwater quality led to UNESCO initiating a pilot study on the Pretashkent Aquifer (IGRAC, 2018).



Conceptual model of the Pretashkent Transboundary Aquifer (the pale green layer overlaying the lowest green layer depicts the PTBA)

Figure 4: A model of the Pretashkent Aquifer created by IGRAC (2018).

The pilot study began in 2013, at a time when Uzbekistan's leadership considered sharing information (including groundwater data) inopportune; that is why the first phase of the GGRETA Project could only be carried out with Kazak scientists (IGRAC, 2018). Uzbekistan's first president, Islam Karimov, was not keen on regional integration or cooperation (Putz, 2017). Karimov closed the borders periodically and encouraged nationalist sentiments in an attempt to protect Uzbekistan's independence (Putz, 2017). This led to isolation from other Central Asian countries. Under Karimov's leadership, Uzbekistan's relationship with Kazakhstan was characterized by strong-arm politics, intense border negotiations and mutual distrust (Tyran, 2017).

However, following Karimov's death in 2016, Uzbekistan's new president, Shavkat Mirziyoyev, has been trying to improve regional relationships – including with Kazakhstan. Mirziyoyev quickly began making progress with Kazakhstan's president, Nursultan Nazarbayev,

on settling border disputes. According to Nazarayev, Uzbekistan is a "brotherly nation" (Putz, 2017). Both sides are currently working to strengthen a strategic partnership (as demonstrated in Figure 5). In terms of geopolitical power, Uzbekistan has the population advantage, with around 30 million people, while Kazakhstan is home to about 17 million people (Putz, 2017). However, Kazakhstan is geographically much larger and also boasts an economic advantage, as they have a significantly higher gross domestic product (GDP) than Uzbekistan (Tyran, 2017).

Figure 5: Nazarbayev and Mirziyoyev meeting in Kazakhstan in 2017 (*The Diplomat*, 2017).

OSU and UNESCO have led a series of workshops with water experts from the region, which may have helped increase the "ripeness" for cooperation between Kazakhstan and Uzbekistan over groundwater resources. Now, experts and officials from both countries have expressed interest in exploring options for collaborative management of the Pretashkent Aquifer. As UNESCO's partner in the GGRETA project, OSU has been tasked with providing a foundation for how these countries may begin groundwater collaboration. Therefore, the toolkit elaborates on experiential learning tools that the water ministries of Kazakhstan and Uzbekistan can use to build their capacity for joint management of the Pretashkent Aquifer.

Chapter 2: Justification for Groundwater Hydro-diplomacy Toolkit

Section A. Justification for Enhanced Groundwater Education

In order to build institutional capacity for collaborative groundwater management and governance at any level, education is the first step. Spanish hydrogeologists Llamas and Custodio (2013) explain that public education programs and increased capacity of public water authorities are two crucial pillars of improving groundwater management. Unfortunately, in many schools and government offices, existing groundwater educational materials, along with laws and doctrines relating to groundwater, "were developed [during a time when] the science of water movement was rudimentary" (Leopold, 1997, p. 35). Thus, "unscientific and ill-defined terms" persist within the groundwater lexicon today, making management more troublesome (Leopold, 1997, p. 35). Due to these ill-defined terms, it can be difficult for politicians, water managers, and other learners to generate clear-cut mental images of how groundwater functions. According to science education experts, "constructing mental pictures of what happens to the water when it cannot be seen becomes necessary to construct complete and appropriate understandings" of groundwater and how to manage it (Dickerson et al., 2017, p. 48).

Adding to the challenges of groundwater education, many of the core concepts and terms are difficult to quantify and are subject to varying opinions. Even within the scientific community, experts from neighboring aquifer states frequently disagree on how transboundary aquifers recharge and discharge, where the geologic boundaries are, and how the aquifer connects to surface water (Welch, 2017; Jarvis, 2014). Dickerson et al. (2017) underline that reaching consensus and "constructing appropriate understandings of subsurface processes [is] problematic" precisely because it is hard to directly observe these phenomena (p. 48). Without a common understanding

of shared groundwater resources and a common vocabulary with which to communicate, transboundary groundwater cooperation is arduous.

Another challenge is that historically, politicians have not thought of groundwater education as a priority when crafting policies or training programs; some governments have only very recently begun to allocate resources to groundwater education, and many still do not (McClurg & Sudman, 2003). Put simply, since groundwater science education "is not a priority in most cultures and countries [and] much of the common understanding about groundwater involves inappropriate mental models", misconceptions are widespread (Dickson & Callahan, 2006, p. 135). One problematic misconception is that groundwater functions like surface water, and wells cannot run dry because "they are fed by rapidly flowing underground rivers" (Dickerson et al., 2017, p. 49). These types of fallacies can lead groundwater users to believe that their supply is inexhaustible, which may have detrimental effects in terms of drawdown rates. Of course, poverty and the ever-growing need to produce more crops add more stress to the system. Refined educational materials are "especially critical today" as many regions "face the twin pressures of continued economic growth and the desire to protect and preserve the environment" (McClurg & Sudman, 2003, p. 271).

In short, groundwater education is a weighty challenge that needs to be addressed as soon as possible. McClurg and Sudman (2003) emphasize the need for enhanced groundwater education for both "policy-makers in the government and leading stakeholders in the agricultural, environmental, and urban water communities" (p. 271). Since politicians are the gatekeepers who control access to water, it is crucial for governments to train all of their water managers and officials in groundwater hydrology. However, the reality is that groundwater management issues are "often compounded by a lack of expertise within governments"; this is partially because many

governments are underfinanced and hire less hydrogeologists than are needed (Wijnen et al., 2012, p. 44).

Reinforcing this idea, Knuppe (2011) identifies key challenges that stand in the way of sustainable groundwater management in an international context; the top two are: "the undervaluation of groundwater importance and significance [and] the need for [greater] expertise and information at all scales" (p. 67). The lack of technical expertise among national and regional water agencies is only one aspect of the problem. Another noteworthy hurdle is that governments often do not give priority to groundwater issues until the problems become severe.

Once groundwater does become a priority for a particular government, there is still a need for water managers to understand and "explore the varied viewpoints" regarding groundwater resources (McClurg & Sudman, 2003, p. 271). Governance challenges are "not only constrained by lack of information and education, but also by local tensions and by the lack of history of dialogue" about groundwater use (Wijnen et al., 2012, p. 55). These tensions over groundwater use and management exist around the globe (including in Central Asia), which demonstrates the relevance of educational resources that aid cooperative dialogue and enhance understanding of groundwater resources.

In order to address the challenges of sustainable groundwater management, Knuppe (2011) and Wijnen et al. (2012) point out that national governments need to be better equipped with cooperation and hydro-diplomacy tools. Regions with transboundary groundwater resources and histories of acute tensions have an escalated need for these resources to help them begin creating mutually beneficial solutions that address their groundwater problems. One such region is Central Asia, where a complex timeline of events has contributed to contemporary groundwater struggles.

The Pretashkent Aquifer is one of several transboundary aquifers in Central Asia that is being "aggressively exploited leading to increased aquifer vulnerability" and increased vulnerability of Uzbek and Kazakh populations that rely on it (Lee et al, 2018, p. 107). For both countries, the Pretashkent Aquifer is one of the main sources of irrigation water and drinking water. Due to the worsening depletion of groundwater storage and the heavy regional reliance on it, groundwater experts at UNESCO feel that is one of the most crucial transboundary waterbodies in the world to study. For this reason, the GGRETA Project focuses on supporting the collaborative research and management of the Pretashkent Aquifer between the water ministries of Kazakhstan and Uzbekistan. The GGRETA team includes groundwater experts at the UNESCO and IGRAC, hydrogeologists and mediators at OSU, and graduate students (such as myself) who study Water Cooperation and Diplomacy and Water Resources Policy and Management.

Section B. My role in the GGRETA Project

Currently, the second phase of the GGRETA Project is in motion. The main deliverable for this phase is a groundwater hydro-diplomacy toolkit, which is a stand-alone educational resource containing cooperation frameworks, international water law principles, relationship-building exercises, role plays/simulations, and an outline of possible options for Kazakhstan and Uzbekistan as they initiate a collaborative process. My role is to lead the research, synthesis, design, and creation of a "Groundwater Hydro-diplomacy Toolkit" to serve as the basis for workshops, trainings, and dialogue as Kazakhstan and Uzbekistan begin the collaborative process. There is currently no international groundwater cooperation toolkit, so the creation of such a toolkit represents a unique contribution to the growing field of water cooperation.

The overarching goal of the GGRETA Project is to enhance the technical and hydro-diplomacy skills of the water ministries of Kazakhstan and Uzbekistan in order to support the

collaborative management of the Pretashkent Aquifer. In order to build the necessary skills and promote integrated approaches to water management, I focus the toolkit on experiential learning methods. Through experiential learning, new concepts and abilities can quickly be integrated into one's work because participants actively create that new knowledge. Therefore, the learning is personal and sometimes even emotional. Through the simultaneous generation of personal experiences and new knowledge, participants can better retain that information in their memory (Eyler, 2009).

Section C. Justification for the Toolkit

Toolkits are an effective way to organize experiential learning exercises and activities because they function generally as guidebooks that can support both group bonding and skill-building over any period of time. Another perk is that using a toolkit generally does not require outside facilitators. In the context of Central Asia, using this GGRETA Hydro-diplomacy Toolkit will provide plenty of ideas while still allowing the water ministries of Kazakhstan and Uzbekistan to lead collaborative processes in their own way and in their own time. In other words, the toolkit will allow water leaders a degree of self-sufficiency and freedom.

Toolkits in general are easily adaptable resources that may be used in a variety of ways depending on the context. Today, experiential learning toolkits are being used in an array of settings. For example, toolkits are used to train leaders of companies and organizations, to facilitate bonding between international students, to prepare university professors to use new technologies, and to support health care professionals entering new care-taking roles. In terms of teaching methods, toolkits have become popular because they offer a flexible structure for a series of applied and meaningful adult learning experiences (Bryan, 2014). Toolkits can be especially helpful as the

basis for workshops and trainings as they present a host of information and exercises, which may be selected, based on their relevance and appropriateness for a particular group.

In the context of Central Asia, the experiential learning tools provided in the toolkit must accommodate the needs of a group of diverse leaders and experts with different learning styles, professional strengths, and cultural backgrounds. Undoubtedly, the targeted end users within Kazakhstan's and Uzbekistan's Water Ministries have a wealth of knowledge already, but it is important to "level the playing field" to make sure that the technical and social capacities of the collaborators is relatively balanced. Therefore, one function of the toolkit is to fill knowledge gaps by spurring collective learning.

Before compiling the toolkit, my goal is to understand how people effectively learn about complex groundwater dynamics and intercultural relations, as well as how they can integrate this set of tools into their work. In literature about groundwater education, it is clear that grasping groundwater concepts through lectures and reading alone is not realistic; "the complex and abstract qualities of groundwater make the accurate conveyance" of how it functions "through two-dimensional graphics and language" difficult (Dickerson et al., 2017, p. 51). Participants can better understand groundwater dynamics through involvement in simulations, monitoring activities, and interactive data collection.

Illustrating the need for experiential learning in groundwater education, Dickerson et al. (2017) argue for the use of hands-on activities, such as the creation of three-dimensional models and participation in fieldwork, to help people understand groundwater behavior, achieve consensus, and create more accurate mental models. These types of activities are a critical part of the learning experience, and can be found in the sections of the toolkit entitled "physical tools" and "intellectual tools".

While the tools in the physical and intellectual sections are undoubtedly necessary, it is important to keep in mind that transboundary collaborative groundwater management requires more than understanding groundwater phenomena. Successful collaboration requires adept communicators that can help attune the group. To learn how to be better communicators and collaborators, participants need to develop intercultural skills and practice using tools to ease tensions. Experiential learning has also proven to be effective for the purposes of improving social dynamics. Crossman (2011) examines how experiential learning benefits professionals who work within intercultural groups, emphasizing that participating in intercultural communication through collaborative projects is perhaps the most powerful way to learn about intercultural communication.

When team members naturally begin helping one another "untangle the complex influence of culture on interpersonal communication by drawing upon and sharing the perspectives of their own cultural heritage and experience", each group member becomes an indispensable teacher (Crossman, 2011, p. 2). This simultaneous teaching and learning experience leads to a deep level of engagement and investment in the collaborative process.

Institutional capacity building to address technical and social challenges related to transboundary collaborative groundwater management requires active involvement of participants. However, some experiential learning activities will be more effective for some individuals (and less helpful for others) because of their learning styles. Generally, the founders of experiential learning theory agree that there are four basic learning styles: accommodating, diverging, assimilating, and converging (Kolb, 1984).

Each of these learning styles relies on a different set of skills. Therefore, in my construction of the toolkit, I consider how to bring out the strengths of each individual and how each person

may develop new skills. The goal is that everyone can contribute to every step of the collaborative process. Table 1 demonstrates the relationship of learning styles, corresponding skills, how those skills may benefit groups, and finally, the toolkit section that contains tools likely to be compatible with that learning style. With this framework, there will naturally be different leaders for each of the experiential learning exercises, which will help group dynamics by spreading out responsibilities.

Learning style	**Specialty skills**	**Example of how they benefit groups**	**Toolkit section**
Converging	Decision skills	Using technology for quantitative analysis	Physical tools
Accommodating	Acting skills	Leadership on fieldtrips	Emotional tools
Assimilating	Thinking skills	Information-gathering	Intellectual tools
Diverging	Valuing skills	Relationship-building	Spiritual tools

Table 1: The four learning styles identified by experiential learning experts each have accompanying skills that can be instrumental in collaborative projects (Kolb, 1984).

