Restoring the Colorado River Delta

International and National cooperative measures in the Colorado River Basin

(Photo source: Sonoron Institute, 2014)

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INTRODUCTION

The Colorado River is one of the largest rivers in North America, providing an economic and environmental lifeline to more than thirty-six million people (EDF 2014). Water has been diverted from the River for recreational purposes, agriculture, industry and municipal use, as well as water storage. The Delta of the River has suffered the consequences, and its ecosystem is showing the signs. It saw little to no water from 1935 to 1957 as a result of Hoover Dam's water storage facility Lake Mead, and then again from 1964 to 1981 as Lake Powell filled behind Glen Canyon Dam (Glenn et al 2001). And even since then, the River's water has only reached the Gulf of Mexico during flood releases: when there was simply too much water to store.

The United States and Mexico signed the first binational water treaty in 1944, aimed at sharing most of the River's renewable water, and established the International Boundary and Water Commission (IBWC) to manage the limitrophe section of the River and the Delta. Yet their governance has been failing the Delta, and this has not escaped the attention of locals, NGOs and scientists. Meanwhile, agricultural waste water releases have created three anthropogenic wetlands in the Delta, giving new hope for delta-wide restoration. One of these wetlands is Cienega de Santa Clara, the largest marsh in the Sonoran desert (Glenn, Flessa and Pitt 2013). In the 1990s, scientists discovered that relatively small pulse flows benefited the ecosystem considerably, and started campaigning for pulses at regular intervals.

Minute 319, signed by the IBWC in 2012, has been praised as the answer that activists have been hoping for. The Commission specified a framework for the scientific exploration of the Delta in 2000, and Minute 319 has used those findings to include cooperative measures for the restoration of the Delta in the agreement (IBWC, 2000; 2012). This paper aims at reviewing the capacity of the Minute, as well as other Colorado River water governance policies and instruments, in coming to terms with the challenges of restoring the Delta. We first assess the needs of the Delta for restoration, and then apply the Integrated Method to Assess the Governance of Water (IMAGW) to see if Minute 319 meets the challenge, and how the governance of the Delta could improve in the future (Brouwer et al 2012). We use a chronological approach to the IMAGW in applying the nine building blocks (see Figure 1): (1) water system knowledge; (2) values, principles and policy discourses; (3) stakeholder involvement; (4) trade-offs between social objectives; (5) responsibility, authority and means; (6) regulations and agreements; (7) engineering and monitoring; (8) enforcement; and (9) conflict prevention and resolution.

Figure 1. The multiple dimensions of water management and governance which are used as assessment criteria in this paper and as outlined by Brouwer et al (2012).

THE RIVER DELTA

"On the map the Delta was bisected by the river, but in fact the river was nowhere and everywhere, for he could not decide which of a hundred green lagoons offered the most pleasant and least speedy path to the gulf." – Aldo Leopold, describing the delta in 1922 (Leopold 1949)

Ecosystem Functions

The Colorado River supports the largest acreage of riparian and wetland habitat in the Sonoran Desert and is home to many endemic species. However, most of the native riparian corridor along the River is gone, and the most important ecosystems in the current Delta are anthropogenic wetlands, because they provide water to the rest of the delta during winter. In 1993, the Mexican government established the Biosphere Reserve of the Upper Gulf of California and Delta of the Colorado River, which covers a large part of the River Delta (Glenn, Flessa and Pitt 2013). It has been inscribed in the UNESCO World Heritage List, as well as under the Ramsar Convention as an Audubon Society Important Bird Area and a Wetland of International Importance (Aragon-Noriega et al 2010).

Fishing is an important source of income around the Gulf of Mexico (Glenn, Flessa and Pitt 2013). Fishermen use the wetlands for aquatic farmsand the estuary for fishing of local species, threatening the endangered and/or endemic species totoabo fish, desert pupfish and vaquita porpoise, who depend on a healthy delta for survival (Aragon-Noriega et al 2010; Tiegs et al 2005). In the middle of the estuary, Montague Island hosts seven species of waterbirds as well as an endangered clam species (Glenn, Flessa and Pitt 2013). Part of the Delta floods with seawater on average every month, and the water is trapped by the varied landscape and vegetation (Morziana-Luna et al 2014). Native riparian vegetation[1] suffers under these salt intrusion and are making place for a single invasive species: salt cedar (Glenn, Flessa and Pitt 2013). Migratory birds that use the Delta as a stopover in the Pacific Flyway depend on salt grasses as a food source (Glenn et al 2006). Endangered and/or endemic (migratory) bird species in the Delta include the Yuma clapper rail, southwestern willow flycatcher, western yellow-billed cuckoo and Bells vireo (Aragon-Noriega et al 2010; Tiegs et al 2005).

