

IX

Opposing Approaches to Managing Shared Water Resources: The Lining of the All-American Canal and the Valley of Mexicali—Static Market Equilibrium or Nash Equilibrium?

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The region composed of the bordering states of California, Arizona, Baja California, and Sonora has an annual average water volume of 4.83 million acre-feet (MAF), which is supplied by the surface flows of the Colorado River and groundwater extracted principally on the Mexican side. The majority of this water is used to irrigate 450,000 hectares (ha) (1.1 million acres) of agricultural fields on both sides of the border. This water also supplies cities, including those on the coast such as Tijuana in Baja California and San Diego in California (Cortez, et al. 2002).

Despite the perceived abundant availability, growing competition for water, not only in this region but in the Lower Colorado Basin,¹ has led to efforts to decrease losses and optimize use through supply systems that would increase availability and meet demand, particularly in urban areas. The proposal to line the All-American Canal (AAC) is among the principal projects U.S. authorities are relying on to recover water losses.

Lining the All-American Canal: Competition or Cooperation for the Water in the U.S.-Mexican Border?

The AAC conveys water from the Imperial Dam, 40 kilometers (km) (25 miles) upstream from the point of delivery, to Mexico at Morelos Dam, located in Algodones, Baja California. The AAC is the only source irrigating 198,296 ha (490,000 acres) and supplying water to 154,362 residents in Imperial County, California.² An annual volume of nearly 360,000 acre-feet per year (AF/y) flows through the AAC and U.S. government estimates indicate that seepage losses total as much as 91,610 AF/y, of which 10,540 AF/y flow north and 81,070 AF/y flow south. This water enters Mexicali's Irrigation District 014 as groundwater, where 56,750 AF/y are extracted from federally or privately owned wells and the remaining 24,320 AF/y are extracted by runoff collection at the La Mesa Drain.

The proposed lined AAC, which would run parallel to the existing canal, would be 37 km (23 miles) long and would begin 2.5 km (1.6 miles) west of Pilot Knob Peak. It would travel through the plateau of the same name, the Algodones Dunes, East Mesa, and end at Drop 3. The lining is expected to result in the conservation of 67,700 AF/y (DOI 2002).

Until very recently, the implementation of this project had been delayed by legal issues within the United States. With the enactment of Public Law 100-675 (U.S. Congress 1998), though, Congress authorized the U.S. Department of the Interior to move forward with the project.

However, international water regulations to which both countries are party seem to prohibit the project unless both the United States and Mexico agree to it, as set forth in the International Boundary and Water Commission's (IBWC) Minute 242, signed in August 1973. Specifically, it reads:

With the objective of avoiding future problems, 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.

Opposing Approaches to Managing Shared Water Resources:
The Lining of the All-American Canal and the Valley of
Mexicali—Static Market Equilibrium or Nash Equilibrium?

By carrying out this project the United States would be violating what was stipulated in this Minute and would also potentially cause adverse effects.

WATER-AVAILABILITY TRENDS IN THE AREA OF INFLUENCE

Studies carried out by Mexico's Comisión Nacional del Agua (CNA, in English National Water Commission), and in particular those conducted in 2000, indicate that lining the AAC would reduce water availability by as much as 81,070 AF/y. Of that water, 56,750 AF/y would have recharged the aquifer underlying the Mexicali Valley and 24,320 AF/y would have reached the La Mesa Drain (at its starting point, this drain runs on the Mexican side parallel to the AAC).

CNA also reports that all 328 wells—from which 3.16 MAF/y are currently extracted and used to irrigate 32,200 ha of agricultural fields—would be negatively affected to some degree or another. Negative effects would also be felt in the 1,200 ha currently irrigated with water collected at the La Mesa Drain. The total area facing potential affects by lining the AAC is estimated to be 33,400 ha largely located in the northeastern portion of the Mexicali Valley. Historically in this area a variety of crops have been grown, such as cotton (14,300 ha), wheat (8,400 ha), alfalfa (3,500 ha), vegetables (700 ha), and other smaller-scale crops (6,500 ha).³ Another study indicates a reduction in the water table that would lead to a 15% increase in power and electric energy demand (Navarro 1998).