Section D. Methods, Assessment of Tools, and Discussion of Literature

Within each of these learning style categories, there are a plethora of educational tools and exercises that may be appropriate. I choose which to include in the toolkit based on scholarly articles and in some cases, first-hand individual accounts of how well the tool works. My goal is to investigate the utility of each individual tool in real-world collaborative group processes. My assessment of each tool is based on:

- Usefulness to collaborative groups (proven through documentation of successful case studies)
- Ability to be adapted to a transboundary setting

- Compatibility with one of the primary learning styles
- Alignment with experiential learning principles
- Satisfaction of at least one of the core human needs as expressed in the Four Worlds Framework

I use the Four Worlds Framework to structure my presentation of tools in order ensure that all types of human needs (physical, emotional, intellectual, and spiritual) and water management challenges are accounted for in the toolkit. The four levels of the Four Worlds Framework (explained in Chapter 3) fit cohesively with the primary experiential learning styles (Wolf, 2008).

First, the physical level of the Four Worlds Framework connects well with the converging learning style. Using technology to quantitatively analyze data is an example of how people with this style learn and thrive. These individuals can be crucial in tackling challenges related to physical groundwater uncertainties and data gaps.

To address these challenges, I review articles about ways to enhance knowledge of drawdown rates, current groundwater availability, etc. My investigation of possible groundwater monitoring methods begins with looking at the feasibility of installing pressure transducers and relying on citizen well reporting. While these strategies do have their merits, I will not include them in the toolkit because they require long-term funding as well as strong public and political will.

Through conversations with hydrogeology experts such as Dr. Todd Jarvis, I am now aware of the valuable role that satellites and radar technologies can play in filling groundwater data gaps. Papers by water science experts such as James Famiglietti and hydrogeologists like Pascal Castellazi confirm this notion. These relatively new technologies show promise of helping

bilateral negotiations by building consensus about the physical characteristics of groundwater resources and helping scientists understand the changes that are occurring.

The tools that may be most appropriate for addressing data gaps and employing the strengths those with converging learning styles and quantitative analysis skills are: the Gravity Recovery and Climate Experiment (GRACE) Satellite and the Interferometric Synthetic Aperture Radar (InSAR) technique. Both offer free, accessible online databases. When used together, GRACE and InSAR allow for enhanced understanding of changes in groundwater storage and land subsidence, providing a more complete picture of the drawdown situation. Exploration and synthesis of data from these databases can also serve as a great starting point for joint fact-finding exercises.

Certain people will bring the group closer to cooperation by enhancing the emotional dynamics rather than offering quantitative skills. The accommodating learning style pairs well with the emotional level of the Four Worlds Framework. People with this learning style may possess emotional intelligence and have the ability to thoughtfully help plan group activities. Accommodating learners may provide leadership during trust-building experiences like field trips. In well-cited literature, such as *Making Collaboration Work* by Steven Yaffee and Julia Wondolleck, field exploration is touted as a tool for catalyzing cooperation.

There are numerous cases of multi-agency groups coming together during the course of an excursion in literature on collaborative natural resource management. An article by Davis et al. (2018) stands out because it explains how field trips can help bring stakeholders together; it outlines how historically conflictive relationships between land managers in Oregon were transformed through field trips. The case study highlights how field trips can begin to blur divisions, create affinitive trust and ultimately help build a collective identity. While Kazakhstan

and Uzbekistan have historically "been involved in high stakes negotiations to define their respective borders", exploring the land above their shared aquifer may promote amnesty (Tynan, 2017).

However, it is also possible that these groups, with their significant past tensions, may not be ready to embark on a trip with one another. Therefore, the toolkit must include ways to ease tensions between people who have a history of hostility. Conflict transformation strategies are important tools for reconciling difficult feelings associated with water. One of my intentions with the toolkit is to lend more prominence to conflict transformation tools that have the potential to benefit the field of hydro-diplomacy.

A book entitled *Decolonizing Conflict Resolution* (2014) by scholar Polly Walker is useful to helping readers understand that there are a plethora of underutilized tools for conflict management born from indigenous cultures around the world. Walker, along with anthropologist Steven Picou, document how talking circles can be effective for facilitating emotional processing in cases of one group feeling like they have been wronged by another (Walker, 2014; Picou, 2004).

Accommodating learners in the group may be instrumental in ensuring that talking circles are carried out respectfully with the emotional needs of every participant in mind. It seems likely that water managers, experts or officials in Kazakhstan have felt rejected by their Uzbek counterparts in the past and may need to talk through those feelings. Uzbekistan under its first president did not agree to regional cooperation, which also may have left some Uzbek water leaders feeling isolated. Talking circles, therefore, may be useful either for Uzbeks or Kazakhs to conduct on their own, or if gracefully led, to help representatives from each country express their feelings to each other.

Figure 6: Talking circles can be adapted to a more formal setting, which may help facilitate positive communication in bilateral cooperation (O'Connor, 2015).

The work of Dr. Aaron Wolf celebrates *sulhas* as a ceremonial forgiveness process. Although no literature exists on the use of *sulhas* in international water cooperation, they show promise because they provide a fairly formal process for: recognizing past conflict, offering compensations if necessary, sharing a symbolic meal, and making peace with the help of a mediator. The *sulha* ends with a restoration of dignity to all parties. While it is difficult to find academic literature on the use of *sulhas* in the international arena, there are websites, blogs, and first-hand accounts of organizations in the Middle East that continue to use them successfully. *Sulhas* serve as a tool for forgiveness between citizens of war-torn communities in Israel and Palestine. From the outcomes reported by *sulha* participants, it is logical to assume that this tool may also benefit other nations that have historical tensions. The main benefit is that it helps communities with past grievances reach a level of understanding and acceptance that allows them to focus dialogue on the future instead of the past (Wolf, 2008).

The water ministries of Kazakhstan and Uzbekistan will also need to utilize intellectual tools as they pursue a feasible collaborative groundwater management plan. Assimilating learners in the group can offer information-gathering skills that may prove critical in coming to shared understandings of the Pretashkent Aquifer. Through the work of serious gaming expert Dr. Todd Jarvis (as well as his graduate students) and participating first-hand in role plays with a diverse array of international students, I have come to understand the benefits of simulations and serious gaming. There are always multiple perspectives on water resource issues, and often it is hard for us to step out of our own shoes to understand another's reasoning with engaging in serious gaming.

That is why some water conflict mediators specifically advocate for "social learning through serious gaming"; these games allows diplomats, water managers, or any other participants to "discuss their conflicting positions to come up with a mutual agreement in regards to the use of the resource" (Hockaday et al., 2017, n.p.). Ultimately, this may contribute to water conflict prevention by expanding personal views on water issues.

Today, serious gaming is helping collaborators discover creative solutions from the intra-agency scale (as seen in the U.S. Bureau of Reclamation case study) to the transboundary scale. Medema et al. (2016) believe that serious gaming is "particularly important in transboundary contexts, where it is necessary to reframe problems" (p. 1). Assimilating learners can help with problem reframing and incorporating multiple new viewpoints to craft creative solutions (Kolb, 1984). Researchers often have an assimilating learning style and thrive on compiling "a wide range of information and putting it into a concise, logical form", which is important for both serious gaming and joint fact-finding (Kolb, 1984, p. 230).

Within important intellectual exercises like joint fact-finding, assimilators play a crucial role, which is to distill the breadth of information into a few core points. Joint fact-finding seems

like an extremely logical component of the initial collaborative process between Kazakhstan and Uzbekistan since both parties have expressed interest in joint modeling. Ehrman and Stinson (1999) demonstrate the benefits of conducting joint fact-finding before joint modeling; the fact-finding process can help the involved modelers from both countries organize the research process to increase the productivity of joint modeling. For example, within the joint fact-finding process, participants will have a chance to come to a consensus on the research questions they are trying to answer (Ehrman & Stinson, 1999). Together, they can define areas of uncertainty within the aquifer that need further research before modeling begins. Whenever there is a case of dueling experts, or any form of disagreement about an aspect of the aquifer, joint fact-finding may be a helpful exercise. Once there is more clarity within the group, modeling can begin.

While assimilating learners specialize in information-gathering, those that fall within the diverging learning style usually possess an active imagination, have broad cultural interests, enjoy working in groups, and are excellent listeners (Kolb, 1984). These skills and strengths are key within the spiritual realm of the Four World Framework. The tools I feature within the spiritual section of the toolkit help parties focus on shared values and practice future-centric, respectful dialogue.

Through literature written by Carol Hwochinsky, Aaron Wolf, and other mediators, I realize that transformative listening (also called deep listening or compassionate listening) is an invaluable and powerful practice for both managing and preventing conflict (Hwochinsky, 2006; Wolf, 2018). However, outside of Dr. Wolf's work, it is not commonly discussed in regards to high-level international relations.

It is fairly easy, however, to find case studies or first-hand accounts of everyday people practicing transformative listening and thereby, shedding prior misconceptions (of another

individual or group). Most of the accounts describe the listener developing real empathy and understanding through practicing transformative listening for a speaker. In the toolkit, I highlight a case in which a Jewish woman visits a Hamas leader. She enters the room with skepticism and distrust (that are present due to seemingly divergent values), but leaves feeling deep affinity with the man. Transformative listening has documented power, not only to develop rapport, but also to facilitate healing in the speaker. Diverging learners will likely excel at this practice and help cultivate trust within groups by bringing this form of deep listening into formal negotiations as well as casual, hallway conversations.

Kazakhs and Uzbeks may feel some level of alienation or wariness towards each other due to their lack countries' past political tensions. The use of transformative listening exercises will likely help them to understand each other's diverse backgrounds, feelings and perspectives. Achieving a sense of community will come easier if all participants feel listened to.

Focusing on shared values is another method that is likely to help Uzbeks and Kazakhs foster a collective aquifer identity (Shah, 2009). Since diverging learners tend to have broad cultural interests and tend to keep an open mind, they may be helpful at identifying where participants' viewpoints and cultural values overlap. In his book, *The Spirit of Dialogue*, Dr. Aaron Wolf explains the usefulness of focusing on shared values to promote collaborative transboundary water governance. Along with transformative listening, focusing on shared values is a simple and practical tool that deserves more attention from water experts and diplomats.

Since these Central Asian neighbors were once both part of the Soviet Union, some ethnic groups exist on both sides of the border; to this day, some Uzbeks have friends and family that live just on the other side of the border (Tynan, 2017). Thus, there are likely some overlapping values although they may have been obscured by years of Uzbekistan's self-imposed isolation in the

region. If diverging learners within the group do not spot them or verbally acknowledge them, a skilled mediator may be able to bring these shared values to light. By framing questions and conversations in a strategic way, participants may realize that what unites them is greater than what divides them (Furman, 2010).

The future of the Pretashkent Aquifer is an undeniably unifying factor for this bilateral group of leaders; each person in the negotiation room has a stake in what happens to the aquifer. It is important for all of the participants to be comfortable with how collective visioning exercises work and to understand the value of visioning to the overall collaborative process. The collective visioning tool is compelling because it can instill hope in participants, according to non-profit organizations and records from university-led stakeholder workshops (University of Wisconsin Stevens Point, n.d.). In another inspiring collaboration, leaders from sixteen different nation-states identify their shared values and from them, construct a collective vision for the region of South Africa, which is now the basis for The Southern African Development Community (SADC, 2018). Despite the fact that these case studies are featured in organization's reports rather than formal academic literature, they still provide reason to believe that collective visioning exercises can create positive momentum for transboundary water cooperation.

This tool works by allowing each participant to envision how they would like water conditions to be decades down the line. Again, the diverging learners in the group may be conducive to productive collective visioning because they tend to be imaginative and open-minded to new possibilities (Kolb, 1984). Exercises like collective visioning may be particularly beneficial to Kazakhstan and Uzbekistan because they create space for the water ministers to hone in on their shared future, rather than fixating on their past conflicts, like border disputes. I recommend having

a whole workshop or meeting that is dedicated to collective visioning exercises because it will allow ample time for brainstorming and discussion.

In regards to all of the tools in the spiritual section, I do acknowledge the lack of coverage by existing academic literature. However, I do not believe that this lack discounts their value. Instead, I believe it is a reflection of the Western tendency to discard and fear the inclusion of spirituality in "rational" processes (Wolf, 2008). Perhaps the field of conflict management can benefit from expanding its toolkit of strategies and recognizing the value of spiritually-based practices like transformative listening.

It is my intention to help speak to the merits of the underutilized, as well as the tried-and-true, methods for facilitating social learning and cooperation. The following chapter aims to facilitate cooperative management, by providing information on how to strengthen intercultural alliances and empower Uzbek and Kazakh water ministers, through experiential education. This chapter represents the final chapter of the GGRETA Hydro-diplomacy Toolkit, which may be distributed to individuals to study independently, or may act as the focal point of interactive groundwater governance trainings/workshops.

Chapter 3: Exploring Potential Tools for Transboundary Groundwater Management

Section A. Introduction to the Toolkit

The overarching purpose of this toolkit is to be a stand-alone educational resource that will increase the effectiveness of collaborative water management and governance efforts by helping build technical knowledge as well as practical skills. Essentially, it is meant to serve as the foundation for collaborative processes, and to help leaders craft more effective solutions. It is the hope of the GGRETA team that the toolkit will facilitate cooperative dialogue, thus preventing future conflicts over critical groundwater resources in Central Asia. It is intentionally designed to support hydro-diplomacy at the international, transboundary scale, but may also be helpful for water managers operating at a regional or local level.

While the toolkit will ideally be relevant in all regions of the world, initially it will be utilized by the water ministries of Kazakhstan and Uzbekistan, as a guide, to begin working towards a groundwater cooperation framework. The toolkit's ultimate aim is to enable the reader to guide or participate in collaborative groundwater management discussions and decisions. The primary distinction between this text and similar texts for surface water is the physical tools; these address the data gaps that are more prevalent in groundwater science than surface water science.

The following chapter represents a key component of the toolkit for Kazakhstan and Uzbekistan. I provide synopses, case studies, strengths, and considerations of ten valuable tools for transboundary water management. The Four Worlds Framework offers a structure for presenting the tools according to which of the core human needs they address.