Lastly, wetlands filter toxins and pollutants out of the water, and release purified water into the ocean. More than 95% of Cienega de Santa Clara's inflow is US agricultural drainwater, and various scientists[2] have expressed concerns about the levels of chemicals found in water, soil and animal samples (Glenn et al 2012). It is uncertain what the effects of the chemicals would be on (marine) life without the wetlands.

Current State

Flow regulation and water diversion for irrigation have considerably affected the exchange of surface water between the Colorado River and its floodplains. However, the way in which both have impacted groundwater–surface water interactions is not completely understood (Ramírez-Hernández et al 2013).Bioaccumulation of chemicals and hyper-saline environments have degraded the ecosystem in the nearby anthropogenic lake Salton Sea and caused fish deformities (Daessle et al 2009; Mexicano et al 2013). In the Delta, the head of the estuary is saltier than the mouth except during flood releases, posing problems for local fish species (Glenn et al. 2006). Salinity levels are also posing problems for the native vegetation, which is outcompeted by invasive species better adapted to highly saline environments

[1] Native vegetation includes cottonwood, (seep)willow, cattail, common reed, mesquite bosques, salt bush, salt grass and arrowweed (Glenn et al 2001; Glenn, Flessa and Pitt 2013)

[2] Dangerous levels of selenium, boron and zinc have been found in birds as well as dangerous mercury and cadmium levels in organic samples (Deassle et al 2009). Furthermore, the agricultural release waters contain high concentrations of agrochemicals such as insecticides. Parts of accumulated arsenic, lead and copper came from anthropogenic sources, most likely arsenate pesticides. Another problem comes from a nearby geothermal plant, which has caused bioaccumulation of selenium (Garcia-Hernandez et al 2000), air and water pollution of mercury (Daessle et al 2009), and discharged water contaminated with polychlorinated biphenyls damaging the sediment (Lugo-Ibarra et al 2011).

(Glenn et al 1998). A recent study[3] has identified chemicals of concern (COPECs) for the Delta, warning for the effects on keystone species in the ecosystem (Garcia-Hernandez, Glenn and Flessa 2013). Bioaccumulation of toxins may become a problem as the climate changes, making the area more arid and more prone to the phenomenon (Daessle et al 2009; Morziana-Luna et al 2014). Sea level rise will move the Delta land-inward, and it is unclear how the ecosystem might react. Scientists also worry about increasing temperatures, ocean acidification and extreme storm events.

A Possible Solution

After 1981, on an average of once every two years, a flood release was sent to through the Delta. Scientists noticed that the ecosystem responded well to these pulse flows. In combination with a stable base flow, they mimic the natural, pre-dam situation most closely (Tiegs et al 2005).The pulses restore the groundwater table and prevent bioaccumulation of dangerous chemicals and salt. Riverbank flooding happens easily, and creates small pools of water all over the Delta. These pools are home to the salt grasses which migratory birds use as a main food source. In addition, they expand the estuarine area. Many native plants germinate more successfully during pulse flows, whereas it does not have this effect on the invasive species. Scientists hope repeated pulse flows will restore the estuary in the Delta and improve water circulation, which has now largely disappeared because the river only reaches the sea during rare, major flood releases (Cintra-Buenrostro, Flessa and Dettman 2012; Lauer 2012).

We will assess the effectiveness of the Delta's governance by Minute 319's ability to provide the ecosystem with pulse flows sufficient to ensure these long-term benefits.

RIVER DELTA GOVERNANCE

Fighting for Water

When the 1922 Colorado River Compact was signed, it was an attempt at river basin management from the federal government in the U.S. (Mumme, 2003). It allocated 7.5 million acre feet (MAF) to both the Upper and Lower Basin[4]. Stakeholder participation and environmental conservation, however, were not priority issues (Gelt 1997). During that same time, more and more Asian immigrant farmers settled around the U.S.-Mexican border (Boime 2009). Farmers in the U.S. felt threatened, both by the agricultural competition and the numbers of immigrants, and built the All American Canal and the Hoover Dam, thereby restricting water flows into Mexico in favor of using the water in the United States. Mexico was not considered during the time of the treaty. The sentiments of "America for Americans" and "America first" were still very much alive at the time of the 1944 Treaty. While the IBWC was established as the main international authority for the River via the 1944 Treaty, the commission was primarily considered by the US to be responsible for transboundary dialogue and conflict resolution and consequently allocated 1.5 MAF annually to Mexico (Gelt 1997). But the Colorado River Water Users Association (CRWUA) clearly opposed the US ratification of the 1944 Treaty in their 1945 resolution, listing 12 arguments how the treaty is not in the interest of the USA and the river's water users (CRWUA 1945).