Section B. Introduction to the Four Worlds Framework

Knowing that Kazakhstan and Uzbekistan are under pressure to address the depletion of the Pretashkent Aquifer, I will utilize what is known as the "Four Worlds Framework" as a foundation to present potential options for experiential learning that facilitates positive transboundary groundwater cooperation (Wolf, 2008). The Four Worlds Framework reflects an apparently universal structure of how people view their relationship with their environment. One could compare it to Maslow's Hierarchy of Needs, commonly referenced in Psychology, in that it recognizes several different "worlds" of needs within human life: physical needs, emotional needs, intellectual needs, and spiritual needs. One of the main differences between the Four Worlds Framework and Maslow's Hierarchy of Needs, is that in The Four Worlds, each of the needs are viewed as equal. There is no hierarchy of needs in the Four Worlds Framework, nor do they need to be viewed linearly.

Section C. How the Four Worlds Framework Benefits Dialogue

The Four Worlds Framework contributes by allowing water managers, government officials, and facilitators to think through and discover effective ways to meet each of the parties' various needs throughout negotiations. By thinking in terms of these four realms of needs, parties naturally humanize each other. In addition, the Four Worlds Framework demonstrates how to create a process that recognizes and integrates the physical, emotional, intellectual, and spiritual components of water. Ultimately, the Four Worlds Framework facilitates a more holistic approach to collaborative management than conventional negotiation processes (Wolf, 2008).

Beginning with the first level, the physical challenges of water issues, I will discuss how satellites and radar techniques can help fill data gaps and build knowledge about the physical

characteristics of poorly-understood groundwater systems. I will investigate how new technologies may contribute to publicly-accessible databases. This is important because without knowing how much water is physically available, it is impossible to discuss how to share water in a way that meets the needs of each nation.

To address the second level, the emotional aspects of water issues, I will describe a few effective methods to build trust between parties. This section will explain a couple of ways to ease tensions if the groups have a history of hostility. First, I will outline the Arabic peacemaking process, *sulha*, which maintains the honor of both parties following a dispute, and resolves conflicts in a way "that involves no humiliation" (Wolf, 2017, p. 31). Then, I will distill the main purpose and techniques of Native American talking circles, which allow each person to express themselves in whatever means necessary and for as long as necessary, to facilitate emotional processing (Polly, 2004). Both of these methods were born of specific cultures, and will almost undoubtedly need to be modified to fit the context. Therefore, they mainly serves as examples of the types of reconciliation processes that may be beneficial for easing tense dynamics. Another way to create a more amicable atmosphere, is to begin collaborative efforts by going on a group field trip. I will provide a case that demonstrates how field trips can promote collective identities.

The next level in the framework is the intellectual. I will address the intellectual aspects of water resources management by offering means for reconciling divergent understandings of groundwater systems. The question I will try to answer in this section is: How do dueling experts, competing users, and government officials from different countries, come to shared understandings about groundwater? I will offer an explanation of the benefits of joint fact-finding, and provide an outline of how to conduct joint fact-finding exercises. In this section, I will also describe the benefits of joint monitoring. Finally, I will highlight serious gaming and describe a case where a

role play game was used to improve understanding and relational dynamics in a multi-agency water management situation.

Lastly, I will offer tools that can help elevate conversations to a level of harmony and collective wellbeing. Specifically, I will illustrate the concepts of transformative listening, focusing on shared values, and collective visioning. Each of these strategies can build common ground and help groups nurture positive momentum for collaboration.

Section D. Physical Tools

'Determination of the average rate of replenishment is usually difficult… Pumping may continue for years before it can be determined [if] the water supply is large enough to keep all the wells supplied…' (Leopold, 1997, p. 32).

An important step in bilateral or multilateral water cooperation is to agree on the physical characteristics of the water in question, which in this case, would involve an assessment of the Pretashkent Aquifer. Currently, data on abstraction rates and water levels in Uzbekistan is missing (IGRAC, 2018). Without agreeing on how much water is physically available, it is impossible to discuss how to meet everyone in the basin's physical needs for water. Therefore, understanding the physical hydrology is valuable for beginning discussions about how to share groundwater.

Within the Four World Framework, the physical level refers to the tangible, measurable water. There are many tools that parties could use to increase their hydrological understanding of physical groundwater parameters, including citizen reporting, groundwater simulation modeling, using sensors to monitor irrigation, or installing pressure transducers to monitor groundwater levels (California Department of Water Resources, 2019). However, it is difficult to enforce citizen well reporting and may be expensive to install new monitoring infrastructure to measure drawdown.

Therefore, this section will explore how water managers may utilize new technologies to start building consensus about the physical characteristics of their shared groundwater resources.

I chose to look specifically at the Gravity Recovery and Climate Experiment (GRACE) satellites and Interferometric Synthetic Aperture Radar (InSAR) techniques, because there are already numerous, free, open databases that provide data using these tools. For example, both the National Aeronautics and Space Administration (NASA) and the European Space Agency (ESA) now have free and easily accessible databases filled with accurate GRACE and InSAR data that is relevant for groundwater monitoring (University of Alaska Fairbanks, 2019). Thus, these tools (further detailed in Table 1) can increase hydrologic understanding for ill-monitored and poorly characterized groundwater systems - even if the parties lack funding or political support.

Name of tool	**Case studies**	**Benefits**	**Shortcomings**	**Considerations**
GRACE Satellite	California and the Middle East	Estimates changes in groundwater storage and rates of depletion	Maps are low resolution and may need to be supplemented with other data	May be less useful for local level management
InSAR Radar Technique	Central Mexico	Measures land subsidence	Issues with temporal decorrelation especially over pasture lands	InSAR used in conjunction with GRACE provides more accurate groundwater understanding

Table 2: Physical tools outlined in the following section each include a case where the tool has been used, the documented benefits and shortcomings of each tool, and special considerations for implementing each tool's use (Steritz, 2019).

D.***1. Gravity Recovery and Climate Experiment (GRACE) satellite mission***

One of the satellite missions that shows promise as a tool to aid transboundary groundwater management is the Gravity Recovery and Climate Experiment (GRACE) mission. GRACE, a pair

of two identical satellites, was launched by NASA in 2002 (Ward, 2003). It produces monthly maps of gravity anomalies caused by mass changes (mostly due to changes in water storage) at fairly large spatial scales (Castellazzi, 2016). GRACE (shown in Figure 7) detects variations in water storage both above and below ground (Ward, 2003).

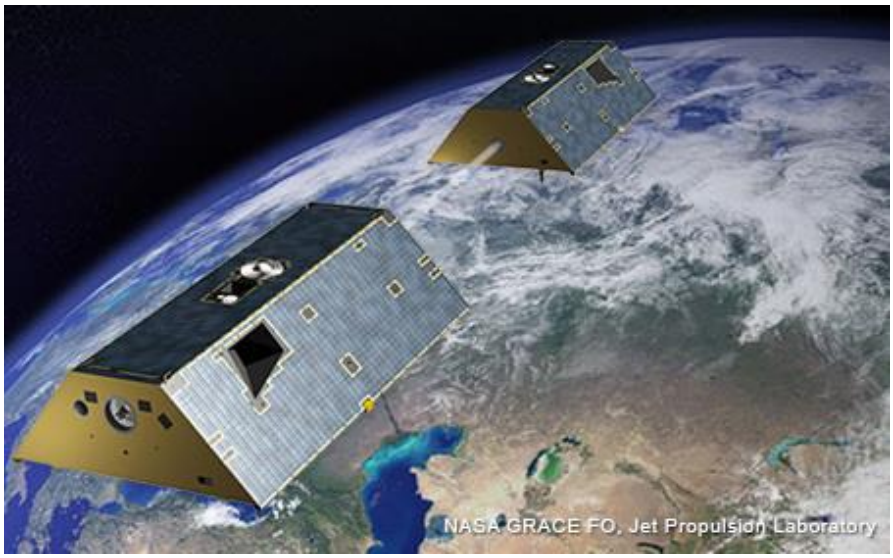


Figure 7: GRACE consists of twin satellites that provide maps of gravity changes (NASA, n.d.).

Famiglietti et al. (2011) report that GRACE is allowing us to visualize how freshwater derived from important aquifers is being redistributed. GRACE generates maps that demonstrate changes in groundwater storage over time, thus highlighting regions where water levels are dropping quickly. In the following case studies, GRACE has proved useful for quantifying the volume of groundwater lost in regions that have become heavily reliant on its use.

Case Study: Using GRACE to understand groundwater in the North-central Middle East

In 2012, Katalyn Voss and her colleagues evaluated groundwater storage trends in portions of the Tigris and Euphrates River Basins using GRACE. Underlying the region is "a complex system of transboundary groundwater aquifers", shared between Turkey, Syria, Iraq, and Iran (Voss et al., 2012, p. 904). Regardless of the high degree of regional reliance on groundwater,

monitoring and regulation of groundwater use is limited (Voss et al., 2012). Mirroring the global trend, the lack of consistent groundwater monitoring has led to data scarcity.

According to Voss et al. (2012), "satellite observations of time-variable gravity from the GRACE satellite mission, present a new and valuable tool to fill these [data] gaps" (p. 906). In this study, data derived from GRACE was combined with auxiliary data from the NASA Global Land Data Assimilation System, and processed to provide monthly groundwater storage variations (Voss et al., 2012). Voss et al. (2012) add to the literature that reveals, "the groundwater component of total water storage can be successfully isolated from the GRACE data" using the equation below (p. 907).

$$G' = S' - SWE' - SW' - SM'$$

G=Groundwater storage
S=Total water storage
SWE=Snow water equivalent
SW=Surface water storage
SM=Soil Moisture

After completing their calculations, Voss et al. (2012) found the volumetric freshwater loss (144 km^3) in the north-central Middle East to be among the largest in the world during the seven-year study period (p. 909-910). Downstream countries, Iran and Iraq, have been using more of their fossil groundwater since the surface water they traditionally relied on has been dwindling. Voss et al. (2012) found that 60% of the total water storage losses were from groundwater depletion (p. 910). Ultimately, the GRACE data may benefit the north-central Middle Eastern nations by helping them to quantify drawdown rates and the physical quantities of water remaining.

Currently, there is no evidence that the emergence of this data has sparked new groundwater dialogue, but the knowledge of rapid depletion may spark future cooperation, as Conti (2014) explains: A need for mutually beneficial solutions regarding aquifers can overpower

political tensions especially when rapid depletion is occurring and is recognized by aquifer states. The new knowledge gained from the GRACE satellite might provide a starting point if the countries in the crucial Tigris-Euphrates basin decide to begin joint aquifer management efforts in the future. Access to better groundwater data will likely improve joint modeling processes, and ultimately, promote science-informed transboundary management.

Case Study: GRACE data, coupled with observational data, reveals dramatic drawdown rates in California's Central Valley

The Central Valley of California is home to the San Joaquin and Sacramento River basins. Even though this valley is one of the most important agricultural regions of the United States, groundwater monitoring infrastructure is insufficient, and water use reporting is severely limited (Famiglietti et al., 2011). Therefore, despite the fact that "groundwater often supplies the bulk of water required for irrigation", scientists have struggled to quantify aquifer depletion rates (Famiglietti et al., 2011, p. 1).

In 2011, James Famiglietti led a study to assess groundwater storage changes in California's Central Valley, using GRACE data coupled with observational data. Like Voss and her colleagues in the previous study, Famiglietti and his colleagues utilized data from the NASA Global Land Data Assimilation System to enhance accuracy. Groundwater storage trends were calculated using the same equation as provided in the Middle Eastern case study, subtracting surface water, soil moisture, and snow water equivalent from the total water storage amounts provided by GRACE.

Results depicted a "steep decline in groundwater storage" beginning in 2006 (Famiglietti et al., 2011, p. 3). With the help of GRACE data, Famiglietti et al. (2011) could see that approximately 80% of the groundwater depletion took place in the San Joaquin River basin, and

affected the Tulare basin substantially (Famiglietti et al., 2011). With the GRACE-derived data, these scientists were able to identify which basins needed new groundwater pumping policies.

Since the Central Valley accounts for approximately 20% of the total groundwater demand in the U.S., it is important for water managers to know how the groundwater storage is changing (Famiglietti et al., 2011). Thanks to this study, Californian water managers are better informed about the severity of their over abstraction problem. While it is not a hopeful message, perhaps the results will help state leaders express their physical water needs and concerns during meetings between the Western U.S. states, in negotiations with Mexico and Canada.

Skeptical water managers may ask: How accurate is GRACE, and how can it assist in collaborative, transboundary groundwater management? Leading hydrologists, like James Famiglietti et al. (2011) and Matthew Rodell et al. (2007) (among others), have compared GRACE data with observational data of water storage variations, and have found them to match quite well. Still, we must acknowledge that data from GRACE has limitations. Castellazi et al. (2016) warn that GRACE may operate at too large of a scale because the satellites cannot provide "groundwater storage estimates at local scales relevant to most aquifer systems" (p. 768). In other words, the maps produced by GRACE data may have too low of resolution for practical utility in local water management.

While GRACE data may be large-scale in nature, the potential of the data for transboundary groundwater governance should not be written off. Since there is currently "no comprehensive framework for monitoring the world's groundwater resources", GRACE-derived data is an important resource for estimating variations in groundwater storage (Famiglietti et al., 2011, p. 1). GRACE can create a more holistic view of the physical quantities of water available across basins and can shed light on rates of depletion. It may be particularly beneficial to stakeholders with an

absence of monitoring infrastructure as it provides an enhanced understanding of large-scale aquifer behavior (Voss et al., 2012).

Interestingly, GRACE may encourage neighboring nations to share data because their neighboring stakeholders will be able to see how much water each other are pumping. Simply stated, "The synoptic view from space may render data denial and management opacity policies obsolete" (Voss et al., 2012, p. 912).

In addition, groundwater models may become more accurate thanks to GRACE and other water sensing satellites. Hydrologic modelers have utilized GRACE data to "calibrate and improve model simulations of total water storage" (Voss et al., 2012, p. 908). Access to better groundwater data will likely improve joint modelling processes, and ultimately, promote science-informed transboundary management. GRACE data can be viewed online and for free, at the following website: https://grace.jpl.nasa.gov/.

D.2. Interferometry of Synthetic Aperture Radar (InSAR)

GRACE can be used in conjunction with the Interferometry of Synthetic Aperture Radar (InSAR) technique to produce more accurate assessments of aquifer changes. InSAR's most critical measurement is land subsidence over time. By providing precise measurements and images of land subsidence (as seen in Figure 7) and ground deformation, InSAR allows us to predict hydraulic conductivity and storage. From these predictions, we can estimate future hydraulic head. Then, we can generate water management schemes to maintain hydraulic head above the critical level for that particular aquifer system (Zekber, 2014).

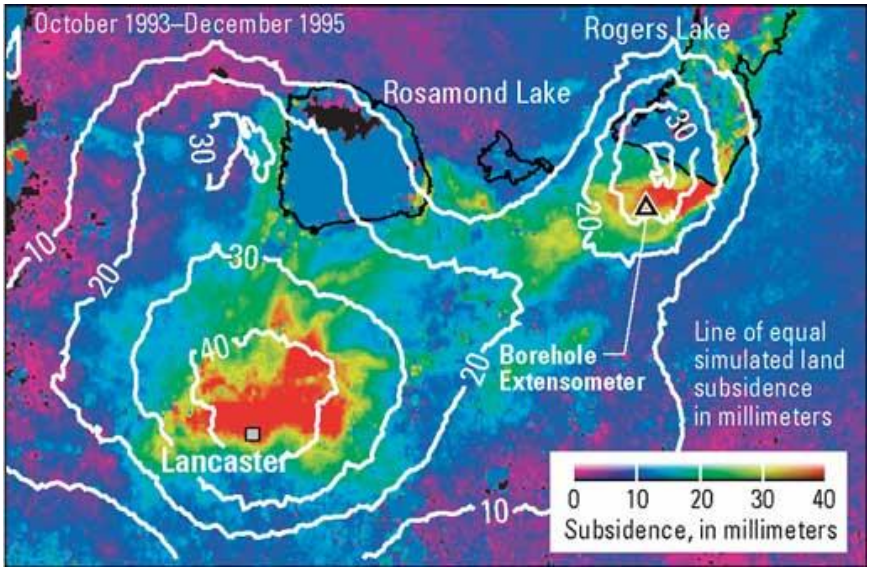


Figure 8: An example of an InSAR image demonstrating land subsidence (USGS, 1995).

Galloway and Hoffman (2007) have identified the following uses for InSAR in the field of hydrogeology:

- Estimate the hydro mechanical properties of an aquifer system.
- Enhance groundwater flow models by adding numerical parameters related to land subsidence and the compaction of an aquifer system.
- Identify the heterogeneity of an aquifer system. (p.3)

In summary, InSAR is another technological tool that may help water scientists and managers understand how the groundwater components of their watersheds have changed, or are changing. Once again, these technologies are more beneficial when used together, and especially crucial in regions with sparse groundwater monitoring infrastructure in place. One such area is Central Mexico, where groundwater drawdown been difficult to quantify due to a lack of hydrogeological field data (Castellazi et al., 2016).

Case Study: Central Mexico study discusses how InSAR and GRACE complement each other

In 2016, Castellazi et al. completed a study to investigate how GRACE and InSAR, in combination, might shed light on groundwater depletion trends in Central Mexico's Lerma-Santiago-Pacifico Basin. Castellazi et al. (2016) estimated the change in groundwater storage using GRACE data, and integrated vertical land displacement measurements from InSAR. Using GRACE maps and data, the researchers were able to estimate that 158 million cubic meters of groundwater storage were lost per year, in a study period from 2002-2014 (p. 5994). One noteworthy limitation Castellazi et al. (2016) explained is that, the low resolution of GRACE's maps left them with uncertainties about where exactly groundwater "leakages" or losses were occurring. In the case of Central Mexico, the close physical proximity of aquifers in the basin made it difficult for Castellazi et al. (2018) to determine which aquifer was suffering the greatest losses with GRACE data alone.

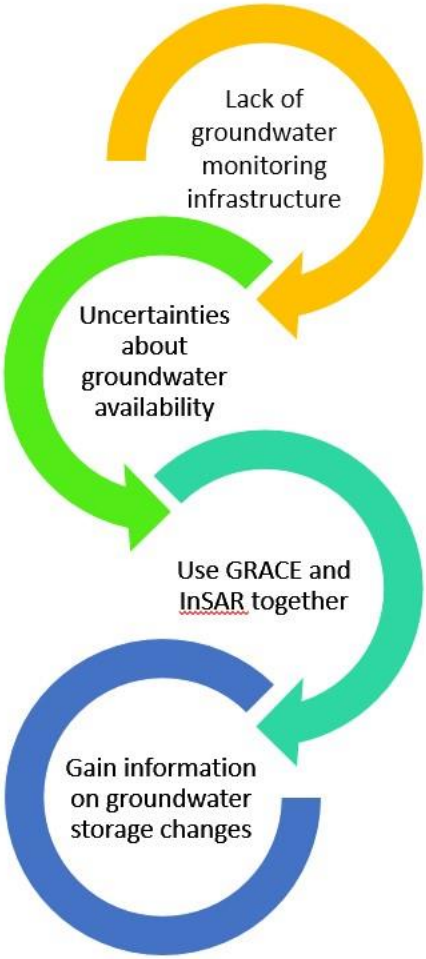


Figure 9: Using a combination of GRACE and InSAR, Kazakhstan and Uzbekistan may be able to fill data gaps (Steritz, 2019).

However, using high resolution, InSAR-derived land subsidence maps, the team was able to clarify which aquifers were experiencing significant groundwater deficits and severe land subsidence. Additionally, the InSAR data was used successfully in forward modeling exercises that simulate possible future groundwater scenarios. Castellazi et al. (2016) suggest that using InSAR "to refine GRACE's groundwater storage trend maps" will improve the accuracy of groundwater depletion estimates in future studies (p. 6000).

Summary of Physical Tools

Without establishing an accurate idea of how much water is physically available in each aquifer, collaborative management schemes lack a foundation, and therefore, may find planning and management difficult. This discussion has outlined how GRACE and InSAR can assist water ministries, River Basin Organizations (RBOs), water scientists, water managers, and concerned citizens to fill data gaps. With a more complete picture of the water table levels, the drawdown rates, and the changing physical parameters of their aquifers, all parties can begin to contemplate which courses of action may meet their future needs.

Both GRACE and InSAR create new knowledge about transboundary aquifers, which can bring about dialogue between the aquifer states (especially if the data points to problems associated with the aquifer). Not only do these tools help fill data gaps and identify issues, they also help level the playing field by providing both parties with the same knowledge. Since there are many free and open access databases with GRACE and InSAR-derived data, these tools can help create more equal technical capacities between aquifer states. Having the same access to information about the physical parameters of the aquifers can help parties feel ready to collaborate. In the physical realm of the Four Worlds Framework, the focus is on the tangible, material, measurable aspects of daily life. With regards to groundwater, one of the main challenges historically has been that scientists could not easily measure how much water tables were changing. With technologies, like GRACE and InSAR, these data gaps can be filled.

Section E. Emotional Tools

'Conflicts and disputes arise about groundwater protection and allocation because it's personal - people are sustained by their water…' (Vinett and Jarvis, p. 12, 2012).

Water management can be very emotional because many groups of people have strong ties to their water. Indigenous people around the world have generations of memories associated with

certain water sources, and their identities may be rooted in those waters. From Australia to Egypt, there are origin stories that are center around bodies of water – and some in groundwater specifically. For this reason, emotions may run high when two countries begin to discuss the possibility of collaborative management.

In international water negotiations, one side might think, "We have the rights to this water because we have been here since the beginning of time", and may feel resentful, sad, or angry if those water rights are threatened. In turn, those strong emotions may impact their ability to focus on what is happening in negotiations since emotions are connected to attention (Tyng et al., 2017). Likewise, the neighboring country may also feel a strong emotional attachment as to that water, which may influence their actions and behaviors within negotiations as well. This is natural. Cooperation is still possible - so long as the emotions present in the room are taken seriously and processed consciously.

This second level of the Four Worlds Framework helps us acknowledge that we are emotional beings by nature. In fact, our emotions influence many facets of our lives, including the way we learn, problem solve, reason, perceive, and create memories; in other words, emotions are closely tied to many other cognitive functions (Tyng et al., 2017). The emotional dynamics are thus a crucial consideration within any water negotiation or collaboration.

There are a plethora of tools that may be used to build trust and improve the emotional dynamics between co-managers. Among them are: creation of feedback mechanisms, engagement with cultural rituals or celebrations, expressions of appreciation for individual contributions, story-telling, acknowledgement of mistakes, and following through with stated commitments. While there are many ways that parties can nurture positive relationships and build trust, I will focus on the three tools listed in Table 2, *sulhas*, talking circles, and field trips.

Name of tool	Case studies	Benefits	Shortcomings	Considerations
Sulha reconciliation ceremonies	Israel and Palestine	Restores dignity and respect following conflicts	May restore to pre-conflict situation without addressing root causes	May not be appropriate for all cultures or may need significant adaptation
Talking circles	Alaskan Native communities	Facilitates emotional processing, release, and validation	No record of use as a tool at the international level	Circular seating may not be appropriate in all cultures
Field trips	Oregon's Malheur National Forest	Often builds affinitive trust and positive, communal feelings	May highlight differences of opinions regarding boundaries, etc.	Requires careful planning (to meet all needs of participants) and funding

Table 3: *Sulhas*, talking circles, and field trips are tools for improving emotional dynamics (Steritz, 2019).

E.1. Sulhas

A *sulha* is a "ritual ceremony of forgiveness", stemming from the word, *musahala,* which means "reconciliation" in Arabic (Wolf, 2008, p. 59). The process is outlined by mediator Peter Phillips (2011):

- Once a past injury or conflict is acknowledged, a highly respected person, or mediator, is sought to intervene.
- Both, or all, parties must then accept the mediator. (Consent is a generous gesture towards peace.)

- A “truce” is in place once the mediator has been accepted, meaning no form of revenge should be sought.
- Then, some kind of compensation is offered to the party that has been wronged. This may be monetary compensation or a verbal, public statement provided by the party seeking forgiveness.
- The ceremony ends with individuals from both sides shaking hands with one another as the community bears witness.
- Finally, a peace knot is tied by the participants.
- In private, the parties share coffee and a meal together.

Case Study: Using sulhas to build peace between citizens of Israel and Palestine

In 2001, “when Israel and Palestine were locked into terror of the other side, the Sulha Peace Project was born” (Sulha Peace Project, 2013). The co-founders were a Jewish Israeli and a former Palestinian-Israeli peacemaker. Together, they began planning annual *sulhas* to build trust and restore dignity between citizens from Palestine and Israel, including community organizers, spiritual leaders, professionals, soldiers, and anyone else willing to engage in emotional processing. Eventually, the *sulhas* became bimonthly gatherings centered on music, dance, food, and story-telling circles, illustrating that the traditional *sulha* practice can be successfully modified to fit the needs of the involved parties (Sulha Peace Project, 2013).

According to one of former directors, Elad Vezana, “when Jews and Arabs from all different cultures meet for *sulhas* and share their life stories, it softens the hate and demonization” (Sulha Peace Project, 2013). These *sulhas* have proven to be an “effective cross-cultural communication tool” that stimulates meaningful dialogue. (Barker & Gower, 2010, p. 295).

Through the process of ceremonial reconciliation, people from Israel and Paestine have begun to understand where each other are coming from, making it easier to forgive and cooperate. One participant reports that "it was very humanizing to see that they have a day to day life, just like we have our day to day lives" (Sulha Peace Project, 2013).

In this context, the *sulhas* have created two-way, respectful communication, group learning, and validation of past grievances between Palestinian and Israeli participants, and fostered feelings of peace and hope for the future (Sulha Peace Project, 2013).These impacts reflect the strengths of *sulhas* to improve intercultural dynamics. However, it is also important to examine the weaknesses of *sulha*. As scholars Tarabeih et al. (2009) point out, "the traditional nature of *sulha* can be a weakness… because disputes today differ from past conflicts in many aspects" (p. 55). Additionally, *sulhas* may simply restore the situation before the conflict, without necessarily addressing the root causes of the conflict (Tarabeih et al., 2009, p. 55).

Figure 10: Two men conversing after making peace during a *sulha* (*Uplift,* 2015).

According to tradition, "Once the *sulha* has been performed… reference to the past conflict is halted", which can be seen as either a strength or a weakness (Wi'am, 2016). When dialogue is focused on the future, it may help move co-management plans forward. However, if not all parties

are satisfied with the reconciliation process, they may be frustrated by the inability to discuss the past conflict.

With these strengths and weaknesses in mind, aquifer states must consider whether such a tool could be beneficial with some modification. Since *sulhas* have fostered forgiveness between rival Arab communities, there is reason to believe that they may also inspire amnesty between countries who have experienced water conflicts in the past (Phillips, 2011). An international groundwater *sulha* might look different than traditional *sulhas*. Imagine a case of one aquifer state polluting groundwater, which negatively impacted a neighboring country. In a case like this, the *sulha* might begin with a verbal acknowledgement of the cause of pollution (the polluters taking responsibility), and an apology for any harm that it has caused. For *sulhas* to be a successful tool at an international level, a mediator from each country may be necessary. Those mediators may modify the process to be appropriate for the cultures of participants. Certain elements of the process may be discarded, or the ceremonial elements may remain while given a different name.

Their subsequent truce might revolve around accepting relevant tenants of international legal principles, such as an agreement that neither side will take any action that may threaten the shared water source. Next, the polluting country could perhaps offer monetary compensation for the damages done to their neighbors. If an exchange of currency is not appropriate, providing a water-related service could be another option. Finally, members from both water ministries might discuss if any other actions need to be taken in regards to reconciliation. Finally, they may shake hands and share a meal consisting of foods from both cultures.

E.2. Talking Circles

Respect is also a major theme in Native American talking circles. For the Cherokee people, talking circles (pictured in Figure 10) are a tool that allow individuals to speak one at a time, and

express their emotions in any respectful way that promotes their personal healing. Participants may tell stories, cry, speak about emotions, pray, sing, or remain silent. Traditionally, a talking stick indicates whose turn it is to speak, so that nobody will speak over them (Polly, 2004, p. 539).