[3] Researchers studying chemicals of concern in Cienega de Santa Clara and Rio Hardy found various metals and metalloids (mercury, arsenic, selenium and copper) as well as organochlorine pesticides to be COPECs, because they can have negative effects on freshwater biota, benthic invertebrates, fish eating birds and other wildlife. Other studies have found that chromium, lead, boron, PCBs, organophosphorous pesticides and CECs (contaminants of emergent concern) can also be toxic to e.g. aquatic biota and benthic invertebrates.

[4] The Upper Basin consists of Colorado, New Mexico, Utah, Wyoming and a small portion of Arizona. The Lower Basin consists of Arizona, California and Nevada.

Table 1: Important Agreements within the Basin

1922	Colorado River Compact
1928	The Boulder Canyon Project Act
1944	The Mexican Water Treaty
1948	Upper Colorado River Basin Compact
1956	Colorado River Storage Project
1964	The Arizona vs. California U.S. Supreme Court Decision
1968	The Colorado River Basin Project Act
1970	The Criteria for Coordinated Long-Range Operation of Colorado River Reservoirs
1973	Minute 242 - Permanent and definitive solution to the international problem of the salinity of the Colorado River (IBWC)
2000	Minute 306 – Conceptual Framework for Future Recommendations Concerning Riparian and Estuarine Ecology of the Colorado River and its Delta (IBWC)
2010	Minute 317 - Conceptual Framework for U.S. Mexico Discussions on Colorado River Cooperative Actions (IBWC)
2012	Minute 319 - Interim International Cooperative Measures in the Colorado River Basin through 2017 and Extension of Minute 318 Cooperative Measures to Address the Continued Effects of the April 2010 Earthquake in the Mexicali Valley, Baja California (IBWC)

In hindsight, it has been realized that average flows are about 13.5 MAF and highly inconsistent, ranging from 4.4 to 22 MAF (Gelt 1997). This highlights a lack of knowledge about the variability of the river's discharges and climate altogether. Additionally, historical climate variations have caused prolonged droughts in the basin, reducing annual flows to around 9.7 MAF, which also creates uncertainty for future water security in a changing climate. So not only is the current system over-allocated, demand for water along the river has now surpassed its total renewable supplies (Lauer 2012).

To understand to what extent Mexico was able to influence decisions and practices concerning the river after the treaty, we will use Berry et al.'s (1993) definition of width and depth in participation. The width component is based on to which degree a stakeholder is given the opportunity to participate and the depth is a measure of influence a stakeholder is given on the final outcome (Brouwer et al 2012). However stakeholder involvement can take many forms and is limited by levels of participation (Arnstein 1969) as well as the capacity to influence (Mitchell et al 1997). The management of stakeholders in Colorado River water rights and Delta restoration appears to be based more on Mitchell et al.'s (1997) triage (Figure 2), meaning that some stakeholders are provided more width and depth given their political lobbying power or water dependence, which have traditionally taken precedence over ecological/restorative flows for the Delta.

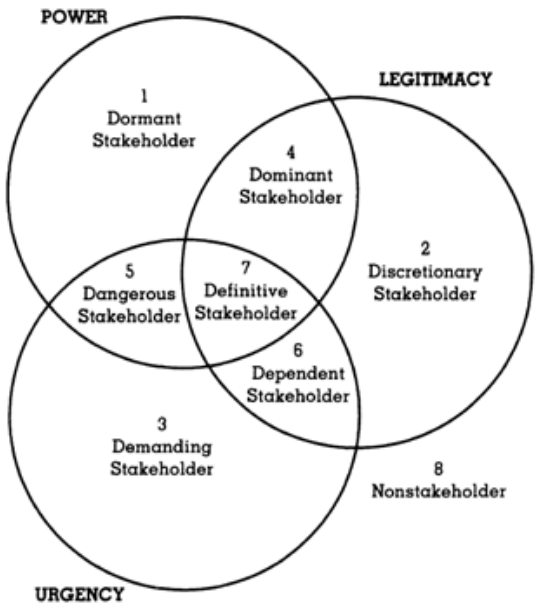

Figure 2: Mitchell et al (1997) stakeholder triage

Additionally, the Law of River allows agriculturalists, domestic and commercial users to continue their consumption behavior based on the US water law doctrine of prior appropriation (Fitzgerald 2013), giving these stakeholders much greater dominance and power over water resources in the basin. Meanwhile, it appears that the Mexicans are only considered by the US in terms of Treaty obligations and represented only by their half

of the IBWC. Because the US assumed the most rights to the water resources, and community stakeholders lacked trust in the IBWC to represent these interests (CRWUA 1945). This lack of trust and political pressure restricted the federal governments in providing the IBWC with the required mandate and authority, which ultimately led to the lack of tangible solutions for the Delta offered by the Commission throughout the last century (Brachet et al 2012).