Figure 11: A talking circle taking place in Portland, Oregon (PSU Native American Student and Community Center, n.d.).

One important point is that each individual is given a chance to be heard. In order to encourage freedom of expression, the time given to each person is not specified in most talking circles (Polly, 2004, p. 538-540). Individuals who are hurting, or who have experienced trauma, may need a longer time to express their feelings. One reason that talking circles may be beneficial for conflict transformation is their potential to alleviate the difficult feelings associated with trauma. One such case is presented below.

Case Study: Using talking circles in Alaskan Native communities impacted by the Exxon Valdez oil spill

In 1989, a huge oil tanker, the Exxon Valdez, crashed into a reef in Prudhoe Bay, Alaska, resulting in over 11 million gallons of crude oil being released into the previously-pristine marine environment (Picou, 2000, p. 77). The subsequent ecological devastation meant a complete

disruption of Native subsistence fishing practices and traditional ways of life. In the year following the oil spill, Alaskan Natives in this region reported high levels of psychological stress and depression, as compared with Natives residing in other parts of Alaska (Picou, 2000, p. 78). Scholar J. Steven Picou (2000) highlights the fact that such human-caused technological disasters (which may have also impacted some aquifer states) are often followed by periods of "long-term collective stress" (p. 79).

Attempting to alleviate the mental and emotional suffering of the impacted, remote communities surrounding the fishing village of Cordova, a local mental health clinic began a healing project in 2014. The initiative centered on the Native cultural concept of the village as a healthy circle, "whose people are safe within its fold" (Picou, 2000, p. 83). They began hosting talking circles to create social spaces where people could express their anguish. Invitations were sent to everyone in Cordova and neighboring villages (Picou, 2000, p. 83).

The actual talking circles began after establishing the basic guidelines of: respect, confidentiality, and *uninterrupted discourse.* Another crucial component was how they framed the talking circles; it was explicitly stated that their purpose was to collectively process the impacts of the oil spill, which had left voids in the cultural connectivity of their villages. In order to align with Native values, the talking circles were held outdoors over a two-day period. Throughout these days, a number of themes emerged, such as: sorrow at the enormous loss of animal lives and disruption of relations within the spiritual realm. Clearly, all of these are difficult topics, but several elders expressed that they must be acknowledged before healing and restoration could occur in their community (Picou, 2000, p. 83-85).

Following the closing of the talking circles, every respondent of researcher Steven Picou's survey reported positive experiences within the talking circles. The specific outcomes they

documented were: increased community connectivity and renewed cultural awareness and appreciation (Picou, 2000, p. 93). This Alaskan case study highlights the fact that talking circles may benefit communities that have suffered due to water contamination or other types of pollution. As Wolf (2017) says, "Having the space to vent about perceived or actual past wrongs is often a key to moving a dialogue forward productively" (p. 130). Thus, talking circles can help a traumatized individual or group become ready for collaboration.

With much research, I could not find a case of a talking circle being used as a tool at the international level. However, the principle tenets of talking circles could be applied to facilitate dialogue that garners understanding, and facilitates dialogue, between aquifer states. Restorative justice scholars Beck et al. (2011) reiterate the key components of effective talking circles (p. 74):

- A well-respected, impartial facilitator (or perhaps a few)
- Consensus decision-making about the guidelines and central topic of the circle
- Circular seating structure (may need to be abandoned if used in certain cultures)
- Opening and closing ceremonies
- A talking piece (such as a feather, piece of wood, or any meaningful object) that directs the listening and attention of the circle

Once again, every aspect of the talking circle should be modified to be culturally appropriate for both parties. For parties who are seeking trust-building but do not need reconciliation processes, the next section is particularly pertinent.

E.3. Field trips

If well-facilitated, embarking on a group field trip can be a powerful bonding experience, and can foster a collective identity. Wondolleck and Yaffee (2000) report that, after a decade of

collaborative natural resource management, they found field trips to be one of the most effective ways to "foster a [collective] sense of identity associated with a watershed" (p. 73). Travelling together and discovering a shared connection to the same land and water can help blur divisions and foster a superordinate identity (Shah, 2009).

Figure 12: Professionals exploring a glacial lake on a field trip in Kyrgyzstan (Bolt, 2019).

Field trips may also be helpful for increasing gender equality in the group and empowering women to participate in group processes. If men and women are able to conduct fieldwork alongside one another, the likely result will be enhanced respect for one another's skills and contributions. If all the participants act respectfully on the trip, women may feel more comfortable talking with the men upon their return to the negotiation room.

Additionally, group trips allow time for one-on-one communication and "the building of mutual respect", outside of negotiation rooms, which is crucial for cooperation (Wondolleck & Yaffee, 2000, p. 161). Field trips have proven useful for building trust at the community, regional, and international levels of governance (Wondolleck & Yaffee, 2000; Barker & Gower, 2010). I

will share a case of multiple levels of government working together to collaboratively manage forests in Oregon.

Case Study: Using group field trips to facilitate collaborative forestry management

Time-consuming litigation over timber harvests created a conflictive atmosphere in the Malheur National Forest of Oregon during the 1990s and early 2000s (Davis et al., 2018, p. 217). Despite their differences, land managers recognized a need for more united forest management strategies. Thus, in 2006, a diverse array of stakeholders from federal, tribal, state, and local governments, private sector groups, and non-profit organizations, came together to form the Blue Mountains Forest Partners (BMFP). This collaborative group was formed to promote both ecological health and economic opportunities alike. Although the various government officials entered the collaboration with seemingly divergent missions, they fostered a group identity through informal outdoor interactions, especially field trips (Davis et al., 2018, p. 218-220).

One participant from the BMFP described the effects of group field trips to Davis et al. (2018) as such, "You and I are standing in the woods, [and] we come from two [completely] different perspectives…. Through the course of one or several days, we realize our views are really not that far apart… And then agreements come easy." (p. 220). Indeed, the majority of BMFP members did feel an increase in affinitive trust after such field trips. Affinitive trust essentially means trust based on shared experiences, which foster feelings of connectedness (Cvetkovich & Winter, 2003). The cultivation of affinitive trust is one of the greatest strengths of field trips as a tool.

Field trips often provide positive memories for participants to recall throughout their collaborative processes. As Wolf (2017) notes, "sharing stories of peak experiences generates

energy moving forward" (p. 165). However, in cases of shared aquifers, field trips may also highlight differences of opinions regarding recharge and discharge areas, aquifer boundaries, hydrologic connectivity, etc. This is not necessarily negative. While the divergent perspectives could cause tensions at first, they can also serve as a starting point for group learning and creating a shared understanding. The next section will describe tools that may assist in consensus-building.

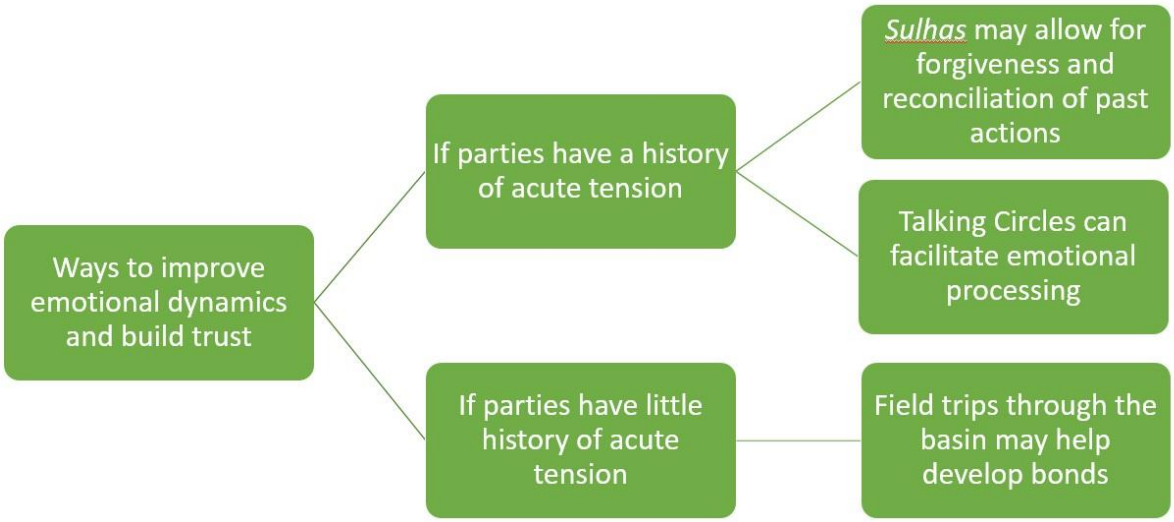


Figure 13: *Sulhas*, talking circles, and field trips may improve trust in groups (Steritz, 2019).

Summary of Emotional Tools

Before moving on to the intellectual tools, let us recap the emotional realm of the Four Worlds. Effective conflict transformation relies on the emotions of all parties being taken seriously. Parties must honor each other by acknowledging one another's complex emotional needs. There are many ways to pursue healthy emotional processing. When parties have experienced water conflicts in the past, they may benefit from some type of reconciliation ceremony, such as the traditional Arabic *sulha,* in which acknowledgement and forgiveness are consciously guided by a mediator (or multiple mediators). In cases of serious trauma resulting

from a devastating event, the impacted party may need to process their emotions and heal together before feeling ready to collaborate. Talking circles have demonstrated the ability to transform trauma (Picou, 2000).

Lastly, if parties have less history of acute tension, they may require less emotional processing and may instead seek a gradual building of trust. Affinitive trust may be built through tools, such as group field trips, where parties can familiarize themselves with one another and start to create friendships. It is important to remember that when using any of the emotional tools, patient and respectful two-way communication is pivotal. The way groups communicate is ultimately going to determine how the emotional dynamics play out, and whether or not collaborations are successful. In the following section, I will lay out methods for collaborative research.

Section F. Intellectual Tools

'A joint scientific effort is necessary for trust building, relationship building, and credibility' (Welch, 2017, p. 105).

The intellectual level of the Four Worlds Framework generally refers to the mental sphere of life. In the context of this toolkit, it refers to how each side intellectualizes groundwater. National leaders may be wondering how their scientists and the scientists from the neighboring aquifer state can reach a unified rational understanding of the groundwater system in question. This task can be quite challenging, and that is why it important to understand ways of navigating the perceptual components of collaboration.

Aquifers are especially difficult to manage at the transboundary level partially due to the vast uncertainties and multiple ways of knowing that are associated with them. Before two nations can create a co-management plan, they must first agree on the basic dynamics of the shared aquifer (Welch, 2017). Therefore, one crucial step in successful collaborative groundwater governance is

to establish a mutually-accepted scientific understanding of the groundwater dynamics at play. This agreed upon understanding will serve as a pillar for cooperation. In order to build a solid intellectual foundation, it is often necessary to engage in exercises that help parties better align their perceptions of their shared aquifer (Jarvis, 2014).

Recognizing that the quantitative characteristics of groundwater are difficult to measure, "it is necessary for scientists to jointly research and agree on area of recharge [and discharge], geologic boundaries, and the connectivity of aquifers to surface water" (Welch, 2017, p. 98). With collaborative learning techniques, experts from opposite sides of a geopolitical border can come to a consensus on previously debated groundwater systems (Islam & Susskind, 2012). There are a vast array of intellectual tools that are relevant for co-managing water resources, from computer modeling to scientific mediation (Jarvis, 2014). I have chosen to focus on joint fact-finding and serious gaming (shown in Table 3) in this section because they are two of the most relevant and useful tools. One reason why joint fact-finding is so practical is the fact that it can underpin future collaborative processes. In other words, the clear definition of problems and concerted research through joint fact-finding can serve as a necessary first step in consensus-building. Joint fact-finding efforts can lead to successful joint monitoring and modeling. (I will highlight one case study that demonstrates this sequence of events.) Next, serious gaming was selected on the basis of its capacity to facilitate social learning, bridge knowledge gaps, and broaden participants' understanding of water problems.

Name of tool	Case Study	Benefits	Shortcomings	Considerations
Joint fact-finding	Northwest Sahara Aquifer System	Harmonizes data acquisition, builds mutual understanding, and clarifies aquifer problems	May run into technical and operational challenges	Often requires long-term, dependable funding
Serious gaming	U.S. Bureau of Reclamation	Builds understanding of other stakeholders' needs	Does not generate scientific data	May require careful introduction to be viewed as a valid tool

Table 4*:* Intellectual tools can be used for group learning and coming to a consensus about shared groundwater resources (Steritz, 2019).

F. 1. Joint Fact-finding

Scientific research - specifically regarding transboundary aquifer impacts – can be very important for spurring cooperative conversations. Conti (2014) explains the value of joint fact-finding like this: "When new knowledge about a transboundary aquifer becomes available, it can bring about dialogue between the aquifer states", which can lead to higher levels of cooperative engagement (p. 40). The joint fact-finding process is especially helpful in cases of "dueling experts", when conversations are deadlocked due to disagreements about groundwater science (Jarvis, 2014, p. 65). Joint fact-finding can also be beneficial if there is an uneven capacity between two parties. Sometimes, one country feels like they do not have a high enough level of knowledge to participate meaningfully in collaboration. Joint fact-finding generates new knowledge that is shared between both sides, creating a more balanced capacity to cooperate (Conti, 2014, p. 43).

First, I will discuss what joint fact-finding is, and then will outline some general steps that are typical of the process. Ehrmann and Stinson (1999) offer the following definition for joint fact-

finding: “a central component of many consensus-building processes [in which] stakeholders with differing viewpoints and interests work together to develop data and information” (p. 376). Basically, joint fact-finding is a concerted research process that can involve government officials, technical experts, scientists, water managers, community members, or other stakeholders from each of the aquifer states; a neutral mediator, expert, or consultant may be a positive addition if there is a lack of trust, or a lack of expertise (Ehrmann & Stinson, 1999, p. 387). Of course, the process should be tailored to fit the parties’ specific situation.

Remembering that modification may be necessary, I will outline the typical steps of the joint fact-finding process, relying on the work on Ehrmann and Stinson (1999):

1. First, the involved parties should define ground rules/guidelines for how the process will go. This could include conversations about confidentiality as well as how data will be recorded, organized, stored, and finally, integrated into their future water management efforts. Possible questions to address are:

    - What is the timeline for the research?
    - Will the data be entered into a shared database? If so, how?
    - Will product(s) be created from the data?
    - Will the new information be used in a joint modeling project or a joint management agreement?

2. Next, it is important to come to a consensus on which question(s) the research will focus on. Consider what the major uncertainties of the particular aquifer are, and which data gaps need to be filled. Framing the problem can be a sensitive step, so take time to hear all the participants’ perspectives, and integrate them.

3. Explore all possible methodologies for answering the chosen research question(s). Make the limitations of each technique explicit, and come to a group decision about which one will be used.

4. After a predetermined period of time, the group should re-convene and evaluate how effective their methodologies are for addressing the question(s). Modify methods if necessary.

5. Once the research process is complete, the parties should all receive the results, and collectively synthesize a final report that outlines how the process went. This creates transparency. (Ehrmann & Stinson, 1999, p. 394-396).

Please keep in mind the possibility that some data may remain incomplete following the joint fact-finding process. In these cases, continuous joint monitoring or modeling may be logical next steps to keep filling data gaps or addressing uncertainties. Any combination of joint fact-finding, monitoring and joint modeling, or the use of all three in conjunction, may form the basis of a mutually-accepted scientific understanding (Ehrmann & Stinson, 1999, p. 396-397)..

Case Study: Using joint fact-finding processes to begin monitoring the Northwest Sahara Aquifer System

The organization for Monitoring and Evaluation of Water in North Africa (MEWINA), has assessed the ongoing collaborative research efforts between Tunisia, Libya, and Algeria regarding the Northwest Sahara Aquifer System. Since this important transboundary groundwater system began suffering from salinization and depletion, "authorities from all three countries have initiated joint studies under the supervision of the Observatory of the Sahel and the Sahara" (MEWINA, 2014, p. 3-4). First, in 1998, they organized a joint groundwater research project, and laid the ground rules for their studies. Representatives from each of the countries came to a consensus on

their research question and selected the most appropriate methods to answer it. By collectively defining their problem, the countries were laying the "groundwork for [collaborative] management" (Wolf, 2017, p. 141).

In order to "monitor generalized drawdowns and abstraction flows", the aquifer states established a joint monitoring network (MEWINA, 2014, p. 24). Collectively, they: established data collection and acquisition mechanisms, defined a set of monitoring indicators, and selected monitoring points in each country. Through six years of joint monitoring and modeling, Tunisia, Libya, and Algeria were able to identify the most significant risks associated with the aquifer system, as well as which areas were most at risk (MEWINA, 2014, p. 26).

The main issues they encountered were technical and operational (MEWINA, 2014, p. 4-25). Seemingly, the aquifer states struggled to homogenize their existing data and create an information system that could successfully integrate the new and existing databases, maps, and mathematical models (MEWINA, 2014, p. 4). After reflecting on the sources of these challenges, MEWINA (2014) offered the following suggestions for other transboundary aquifer states. Before beginning joint monitoring, aquifer states should first:

- Create a monitoring task force
- Agree on data acquisition protocol
- Design a centralized data sharing modality that can synthesize several types of data (quantitative data, maps, models, etc.)
- Solidify long-term, dependable funding for joint research endeavors
- Agree on how often to disseminate reports (MEWINA, 2014, p.26).

The main benefit of this joint process was the creation of a more holistic and harmonized understanding of the negative impacts of drawdown for each of the aquifer states (MEWINA, 2014, p. 26). This case study illustrates perhaps the greatest strength of joint monitoring: the ability to clarify. However, joint research is not the only way to come to a consensus. In the next section, I will present serious gaming as a tool for facilitating shared understandings that support collaborative natural resource management.

F.2. Serious Gaming

Another way to deal with uncertainties is through serious gaming; these games are "serious" because they involve realistic water issues that players solve (Hockaday et al., 2017). Serious gaming can facilitate social learning by allowing players to practice discussing conflicting opinions diplomatically, in a low-stakes setting. In addition, games and simulations can enhance negotiation skills, bridge knowledge gaps, break down communication barriers, and familiarize participants with the merits of opposing viewpoints (Jarvis, 2018). For this reason, "serious games in one form or another are incorporated into nearly all international water negotiation frameworks and trainings" today (Jarvis, 2018, p. 22). Serious gaming options may include role plays, virtual games, and board games, all of which teach about water management and water negotiations in a fun and interactive way (Jarvis, 2018). (The GGRETA toolkit includes four serious games and role plays, two of which are shown in Table 5).

Dueling Experts	Role Play	Groundwater	Two parties and mediator	Groundwater protection boundaries dispute using Scientific Mediation.	Played at University of Oregon Law School, Environmental Conflict Resolution Course and UNESCO-IHE, Delft, The Netherlands. (Jarvis 2014)
Water Message Game	Role Play	Surface or Groundwater	Two or more groups and mediator	Water allocation dispute using Prisoner's Dilemma framework.	Played at Water Conflict Management and Transformation Natural Resources Leadership Academy, and undergraduate courses in International Water Resources Management at Oregon State University. (WaterNet et al. 2003)

Table 5: The "Dueling Experts Role Play" and "Groundwater Message Game" are two of the four groundwater games included in the GGRETA Groundwater Hydro-diplomacy toolkit (Hockaday et al., 2017).

In a playful environment, participants can act out the roles of various stakeholders, expanding their perspectives about water issues. Serious gaming can help groups move from "antagonism to reflection" by asking participants "to role play as someone with whom they disagree" in reality (Wolf, 2017, p. 169). Dr. Aaron Wolf employed this strategy while mediating between the U.S. Bureau of Reclamation (the agency responsible for building many of the large-scale dams in the Western U.S.), environmentalists, and various landholders affected by dams.

Case study: Using serious gaming to improve understanding and relationships between agencies in the American West

Wolf (2017) decided to facilitate a role play following a series of tense interactions between the U.S. Bureau of Reclamation and stakeholders over an irrigation project that would impact an endangered species (p. 136). Since both sides were accusing the other of lacking concern for either the economy, the environment, or people, he felt it was important that they learned about the issue from a new point of view (Wolf, 2017, p. 168). In the role play, Wolf (2017) asked the environmentalists to act as the bureau staff, who had a "clear mission to make the arid potions of the country livable and productive" (p. 169). Likewise, bureau staff were to play the environmentalists. Here is the reason for asking the participants to take on a fictional character

with opposite view opposite of theirs: “There are few better ways to show that one really has absorbed what the other is trying to express than to express it for them” (Wolf, 2017, p. 169).

Therefore, each participant was challenged to outline the concerns of the other side and represent that perspective during the role play. “As each participant in role described the issues as seen through the eyes of the other, it became clear that not only did each side understand each other, but there was actually deep respect for what the other side did” (Wolf, 2017, p. 170).

Following the role play, Wolf (2017) experienced a real turning point in the group’s dynamics, as both sides began to express gratitude for the work of the other (p. 170). The outcome of this role play highlights one of the strengths of serious gaming, which is the ability to bolster “empathy for each side” and cultivate a more expansive understanding of the issues at hand (Wolf, 2017, p. 169).

Taha (2017) also demonstrates that such role plays can contribute to social learning in a safe environment (p. 88). Although the benefits are apparent, the proposal of playing a game in an international negotiation may seem like an insult to some. For example, Wolf (2017) was once yelled at for beginning a meeting with one such game because one of the participants (a leader of a national water delegation) felt that the use of games in such a setting was condescending and not appropriate for the work they were trying to accomplish (p. 87). Therefore, it is important to introduce any serious game with a thorough explanation of why it is being used: as a tool to facilitate dialogue and help create a common understanding.

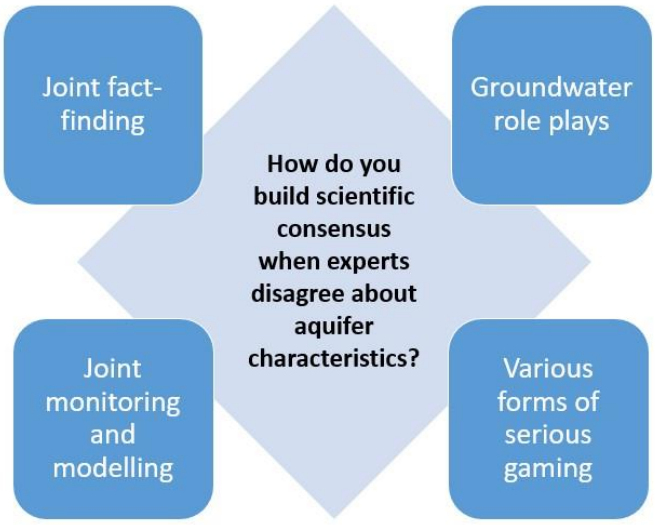


Figure 14: Building consensus may require using a variety of intellectual tools including joint fact-finding and serious gaming (Steritz, 2019).

Summary of Intellectual Tools

In this section, I have discussed the intellectual level of the Four Worlds Framework, which revolves around the mental processes involved in collaboration. Parties coming from different cultures often have different perceptions and ways of knowing their shared groundwater systems. I have outlined why it's important to reach a scientific consensus before strategizing co-management schemes. It is important to create a foundation that future dialogue will be based on. If two groups have divergent ideas about the main issues associated with the aquifer, it may be nearly impossible to brainstorm solutions.

With that said, I recognize that creating a harmonized understanding can be exceptionally difficult especially in cases of dueling experts. Therefore, I have presented several methods that parties may use to help them come to a consensus about the ways they perceive their shared groundwater. Namely, the processes for joint fact-finding (a collective research exercise) have been explained. One of the greatest strengths of joint fact-finding is that can harmonize data acquisition techniques and spark joint monitoring activities. Then, I presented the pros and cons

of using serious gaming to facilitate group learning and expand perspectives on water issues. Using simulation games and role plays can help participants identify and understand the needs of other parties. Often joint fact-finding and serious gaming can spur important conversations about priorities and goals of future collaborative processes (Welch, 2017). Each of these methods offers a starting point for dialogue and can clarify groundwater-related challenges in the region.

Once two parties reach a shared understanding about the aquifer(s), they can explore their collective vision for the shared waterbody. In the following section, I will explain why the means of communication are key in transboundary collaborative processes and will offer ways to practice healthy intercultural communication.

Section G. Spiritual Tools

'Unless peace is generated among the people who live it out, treaties are not really operational on a practical level", so it is critical to "build opportunities for people to listen to each other' (Hwoschinsky, 2006, p. 9).

I recognize that the introduction of spiritual tools and concepts to conflict transformation may be perceived by some as discordant. Please consider the fact that much of the world, especially the global South and East, maintain spirituality as integral to their understandings of their environments (Wolf, 2017, p. 18). Along these lines, it is important to keep in mind that, globally, native and indigenous people see "water as a holistic, spiritual resource." (Wolf, 2017, p. 140). Water is spiritually prominent in the lives of billions of people. Innumerable indigenous cultures trace their origins to some body of water. For many people across the world, local water bodies hold deep cultural significance. Entire collective identities are rooted in water bodies. One of the goals of this section is to provide tools that can help cultivate a sense of community based on a shared waterbody. It is beneficial to explore the spiritual realm of human life and familiarize

ourselves with intangible tools that can aid in creating positive momentum for parties hoping to succeed in water cooperation.

As I mentioned, the spiritual dimension of groundwater cooperation is partially about fostering a collective *aquifer community* identity that allows the group to "assess the needs of the watershed as a whole" (Wolf, 2017, p. 142). If groups can successfully realize their interdependence and interconnection, holding it at the forefront of dialogue, "it becomes more difficult to hate or harm" other parties involved in the process (Wolf, 2017, p. 65). Nurturing a group identity relies on the communication skills of everyone involved (Shah, 2009). A mediator of groundwater negotiations, Jarvis (2014) reminds us that, "listening and communication competencies are lifelong learning skills that regularly require updating and refining" (p. 123).

Each of the tools listed in Table 5 are beneficial for promoting healthy dialogue and elevating conversations to a level of harmony. There are an abundance of tools that may serve this purpose, ranging from active listening to meditation. For the purposes of this toolkit, I will focus on transformative listening, shared values and creating visions of shared water futures, because they are appropriate for people of all faith backgrounds and seem to be adaptable even for more formal negotiations.

Name of tool	Case Study	Benefits	Shortcomings	Considerations
Transformative listening	Jewish woman gains empathy and understanding for Hamas leader	Allows healing for the speaker and cultivates empathy in listener	Groups or individuals may not be ready to listen to their adversaries	Requires practice
Focusing on shared values	Pro-dam and anti-dam representatives on the Mekong River	Helps create a collective identity that blurs divisions and promotes dialogue	No documented downside to focusing on shared values	A skilled mediator can help reveal shared values
Collective visioning	Southern Africa Development Community	Creates positive momentum for collaboration	Transferring visions into policies may be difficult	Important to think about how to adapt to a professional setting

Table 6: These three tools can be used to cultivate a positive aquifer community identity and to raise conversations to a level of harmony (Steritz, 2019).

G.1. Transformative Listening

The crucial practice of transformative listening "is actually the heart of conflict transformation" (Wolf, 2017, p. 120). For groups with a history of hostility, transformative listening may be the most effective way to transform their resentments and hatreds into positive relationships. That is why mediators like Carol Hwoschinsky (2006) have used transformative listening while working to improve dynamics between conflictive groups, like Israel and Palestine. When anger arises, "the only way to figure out what really is going on is to listen. Really listen. With the heart." (Wolf, 2017, p. 96).

What does it look like to listen from the heart? While some aspects of transformative listening, like removing distractions and being fully present, may be intuitive, others, like

refraining from giving advice, may be less intuitive. Transformative listening is a natural part of daily life for very few people. For most of us, it requires constant practice and re-training our brains. It requires humility. It is not about contributing ideas, nor is it about sympathizing. It is about offering space and "allowing the speaker to do the internal work necessary to get at their own root causes of discord", which can be extremely beneficial in conflictive or tense situations (Wolf, 2017, p. 123).