The 1944 Treaty also shows a lack of knowledge or ignorance towards water quality. Signatories failed to recognize that the quality of water that would be significantly altered en route to Mexico, and so no water quality standards were established within the agreement (SoR Research Team 2012). The failure to understand the hydrological process and anthropogenic influences from development meant that water deliveries to Mexico often had near-toxic salinity levels (SoR Research Team 2012). This resulted in the later amendment to the 1944 treaty as Minute 242, in 1973. The countries signed Minute 242, as a 'definitive solution' to the problem, but it took years for the situation to improve. Mumme (2004) highlights the weakness of the treaty amendment since there was little political support or motivation to implement to content of Minute 242. A constant conflict between US state and federal governments, vagueness over groundwater inclusions in salinity levels and lack of clear references between the 1944 Treaty definitions did not promote decisive acts and left much to be challenged (Wolf and Newton2008).The US had originally proposed an agreement where Mexico could 'choose' whether it wanted to receive the deliveries or not, but they would be subtracted from their water budget regardless. This exemplifies the extent to which the US wanted to keep the countries' water policies separated.

In Minute 242 resolution 6 states that: "The United States and Mexico shall consult with each other prior to undertaking any new development of either the surface or the groundwater resources, or undertaking substantial modifications of present developments, in its own territory in the border area that might adversely affect the other country." (IBWC, 2010a) In the US, the federal government's Secretary of Interior has the final ruling on most water conflicts, ranging from the creation of shortage guidelines or settling disputes over definitions in the Treaties (Pontius 1997). Interstate interagency commissions were set up in the 1970s in an attempt at improved state-federal cooperation (Pelgram et al 2013). However, while the commission had legislative power in the Water Resources Planning Act (1965), they were still largely dependent on the member agencies for resources and decision making, and consequently tended towards politically soft approaches, focusing on uncontroversial functions rather than substantive basin planning decision making, regulation and enforcement (Pelgram et al 2013).

Water demand is higher in the lower basin than in the upper basin, because of the presence of agricultural activities and large cities in arid environments. Before 2000, the Lower Basin used more than its 7.5 MAF of allocated water, but the Upper Basin has compensated for this by under-using its share. The continuous political pressure from US citizens to secure water for agricultural and domestic use resulted in the formation of The Colorado River Citizens' Forum. This forum was established in 2003 by the US half of the IBWC, to engage with members of the public about Commission activities in Yuma County, Arizona and Imperial County, California (IBWC 2014).

The Road Forward

The establishment of the Colorado River Delta Water Trust by the NGO coalition in 2008 helped facilitate further pathways forward for the Delta's restoration and after five years of intense negotiations between the U.S., Mexico, and the NGO coalition, Minute 319 was passed in November 2012 (Schatter 2013). The agreement, valid until 2017, attempts to address binational water management issues such as increased flexibility in managing shortages and surpluses, operational flexibility for Mexico to store its water allocations upstream in the U.S., joint water conservation

projects, and an allocation of a base and pulse flow to the river in Mexico with the expansion of restoration efforts in the Delta (Schattler 2013).

Minute 319 opened the door for a large pulse flow through the Colorado River delta by allocating part of the river's water budget, 130 million cubic meters, to the ecosystem if enough water is available (Flessa 2013). NGOs will provide over 50.000 acre-feet of water as base flows, and in addition a 100.000 acre-feet pulse is designed to mimic a spring runoff (Lauer 2012). The Minute also specifies the monitoring of the effects of the pulse on local hydrology and ecology; with the results to be used in determining future cooperative efforts in the Delta. Teams of scientists from various institutional backgrounds will work together to monitor the effects of the pulse both on the ground and through remote sensing. However, no funding is available for monitoring from the IBWC. Though the pulse is relatively small in comparison to historical flows in the region, it is still a large-scale scientific experiment (Flessa 2013). A group of scientists has been given the task to develop a plan for the use of the water, so that it is used to maximize restoration potential.

The fact that Minute 319 provides for the joint actions of the two countries to face times of drought or surplus enhances its legitimacy according to the criteria set by Brouwer et al (2012). It recognizes that there are still aspects to consider, and leads the way for flexibility and uncertainties to be taken into account for any future actions. However this flexibility is also open to manipulation, and while the amendment states that the U.S will contribute a total amount of $21 million dollars to Mexico through the Commission to implement the proposed solutions suggested in the Minute (IBWC 2012), the agreement is restricted to the 1944 Treaty apportionments, meaning the US Government remained stubborn in their refusal to contribute water from their own sources to the Delta (Schattler 2013).

The possible future pitfall of this agreement lies in the fact that while the US will finance the Mexican water and irrigation infrastructure, the amount preserved via those projects would count as a part of the U.S.'s committed water deliveries to Mexico (Schattler 2013). In short, the agreement permits the US to develop Mexico's water to contribute to their share of mandatory water deliveries to Mexico and the Delta. This is somewhat of a double edged sword which is also apparent in other finance mechanisms of Minute 319. For example, Minute 319 broke history books by acknowledging the bi-national NGO coalition, The Colorado River Delta Restoration Trust. Consequently, the Trust was given authority in Minute 319 to secure one-third of the total flows, or 52,700 acre-feet by 2017, to be used for the Delta's restoration (Sonoran Institute 2014). However, while the Trust has been given the authority, little support was provided by the federal government or the Commission and the Trust was under huge pressure to have their water delivery and ecological monitoring plans in place in order to implement the proposed pulse flow in April 2014 (Schattler 2013). Furthermore, the Trust is still seeking donations on its website to fund ongoing purchasing of this water, totaling $10 million, and highlights the weakness of the inclusion in Minute 319; a tokenistic gesture to the Trust without provision of assisted funds towards the restoration of the Delta.

Both governments see Minute 319 as an opportunity to provide *future* generations with water. Climate change is projected to reduce total river flows by 9% or more in the next 50 years (Lauer 2012). Healthy groundwater levels are therefore important during droughts to allow vegetation to grow and prevent soil erosion. Vegetation cover in the Delta will for example be necessary to protect against flooding. Since 1922, US water management has become increasingly state-centered and ignorant of the consequences in other Delta areas (Mumme 2003). But now both governments are recognizing that integrated and cooperative river basin management is a better strategy for long-term planning (IBWC 2010). This means that the governments will have to work together to solve their current and future problems (Pelgram et al 2013; Speed et al 2011). The U.S. Secretary of the Interior, upon the signing of minute 319, said: "*The United States and Mexico*

are connected by our reliance on the Colorado River and together we face the risk of reduced supply in the years ahead. Minute 319 demonstrates that we are continuing to strengthen our relationship, addressing our common needs for water to make sure there are water delivery and supply available to America and Mexico, people and the environmental needs on the Colorado River." (Lauer 2012).

However, it were NGOs and scientists who took the initiative in pushing for the restoration of the Delta and binational cooperation in the 1990s. The economic valuation of the water in the basin has made strong environmental policy historically difficult. Urban and agricultural water needs are often prioritized over environmental goals, for economic and legal reasons (Medellin-Azuara et al 2007). Before Minute 319 was implemented, water was only diverted out of the basin for agriculture, municipal use and industrial use (Lauer 2012). Additionally, water has been valued for recreational areas such as Lake Mead. But methods for valuing ecosystem services and pricing water used for those purposes are still contested and therefore do not easily allow for a cost-benefit analysis. It wasn't until the year 2000 that Minute 306 was signed in agreement for the formulation of a framework that would help to execute joined studies and exchange of information in order to evaluate and propose measures for the Delta's restoration. This was based on the principle of equitable distribution of resources and the need to examine flows and requirements of water in order to keep the Delta ecosystem viable and robust (IBWC 2000).

Today still, it is NGOs, conservationists and academia that play the key role in representing minority stakeholder groups and other beneficiaries to lobby for environmental flows and built consensus in both countries for restoration of the Delta (Hinojosa-Huerta et al 2005). To facilitate the process of community participation, the Asociación Ecologica de Usarios del Río Hardy y Colorado (AEURHYC) was formed in August 1999, with the assistance of Mexican conservation NGO, Pronatura (Hinojosa-Huerta and Carrillo-Guerrero 2004). In the long run, the restoration of the Colorado River Delta requires authentic stakeholder engagement of equal measures from both nations. In fact, Carpe Diem West (2011) criticize the IBWC and provide several examples of other transboundary river basin management scenarios where holistic and inclusive stakeholder participation is undertaken, and challenge the Colorado River managers to follow suit. The successful restoration of the Delta heavily depends on a multidisciplinary network of stakeholders and collaborators (Marcos and Cornelius 2004). For most NGOs involved, it appears that the intrinsic value of the ecosystem (and nature in general), is the underlying normative foundation for restoration. They embrace the principle of 'water for all', and for them this includes nature. This mindset is also present in the local Mexican communities around the Delta. However, under Mexican law agriculture comes first, and thus NGOs must incorporate the importance of water for food security and agriculture with the environmental concerns of the region. In addition to agricultural benefits, the Minute 319 can also produce benefits for Mexican fishermen by restoring the estuary (Glenn et al 2001; 2007). While Minute 319 has been praised by most stakeholders, the era of cooperation is only just beginning; and the Delta has a long challenging future ahead.