The ultimate goal of the transformative listening process is to allow healing within the speaker and cultivate empathy within the listener. If someone in distress is offered the opportunity to be listened to in this way, the impact can be very calming. While it may be extremely difficult for someone with divergent views to offer this gift, the results can be curative – even for groups with long-standing animosity.

Case study: Using transformative listening to improve understanding between a devout Jewish woman and a Hamas leader

Frida Furman, a devout Jewish woman, wrote about her experience visiting a Palestinian mayor, who was also a leader of the Islamic fundamentalist group, Hamas. Before the meeting, Furman (2010) asked herself, "How can I, as a committed Jew who loves Israel and affirms its right to exist, listen compassionately to someone who shares Hamas's commitment to the destruction of the Jewish state?" (p. 26). Despite their differences, she set her intention to compassionately listen to the story of the mayor's struggles. Although it began as a somewhat mundane conversation, when the mayor began talking about the Israeli occupation of his village and his subsequent imprisonment, the mood changed. Furman began to consciously open her heart and mind to the man as he recounted painful memories (Furman, 2010, p. 25-27).

When the mayor sensed her openness, he dove deeper into personal feelings. The mayor spoke about his need to constantly protect his children, and Furman felt an immediate connection to him. She thought of her own daughter and how she would feel if she had to physically protect her every day. Furman notes that in that moment, her heart broke for the mayor. She began to empathize with him on a real, human level. In her own words: "My heart [cracked] wide open and, in the depth of my soul, I affirmed the conviction that, what unites us – Jews and Palestinians – is greater than what divides us" (Fuman, 2010, p. 28). Later, the mayor wrote to Furman conveying that it was a uniquely powerful experience for him as well (Furman, 2010, p. 28).

In this story, there was a true shift in perspective – definitely for the listener, and perhaps, for the speaker as well. This anecdote demonstrates that the power of transformative listening practice for "connection and healing is unassailable" (Wolf, 2017, p. 112). While it stands out as an especially powerful tool, there is very limited literature on the use of transformative listening to build cooperative transboundary relationships. Perhaps this is due to the lack of academic research on employing the technique. It is logical to assume that some scientists or government officials may be resistant to the practice. The lack of readiness or willingness to listen this deeply to someone you disagree with is understandable. However, if one can adopt the perspective that there may in fact be something very valuable to learn (or gain relationally), it may help one shift into listening mode (Wolf, 2017, p. 176). Finally, transformative listening can also be a noteworthy gender-responsive approach to traditionally male-dominated negotiation dynamics. If the women in the room are listened to in a transformative way, it may allow them to trust in the process and truly engage in collaborative dialogue.

Figure 15: The man in the image shows he is listening with his body language (Gender Intelligence Group, 2014).

If participants are truly not open to transformative listening, then they may focus on the many other techniques to achieve cooperative and effective intercultural communication. Another important strategy is focusing on shared values.

G.2. Focusing on Shared Values

Oftentimes, people focus on what they disagree with in another's point of view. However, "people on seemingly opposite sides of an issue often find that they share basic values" (Wolf, 2017, p. 104). Wolf (2017) reiterates the importance of finding shared values instead of focusing on competing needs or viewpoints, as is typical of conventional water negotiations (p. 111). If groups can focus on their common ground, Van Vugt (2009) suggests that it will help them create a collective, superordinate identity that blurs cultural or national boundaries.

One way to do this is by framing conversations in a way that emphasizes the shared aspects of the parties' lives and values, highlighting that they are in fact *an aquifer community* (Shah, 2009). Wolf (2017) says it this way: "Entering and centering a dialogue where we have some commonality…is fundamental to finding a way through our differences" (p. 111). Despite differences in positions, needs, and interests, there may be some overlapping core values waiting

to be uncovered through conscious communication. Transformative listening is one way to find shared values. Another is the use of open-ended questions in conversation, which can reveal the reasons why a person, or a party, holds a certain position. The following dialogue, provided by Wolf (2017), is an example of how open-ended questions can aid in the discovery of shared values between seemingly opposing parties (p. 106).

Case study: Using shared values to promote dialogue between pro-dam and anti-dam stakeholders in the Mekong River Basin

In the Mekong River Basin, the issue of building dams on the mainstem has been debated for many years. For some downstream countries, like Thailand, Vietnam, Laos, and Cambodia, large dams built upstream are seen by some as immensely destructive to fisheries, livelihoods, and communities; meanwhile, building dams means energy security and economic opportunities for some upstream countries (Bernstein, 2017). In recent years, Wolf (2017) has been involved in facilitating meetings about controversial construction of new dams (p. 123). He witnessed the following dialogue:

> Neutral third party: "What is your position on the proposed dam?"
>
> Pro-dam representative: "I am for it."
>
> Anti-dam representative: "I am against it."
>
> Neutral third party: "Why do you have the position you have?"
>
> Pro-dam representative: ""I am worried about poverty, and I think the dam will alleviate it."
>
> Anti-dam representative: "I am worried about the environment, and I think the dam will damage it."
>
> Neutral third party: "On what core values do you base your beliefs?"

Pro-dam representative: “I love my country.”

Anti-dam representative: “I love my country.”

This shared value (patriotism) established a starting point for dialogue: the love of one’s country. With this common ground established, the mediator(s) could focus the conversation on what they knew was important to both sides. One way to start a conversation based on this shared value may be to ask: how can we improve poverty conditions and environmental conditions to benefit the country as a whole? (Wolf, 2017, p. 108).

Questions like these not only highlight shared values, but also underline the shared future of both parties. There are no documented downsides of focusing on shared values. In fact, future-centric, value-based dialogues may be at the core of effective conflict transformation. Adding to this notion, Wolf (2017) advises: “Speak in the future or present tense, not the past” because it will reduce “the possibility of accusations and allow greater cooperation to build a common future” (p. 116). Collective visioning exercises are another way to directly acknowledge the shared future of neighboring countries with transboundary resources.

G.3. Collective Visioning

While collective visioning can be done in many ways, it almost always involves “intentionally bringing people together across divides to generate long-term, expansive solutions”, and promote collaborative strategizing (Spirit in Action, 2016). Visioning exercises have become popular in strategic and urban planning because they allow stakeholders to create “images that can help to guide change in the city” (UWSP, n.d., p. 1). The goal of collective visioning in transboundary water management is to have each individual visualize what they want the watershed to look like in the future and then integrate all of those ideas to illustrate the ideal shared water future.

Visioning exercises usually begin with a facilitator posing an open-ended question that sparks creativity; “positive questions promote the forward momentum of a good process” (Wolf, 2017, p. 166). To allow for imaginative solutions, the facilitator may ask participants to close their eyes before asking a question, such as: “What would you like this land to look like in fifty years?” (UWSP, n.d.). Next, the facilitator will ask accompanying questions that help participants dive deeper into their mental images: How do the various ecosystems look? How do the waterways appear? Which types of plants or animals are present? What are your children doing for work? What is happening with the agricultural sector? What is happening in the city? (UWSP, n.d., p. 2). Following the visualization exercise, people may express their visions in any way they wish; it could be a drawing, a diagram, a written description, or a verbal explanation.

To create more clarity and transparency, invite participants to add their contributions one-by-one, and discuss the key points of their visions as they post them. These visions can be displayed on a poster, large piece of paper, wall, or whiteboard, depending on what is available. (UWSP, n.d., p. 1-2).

After that, the floor is then open for discussion, planning, and strategizing. It may be helpful to identify themes that arise within the participants’ visions and structure conversations based on those themes. In the case below, the concentration on shared values and subsequent development of a unified vision successfully led to implementation of collaborative plans within the Southern African Development Community (SADC).

Case study: A common vision for the Southern African Development Community (SADC)

The SADC is a political and economic coalition of sixteen member states in Southern Africa that provides “a framework for regional integration” and cooperation (SADC, 2018, p. 2). It began with government officials from seven Southern African countries convening to strategize

about political liberation in the 1970s. Leaders consulted for a long time, and discovered their shared values of: transparency, equal opportunities for all people, sustainable growth, and durable security. Coming to an agreement on core values fostered a collective identity, and they officially formed the SADC in 1980. The leaders also outlined shared objectives like political security, liberation, economic growth and the alleviation of poverty (SADC, 2018).

Figure 16: Leaders from the SADC were successful in creating a collective vision because they focused on shared values (SADC Foreign and Commonwealth Office, 2012).

By focusing conversations on what they had in common, the leaders were able to come up with a joint vision for SADC. That vision is "a regional community that will ensure economic well-being, improvement of standards of living and quality of life, freedom, social justice, peace and security for the people of Southern Africa" (SADC, 2012). With this vision as their basis, the SADC member states crafted a treaty in 1992, which is still honored. In fact their explicitly-stated shared values, vision and the treaty form the framework for how the countries cooperate politically and economically today (SADC, 2018, p. 2). As seen in this case study, collective visioning can help to craft a collective, regional identity that transcends borders.

The SADC case is an example of how dialogue about shared values can lead to shared visions, and finally, frameworks for cooperation. If aquifer states can achieve a sense of unity

through a collective vision for their water future, they may be able to create unified plans for their shared groundwater resources. Here lies one of the main strengths of collective visioning as a tool for transboundary management: If co-management work is grounded "in a collective, positive vision", it will likely help the parties grow into "a strong and connected community" (Spirit in Action, 2016). Another strength is that imagining the ideal vision for a region can facilitate ingenuity and bring up positive possibilities, which may help parties that are "locked into negativity and critique" (Spirit in Action, 2016).

The main drawback is that transferring visions into policies may prove difficult (UWSP, n.d. p. 2). However, that should not deter parties from pursuing visioning exercises. I have seen first-hand the power collective visioning can have; it empowers and inspires people to work towards a more sustainable future. The creation of momentum is incredibly valuable regardless of whether plans are implemented right away.

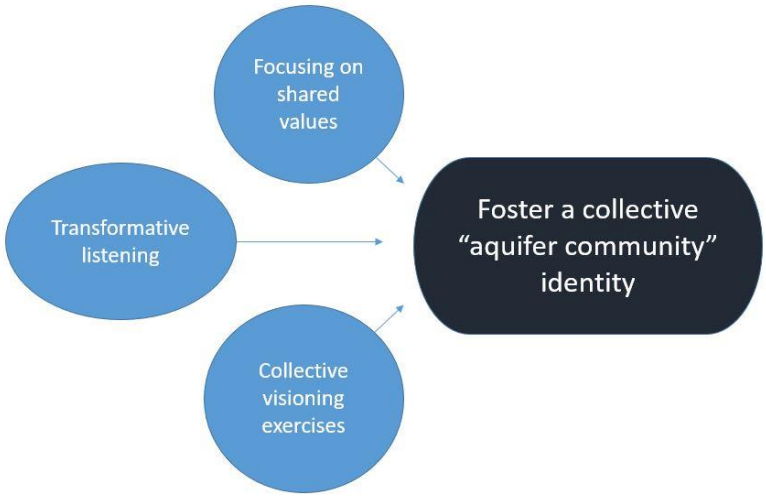


Figure 16: Fostering a collective identity becomes easier if people can practice transformative listening, focusing the values they have in common, and participate in collective visioning exercises (Steritz, 2019).

Summary of Spiritual Tools

Collective identities of various cultures are based on stories and connections to water. The Iroquois Nation believes their entire world started from water. The Aborigines of Australia believe their entire world started from water. The list of worldviews that hold water as central could continue for many pages. History demonstrates that water and spirituality are deeply intertwined, which justifies the incorporation of spiritual practices, or tools, into conflict transformation. The basic idea here is simple: We must respect everyone's intimate connections with their water. We must honor each other by acknowledging not only one another's spiritual needs alongside one another's physical, emotional, and intellectual needs.

Operating from a place of respect, acknowledgement, and understanding of the spiritual needs of those around you will promote more sustainable cooperation. There are numerous tools (many of them revolving around non-violent, intercultural communication) that can help people to operate from a place of empathy and compassion. A few of the tools that have proven to be powerful for these purposes have been described, namely: practicing transformative listening, focusing on shared values, and performing collective visioning exercises.

Using transformative listening, focusing on shared values, and visioning can pave the way for positive dialogue, and eventually, collaborative decision-making. Each of these tools has documented benefits that provide a compelling case for their use at the transboundary scale (Wolf, 2017). These tools are listed as "spiritual tools" because they have the ability to nurture collective identities, which will promote the sharing of benefits that arise from groundwater use (Van Vugt, 2009; Shah, 2009).

Section H. Summary of Tools

This chapter has laid out ten tools that appear valuable for the purposes of transboundary collaborative groundwater management. Each tool has been grouped based on which level of the Four Worlds Framework it relates to, whether that be the physical, emotional, intellectual, or spiritual aspects of water issues.

Now, I would like to briefly review how each of the tools can aid cooperation. To address the physical uncertainties associated with groundwater, the GRACE satellite and the InSAR radar technique are useful. Hydrologists have proved that these tools can successfully contribute to missing data about changes in water table levels and rates of drawdown.

Next, the emotional complexities associated with past water conflicts may be partially healed through reconciliation processes, such as the Arabic *sulha* ceremony. Talking circles are another tool to help negatively impacted parties process trauma or difficult emotions, which may contribute to readiness to collaborate. However, if there is no history of acute tension, countries may simply plan a field trip together to build affinitive trust.

Thirdly, the intellectual tools offer group learning techniques that may help participants reach a consensus about their groundwater resources. There are many ways of understanding groundwater, which can make it difficult to create common accord. Joint fact-finding and serious gaming are strategies that can lead to a shared understanding and more positive relationships.

Finally, the spiritual tools contribute by fostering unified conversations, deeper understanding, and positive visions for the future. Transformative listening has proven fruitful for creating empathy in the listener and helping the speaker process difficult emotions. Another tool for intercultural communication is focusing on shared values, which promotes healthy, forward-

moving dialogue. The last tool, collective visioning, allows participants to imagine their ideal shared water future and discuss ways to move towards their visions.