An Era of Cooperation

In the process of working together, the concept of co-benefits has arisen as one of the most important for collaboration. After water shortages in the U.S. in 2007, NGOs from Mexico and the U.S. began to formally address a new approach to the management of the basin and particularly the lower delta (Glenn, Flessa and Pitt 2013). In 2010, the IBWC released a formal framework for discussions between the two countries (IBWC 2010a). This framework states that the governments should find mutually beneficial solutions to water problems, and Minute 319 was passed with this idea in mind. Delta restoration is mutually beneficial because of the ecosystem and social services it will provide, as well as increasing the chances of long-term water availability for both nations (Lauer 2012).

The governments released a joint statement that the IBWC "should be utilized to expedite discussions to further the cooperation between the United States and Mexico on issues related to the Colorado River" (Glenn, Flessa and Pitt 2013). The 1944 water treaty may not be fair or just, but it is extremely unlikely that the treaty will never be disbanded (Mumme 2003). The task of the IBWC is therefore to find measures that allow for cooperation, but still fit within the framework of the treaty. The Commissioners agreed to establish a binational Consultative Council, which includes representatives from the Commission and both federal governments (IBWC 2010a). They can ask for help from the binational Core Group and any of the binational Work Groups (Water Conservation, New Water Sources, System Operations, and Environmental).

The Consultative Council, Core Group and Work Groups all have the goal of finding areas of potential cooperation between the two countries and investigating what kind of projects or initiatives could be implemented. Cooperation should benefit both countries, promote sustainable water management and be implemented through mechanisms that allow for benefit as well as costs sharing (IBWC 2010a). The IBWC also recognizes that both countries, and groups within those countries, might have different interests. In Minute 319, it is stated that "the Commissioners recognize that various considerations exist in both countries with respect to the implementation of some of the long-term options and activities that have been identified in Minute 317 to address binational cooperative objectives and opportunities" (IBWC 2012). For example, in 2010, a significant sized earthquake struck the Mexicali Valley region damaging important canal systems and due to the infrastructural damage, Mexico was not able to access its full allocation of 1.5 MAF and flows to the Delta were again restricted (Scattler 2013). But the establishment of cooperative amendments Minutes 317, 318 & 319 enabled Mexico to store unused water upstream in Lake Mead, giving them time to repair their infrastructure (Schattler 2013).

Brouwer et al (2012) highlight the use of Service Level Agreements (SLAs) as an instrument to determine whether the existing infrastructure needs to be improved, and/or which improvements are needed. While Minute 306 (2000) established the framework for future recommendations concerning riparian and estuarine ecology of the Colorado River and its Delta, there are no explicit SLAs in place and more implicit SLAs were undertaken by independent researchers and NGOs. The IBWC state within Minute 319, how it is intended to "improve infrastructure and develop projects in Mexico, which will allow both countries to better assess the long term opportunities and cooperative measures for water conservation" (2012). Consequently, a number of water infrastructure projects were highlighted by the IBWC, to contribute to retaining and finding new sources of water for the Delta's areas. These initiatives included the Alamo Canal Regulating Reservoir Conservation Pilot Project, fallowing (paying farmers for their water shares after improved irrigation efficiencies), and the modernization and technical improvements to Irrigation District 014 (IBWC 2012).

Yet Carrillo-Guerrero et al (2013a) claim that even without formal environmental flows, over 36,000ha of valuable Delta wetlands are currently already supported by agricultural return flows and canal operational releases. The authors claim that this is because Mexican farmers are far more efficient in their irrigation methods than US farmers (allowing more return flows) and canal engineering in the Mexicali district allows more seepage losses, which also contributes to non-saline riparian inputs (Carrillo-Guerrero et al 2013a). Meanwhile the saline agricultural surface runoff from agriculture in the US & Mexico has developed the establishment of brackish wetland Cienega de Santa Clara. Now the proposed operation of the Yuma Desalination Plant, threatens this supply of water to the Cienega de Santa Clara (Carrillo-Guerrero et al 2013b). Carrillo-Guerrero et al (2013a) agree that the alternative of obtaining water for environmental flows through increased efficiency in agriculture uses and infrastructure improvements is not sufficient since the delta wetlands are already dependent on canal seepage, return flows and waste spills. Furthermore, while Mexican farmers receive

cash for improved efficiencies in exchange for some of their water rights, American farmers and cities do not have to sacrifice or improve efficiency of their own water use for the benefit of the Delta (Divine 2014).

However, other sources of new water are being investigated as a result of Minute 319; namely Binational Desalination Plant in Rosarito, Baja California; Beneficial use of the New River; and Binational Desalination Plant near the Gulf of California (Sea of Cortez) (IBWC 2012). According to Minute 319 (IBWC 2012) the combined capacity of these infrastructural developments can potentially create 717, 000 acre-feet of 'new water' (see Figure 3). Given that Wheeler et al (2007) use the Bureau of Reclamation's Colorado River Simulation System (CRSS) model to estimate the 50,000 acre-feet which is required annually for delta restoration, the new water sources appear more than adequate. Yet Minute 319 explicitly identifies the need to ensure the infrastructure has the capacity to produce these base and pulse flows and monitor the impacts and effects of such flows on the delta (IBWC 2012). Monitoring of hydrological wetland restoration is crucial to test the mechanisms which release the water and evaluate the ecosystem's response (IBWC 2012).

PROJECT	ESTIMATED ANNUAL VOLUME in thousand acre-feet (mcm)
Miguel Aleman Environmental Restoration	not applicable
Alamo Canal Regulating Reservoir	3.2 (4)
Fallowing Payments	243 (300) one time
Modernization of Irrigation District 014	
First Phase	101 (125)
Subsequent Phases	519 (640)
AAC-Pump Station 0 Connection	to be determined
Rosarito Desalination Plant	56 (69)
Use of the New River	38 (47)
Explore Desalination Plant in Gulf of California (Sea of Cortez)	to be determined
TOTALS	717 (885) annually 243 (300) one time

Figure 3. Quantitative estimates for new water source infrastructure projects in Mexico (IBWC 2012)

One example of monitoring of engineered influences on the Delta was of the replacement flows during the 2010–2011 trial run of the Yuma Desalting Plant (Carrillo-Guerrero et al 2013b). A team of Mexican and US scientists from a variety of institutions conducted the program, which involved monthly monitoring of the Cienega through ground surveys, aerial overflights and satellite remote sensing observations (Glenn, Flessa& Pitt 2013). The results of which will be significantly influential in providing engineering and infrastructure management recommendations to secure a formal allocation of water of adequate volume and quality (Carrillo-Guerrero et al 2013b).

Despite the 1944 treaty providing the IBWC with the appropriate authority for enforcement of such initiatives as outlined in Minute 319, they have traditionally lacked the capacity, political power and motivation to undertake such enforcement. Once more, the federal government agencies such as the Bureau of Reclamation (US) and autonomous researchers have had more enforcement influence without the restrictions of diplomacy which encases the IBWC. Furthermore, until the 21st century agreements between the nations, there was no conformity or conviction between the nations, which is described as essential by Brouwer et al (2012) before any enforcement can be undertaken. Consequently, enforcement has been based on the autonomous academic research, monitoring and publishing, in a 'name and blame' or symbolic damage strategy (described by van Huijstee and Glasbergen 2010). While this stakeholder influence is a positive aspect for transparency in the enforcement and management of flows heading towards the Delta, now that Minute 319 has established conformity with agreed objective, the US and Mexican governments should allocate the IBWC with enforcement and monitoring funding to work alongside such stakeholders.

CONCLUSIONS

We have found that the proposed measures under Minute 319 are in line with current scientific advice on the restoration and conservation of the Delta. The proposed pulse flows are sufficient in magnitude to provide the long-term ecosystem benefits mentioned in the Delta section. Additionally, the Minute prescribes monitoring to review the impacts of the pulses on the local ecosystem. Applying Brouwer et al's framework (2012) has helped to reveal potential strengths and weaknesses in the Delta's governance, which would be missed by only assessing Minute 319's content with respect to the ecosystem. We will present the most important findings related to each of the nine building blocks. In the Discussion will explore the implications of these findings for long-term management of the Delta.