Chapter 4: Conclusions

Section A. Problem Synthesis

Due to the astonishing rates of aquifer depletion and the "race to the pumps" phenomenon intensifying in recent decades, it is especially important to explore tools that address transboundary groundwater management challenges (Jarvis, 2014; Conti, 2014). Llamas and Martinez-Santos (2005) express that "a spectacular increase in groundwater development for irrigation has taken place during the last half century"; some scholars refer to the rush for groundwater as "the silent revolution" (p. 337).

With increasingly chaotic groundwater development taking place around the globe, "adequate groundwater management and governance remains an important challenge to long-term sustainability" (Llamas & Martinez-Santos, p. 339). Indeed, the relevant literature demonstrates that groundwater monitoring, planning, and government control are still insufficient in most countries. This may be partially due to the fact that monitoring and enforcement mechanisms are expensive and require ample time and dedicated personnel. In addition, groundwater governance is arduous because groundwater does not fit neatly into international water law or diplomacy (Jarvis, 2014).

The fact that aquifers extend underneath the geopolitical borders of over 64% of countries worldwide means those countries must also manage complex international relations with regards to water use (IGRAC, 2016). Central Asia is one of many regions worldwide where complicated geopolitical dynamics make managing transboundary aquifers more taxing. UNESCO and OSU focus on supporting the water ministries of the Republics of Kazakhstan and Uzbekistan in hydro-diplomacy because their groundwater governance situation in uniquely difficult and pressing.

With the turbulent political history between Kazakhstan and Uzbekistan due to the collapse of the Soviet Union, subsequent border disputes and the isolationist policies of Uzbekistan's former president, there are naturally lingering tensions (Putz, 2017). A lack of history of dialogue about transboundary groundwater resources means that it is also likely that there is a lack of consensus regarding some aspects of their shared aquifers. These hurdles create an urgent need for the compilation of tools that facilitate social and experiential learning about shared groundwater resources and provide possible ways for water leaders to initiate cooperation. My role is to research the potential of various hydro-diplomacy tools and create a toolkit to contribute to the relevant and important GGRETA Project.

The water ministries of the Republics of Kazakhstan and Uzbekistan are the target audiences for the GGRETA Hydro-diplomacy Toolkit because their shared Pretashkent Aquifer is in critical condition. The Pretashkent Aquifer is currently facing rapid depletion and increasing pressure from industries (IGRAC, 2018). This artesian aquifer is practically non-renewable due to negligible recharge and is of utmost importance as a drinking water source for both countries since surface water bodies fail to meet drinking water standards (IGRAC, 2018). To prevent a tragedy of the commons scenario from spoiling the transboundary Pretashkent Aquifer shared by Kazakhstan and Uzbekistan, innovative ideas are necessary. In order to allow for the development of diplomacy skills and simultaneous cultivation of shared groundwater knowledge, the water leaders of Kazakhstan and Uzbekistan should utilize tools that correspond to each level of the Four Worlds Framework.

There is no hierarchy between the physical, emotional, intellectual, and spiritual levels within the framework – nor is there a correct order in which to employ the corresponding tools.

Rather than considering one level and then another in a linear fashion, it is more beneficial to consider each level of the Four Worlds Framework simultaneously.

In the context of groundwater, the physical level of the Four Worlds Framework refers to how much groundwater is physically available, and the tools within this section (GRACE and InSAR) aim to improve the accuracy and knowledge of physical, measurable quantities of water present in the Pretashkent Aquifer. These technologies may play a crucial role in helping fill knowledge gaps and build consensus about aquifer characteristics and ways to manage drawdown.

Positive group dynamics and the cultivation of trust are fundamental within the emotional level of the Four Worlds. Thus, the tools in this section (*sulhas*, talking circles, and field trips) seek to enhance feelings of connectivity between the water officials of Kazakhstan and Uzbekistan following years of disengagement and dispute. While using these tools may have less tangible results, each has a reportedly positive influence on how relationships within groups develop.

Each party (and probably each person within each party) has a unique way of rationalizing groundwater. Therefore, the tools within the intellectual level (joint fact-finding and serious gaming) represent ways to reach a shared understanding of the primary problems associated with the Pretashkent Aquifer. Often joint fact-finding and serious gaming involve the use of technologies (including computer models), which can help enhance mutual understanding of the aquifer and build consensus.

Immensely important in Central Asia is the blurring of boundaries and the formation of an aquifer community identity that both parties can identify with. The spiritual tools (transformative listening, focusing on shared values, and collective visioning) can help Kazakhs and Uzbeks reach a level of harmony that seems to have been absent for decades. The purpose of including these

tools is to help foster feelings of harmony and create an energy amongst the water ministries that fuels their drive to collaborate.

With the Four Worlds Framework as a guide, those who plan the upcoming bilateral processes between Kazakhstan and Uzbekistan can account for many of the primary challenges of groundwater governance, the variety of human needs and the multitude of learning styles within the group. Although some of these tools have never before been tested at the transboundary level, they all demonstrate the potential to enhance group dynamics. Due to the pressing challenges of this historically tense region, I believe it is important to synthesize both time-tested exercises, like joint fact-finding, with up-and-coming practices, like collective visioning.

Section B. Summary of Tools with Strengths and Considerations

The following are descriptions of each tool, summaries of their strengths, and important considerations to bear in mind before utilizing them:

1. Physical Tools

- *Gravity Recovery and Climate Experiment (GRACE) Satellite Mission:* twin satellites launched by the National Aeronautics and Space Administration (NASA) that produce monthly maps of gravity anomalies caused by mass changes (mainly changes in water masses)
    - ❖ Strengths: free, accessible maps that help to address data gaps and uncertainties about changes in groundwater storage
    - ❖ Considerations: maps are fairly low resolution and may need to be supplemented with additional tools (specifically InSAR)
- *Interferometric Synthetic Aperture Radar (InSAR) Technique*: satellites launched by NASA, the European Space Administration (ESA), and the Canadian Space Agency

(CSA) use radar imagery to provide precise measurements of land deformation (measure distance between satellite and land targets over time)

- ❖ Strengths: provide free measurements of land subsidence changes over time
- ❖ Considerations: some issues with temporal decorrelation (especially over pasturelands), which can decrease data coherence

2. Emotional Tools

- *Sulha reconciliation process*: forgiveness ceremony (from the Arabic world) that allows for acknowledgement and forgiveness of past conflicts
  - ❖ Strengths: dignity can be reestablished after a *sulha* and the process may allow for more positive, future-focused dialogue
  - ❖ Considerations: process will almost surely need to be modified to meet the parties' cultural needs
- *Talking circles*: traditional conflict management tool of Native American tribes that creates space for participants to express emotions in a structured, uninterrupted way
  - ❖ Strengths: can facilitate healing of difficult, deeply-seated feelings associated with past wrongs
  - ❖ Considerations: may need modification for a formal setting
- *Field trips*: outdoor group exploration of land area above a shared aquifer
  - ❖ Strengths: allows for cultivation of trust and group identity through shared experience outside of formal negotiation rooms
  - ❖ Considerations: may at first highlight divergent opinions about recharge areas, aquifer boundaries, etc.

3. Intellectual Tools

- *Joint fact-finding*: process in which experts with conflicting views work together to research and generate new information
    - ❖ Strengths: creates balance in collaborative capacities, prepares parties for joint modeling, and increases clarity about aquifer problems
    - ❖ Considerations: usually requires a sustainable, long-term source of funding
- *Serious gaming:* may include virtual or tangible games, role plays, simulations, etc. that allow participants to explore new viewpoints
    - ❖ Strengths: can diminish communication barriers, highlight or address knowledge gaps, and help participants understand the values of others' views
    - ❖ Considerations: must be carefully introduced because some high-level diplomats may view games as unprofessional

4. Spiritual Tools

- *Transformative listening:* practice of listening from the heart that involves removing distractions, refraining from providing input, and offering space for the speaker
    - ❖ Strengths: not only promotes emotional processing and healing in the speaker but also cultivates empathy and understanding in the listener(s)
    - ❖ Considerations: requires participants to be fully present and step outside the mindset of conventional negotiations
- *Focusing on shared values:* way of highlighting commonalities by centering conversations on shared ethics and beliefs
    - ❖ Strengths: can help blur geopolitical or cultural boundaries and support the building of an aquifer community identity

- ❖ Considerations: may be difficult to find shared values without the use of open-ended questions and may require the assistance of a thoughtful mediator

- *Collective visioning exercises:* involve posing one or more open-ended questions, such as, "How would you like this region to look in fifty years?"
  - ❖ Strengths: allows participants to visualize their ideal future scenarios, express them with words, discuss shared goals, and fuel positive momentum
  - ❖ Considerations: may be difficult to transfer visions into policies

Section C. Recommendations for Toolkit Use

While there is no perfect experiential learning tool that works for every person and situation, all of the tools in the toolkit can be used as educational bonding opportunities that foster cooperation. The tools are grouped based on whether they address the physical, emotional, intellectual, and/or spiritual challenges of transboundary groundwater management. However, many of them actually address multiple levels at once; for example, the intellectual tools contribute not only to a shared knowledge base but also create space for the group to get to know each other better through collaborative research.

As the Kazakhs and Uzbeks begin collaboration, it will be beneficial to have a variety of experiential learning exercises to choose from. Decision skills, acting skills, thinking skills, and valuing skills will be developed through the adoption of tools from each section. I recommend that the water ministries of Kazakhstan and Uzbekistan review each tool and read the case studies to better understand their benefits and nuances before planning group processes.

Selecting a combination of tools from each of the levels within the Four Worlds Framework (physical, emotional, intellectual, and spiritual) will not only ensure that the group's diverse needs are met, it will also help capitalize on the strengths of each of the participants. To

reiterate, the primary founder of experiential learning, David A. Kolb (1984) points to four main learning styles: converging, accommodating, assimilating, and diverging. I intentionally include activities that are well-suited for each learning style so that the participants can rotate who is leading. This will most-likely improve the group dynamics by demonstrating that each person is essential to the process of solution creation.

Section D. Research Limitations

1. This research relies on a subjective assessment of tools, and does not contain a quantitative, objective way of measuring the effectiveness of tools.
2. Due to time limitations, the assessment of tools does not include in-person interviews with people who have first-hand experience with the social learning exercises.
3. I have only a basic understanding of the past tensions and cultural contexts of Kazakhstan and Uzbekistan, so some of the tools I suggest may not be culturally appropriate. (However, most should be modifiable to fit the setting.)
4. The goal of the toolkit is to facilitate dialogue regarding joint management of the Pretashkent Aquifer; it does not address specific management strategies to increase the long-term sustainability of aquifer use.
5. The tools in the toolkit are suggestions of various exercises that may serve as starting points for cooperation, and are by no means an exhaustive collection.

Section E. Recommendations for Future Research

While I feel that the range of options for initiating water cooperation must be expanded beyond its traditional or conventional bounds, it is difficult to know which tools will be accepted within the formal, international water diplomacy arena. It would therefore be beneficial if these experiential learning and cooperation tools could be tested in a real international hydro-diplomacy

setting. I recommend that in the future, anyone implementing the tools for the purposes of water cooperation, create a systematic way to assess each tool and quantitatively score them in terms of their usefulness for helping groups reach specific goals. It would be valuable for each participant to have a chance to make comments on how the tools work in reality and suggestions about how each may be improved for future use.

In the GGRETA Hydro-diplomacy Toolkit, the least tested and least academically researched tools are the emotional and spiritual tools. Thus, I believe it is especially important to focus future research on their appropriateness and adaptability for multiple cultures and a range of diplomacy scenarios. I recommend testing them at all water governance scales – from local to transboundary. It is also crucial to question and document whether they are most suitable for informal or formal processes. They should be tested at both casual "brain-storming" meetings as well as formal, high-stakes negotiations.

Section F. Review of Research and Final Conclusions

To re-cap, this research project seeks to answer the following three questions:

Primary Research Question:

- What challenges are associated with managing transboundary groundwater resources, and how can they be successfully addressed through education and training?

Sub-questions:

- What role will technology and other tools play in addressing transboundary groundwater management challenges?
- How can groundwater education be improved to address transboundary groundwater management challenges?

While there are a plethora of challenges associated with co-management of transboundary groundwater resources, perhaps the most notable hurdles are: the lack of bilateral or multilateral agreements regarding groundwater, the lack of regulations and policies at the national level, the problem of missing or inaccurate data, the lack of bilateral or multilateral dialogue regarding groundwater, and the lack of mutually-accepted models and understandings of shared groundwater bodies. Fortunately, water scientists are finding that technological tools, such as GRACE and InSAR, have the ability to help national leaders build consensus and fill data gaps. These technologies may address some of the physical uncertainties and intellectual challenges of transboundary groundwater management. Meanwhile, other experiential tools, like group field trips, may improve the emotional dynamics by helping participants build trust and rapport. Additionally, the cultivation of intercultural communication skills with tools like transformative listening, may pave the way for positive bilateral or multilateral dialogue. Ultimately, my conclusion is that the strategies for training government leaders must expand to include a wider array of educational tools. From joint research exercises to listening exercises, participating in the creation of knowledge with a group can harmonize relationships and understandings about shared groundwater.

Through the synthesis of research on beneficial experiential learning tools and the subsequent creation of the GGRETA Hydro-diplomacy Toolkit, I aspire to aid the water leaders of the Republics of Kazakhstan and Uzbekistan in the generation of a cooperative framework for the Pretashkent Aquifer. I believe that through the hands-on, participatory practices embedded in each of the above experiential learning tools, the water ministers will successfully deepen their groundwater knowledge and hone their hydro-diplomacy skills. While certain tools, like talking circles, *sulhas*, and collective visioning, step outside the scope of conventional water diplomacy,

they demonstrate promise for helping to gently to repair the previously hostile relationships between Kazakhs and Uzbeks.

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Appendix A. GGRETA Hydro-diplomacy Toolkit Table of Contents

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