Water system knowledge in the Delta has been insufficient since the start of its management, leading to ecosystem degradation. Today still, many questions about the Delta remain unanswered. Climate change, among other factors, poses new questions with regard to the governance of the ecosystem. Values and policy discourses in the Basin have gravitated towards each other over time, but are not yet unified across all actors. Especially the intrinsic value of nature and biodiversity is not shared by all actors. Involvement of stakeholders outside of the US and Mexican governments has been essential to address the needs of the Delta's ecosystem. In particular, NGOs and academia have played key roles. The River's waters can be used to advance a variety of social objectives. Agriculture and municipal use, for example, have historically been preferred over environmental allocation, and long-term benefits for these sectors seems to be more important to the Nations than the restoration of the Delta per se. The authority and means of the IBWC are limited because of its complicated history, as well as having no mandate, yet it is has been given full responsibility over the limitrophe region of the Delta in coordination with both federal governments. Political pressures from both sides have weakened the effectiveness of the IBWC. Minutes 309 and 319 have been breakthroughs in formally addressing the Delta's restoration, and include important flexibility mechanisms with regard to future management. Another important mechanism is that of monitoring; the results of which will determine future treaties in the Basin. Both governments want a confirmation from the scientific world that Minute 319 is indeed having beneficial effects on the Delta's ecosystem and the wider Basin. The IBWC has no enforcement capabilities; enforcement is the responsibility of federal governments in both countries. This means that the IBWC's has limited mechanisms for conflict prevention and resolution. Instead, the Commission is trying to find co-benefits for the governments and stakeholders. These co-benefits have to fit within the 1944 Treaty to be able to implement them.

DISCUSSION

We find that all but one of the nine building blocks substantially influenced the implementation and expected success of Minute 319. Even though responsibility lies with the IBWC, and authority and means with the federal governments, it has been neither of these agencies that facilitated the Delta's restoration. Instead, it have been mainly NGOs and scientists, with limited authority and means that have made this transition possible. Yet we do acknowledge that improving the authority and means of the IBWC would be a positive factor for long-term Delta management. The absence of effective basin-scale management authorities has meant governance of water resources in the Colorado River Basin has been dominated by legal interstate compacts, which while clearly dividing water resources, these compacts provide little opportunity for decentralized decision making or flexibility (Pegram et al 2013).

Walker et al (2010) indicate that policy failures often follow from a failure to take uncertainties and the necessary flexibility into account. This flexibility in policy and governance is exactly what researchers in climate uncertainty claim is vital for managers to incorporate into their decision making processes (Walker et al 2010; 2013). The ability of Delta managers, or in particular, the IBWC, to adapt to climate variability, relies on their ability to develop robust policy and resilience in recovery (Walker et al

2013). By diversifying and increasing preparedness and responses for a range of possibilities, as described by Wardekker et al (2010), a dynamic and robust policy can be developed to maintain the restoration of the Delta. We believe that Brouwer et al's assessment method did not sufficiently address the importance of flexibility in governance (2012).

Lack of water knowledge in the Colorado River system is one of the main causes of the prolonged and ongoing water right disputes throughout the basin and has resulted in the over-allocation of water which is one of the most likely causes of the Delta's degradation, and struggle for ecological flows (Pegram et al 2013). Speed et al (2011) highlight the importance of hydrological study and river classification schemes to ensure important environmental flows are maintained. Additionally, more research into the Delta's ecosystem will be necessary for proper governance in the face of climate change (Morzaria-Luna et al 2014). As a result of Minute 319, new engineering initiatives such as desalination plants, repair of damaged irrigation canals, and improved agricultural efficiencies have been proposed by the IBWC (2012) and NGO coalitions (CRDWT 2010) as ways to provide new water resources for Mexico and ultimately the Delta. However, it is the autonomous initiative of these NGO coalitions and academia that have undertaken the necessary research, monitoring and campaigning to bring these issues into vision.

Diversity in the reasons to address the Delta's restoration is likely to cause problems in the future. Water demand in the Basin will likely increase further, whereas renewable supplies may decrease in a warming world. All parties were able to agree on Minute 319 because of the restoration's possible benefits on other social objectives, but it is not clear that the governments will continue to conserve the delta if it comes at the cost of e.g. agriculture or municipal water use. Monitoring the benefits of pulse flows may provide an incentive to continue restoration and conservation in the future, but the IBWC so far does not provide funding for these initiatives. If these goals are to be met, it will have to be by private actors. This mechanism is therefore not resilient to changes in the social environment. Increasing the IBWC's capabilities for monitoring, enforcement and conflict resolution is expected to make long-term Delta management more sustainable (Brouwer et al 2012).

A limitations for this research was the complete media and internet saturation of the many issues. This information saturation has resulted in a varied quality of resources and opinions on the governance instruments and events which lead to the signing of Minute 319 and Delta restoration activities. This challenged the authors to find suitable information during this research, and we were restricted to English language reports and resources due to our lack of Spanish language skills. For example, the content and publications of the Mexican half of the IBWC was inaccessible due to the fact it was completely published in Spanish. This resulted in a biased utilization of American based research and media publications which could have potentially restricted the overall findings of the paper.

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