There will also be potential direct and indirect negative effects due to volume-quality ratios in the groundwater of the area of influence. Other authors whose estimates are more conservative suggest the direct effects would be felt in only 190 wells serving 19,000 ha of irrigated agricultural land and 800 ha irrigated by water from the La Mesa Drain. The difference in surface area is due to how gradually the effect spreads. It should be stressed that most agree that lining the AAC would cause direct short- and medium-term negative effects on the wells surrounding the area of influence of the AAC, and in the long-term, on the entire Mexicali Valley.⁴

Lining the All-American Canal: Competition or Cooperation for the Water in the U.S.-Mexican Border?

Salinity Issues

The change in salinity is an issue directly related to reductions in available water volumes. According to CNA, in the area of influence of the AAC under current conditions salinity in the aquifer increases by 21.9 parts per million per year (ppm/y), and by 20.6 ppm/y near the old wells. Should the AAC be lined, total salinity in the aquifer would increase 5.7 times the expected norm during the first year. In subsequent years it would stabilize and exhibit an increase of 23.5 ppm/y. This suggests a quick water salinization process. Among the negative effects of increased water salinity on agriculture is a decrease in production of sensitive crops, which are indeed the most profitable.

Social Issues

These shared, fully-allocated crossborder waters further complicate an already difficult situation. The arid nature of the region, population growth trends, and economic activity dynamics make the fair and integrated management and distribution of water resources more complex, not only between the two countries, but also among its users—manufacturing sectors and population sectors (Cortez and Whiteford 1996).

Economic activity in the Imperial-Mexicali border region is predominantly agricultural, with most of the water (between 85% and 90%) used to irrigate crops such as cotton, vegetables, wheat, fruits, alfalfa, and grasses. Alfalfa and grasses alone use 54% and 15%, respectively, of the total amount of water available for agriculture in the region. This, combined with the steep increase in water demand for urban uses, has exerted additional pressure on agencies and manufacturing sectors, which have greater volumes of water available.

This border region includes the municipalities of Mexicali, Tecate, and Tijuana on the Mexican side, and the counties of Imperial and San Diego on the U.S. side. Together they make up the most populated area along the international border between Mexico and the United States. Mexicali, on the east side of the Baja California border, has an urban population of 647,950 and a scattered rural population that includes 214,545 in 294 villages.⁵ The

Opposing Approaches to Managing Shared Water Resources:
The Lining of the All-American Canal and the Valley of
Mexicali—Static Market Equilibrium or Nash Equilibrium?

lining of the AAC would, in the short term, directly affect approximately 1,010 families, 950 of whom use water from the wells and 60 of whom benefit from runoff from the La Mesa Drain.

Impacts of Lining the AAC for Mexicali Valley

Several studies conducted by CNA consider the aquifers on both the Mexican and U.S. sides part of a single hydrogeological unit. The United States, though, conducted technical studies in 1988, 1994, and 2002 without any real participation from Mexican counterparts.⁶

The information collected by the IBWC on existing piezometric conditions in the Imperial and Yuma Valleys provides insight into their evolution since 1911. The static-level configuration analysis for different dates states that the construction of irrigation in the United States resulted in a change in the original groundwater flows on both sides of the border, and that some of the main “positive” effects of the AAC are the feeding of aquifers on the Mexican side, brought about by infiltration, and the formation of a piezometric dome at Yuma Mesa due to irrigation water infiltration.

The hydrogeological study performed in 1972 by CNA indicated that the Mexicali Valley aquifer (not taking into account Mesa Arenosa de San Luis) has an average annual recharge of 567,490 AF/y, divided as follows:

- 405,350 AF/y from vertical feed by infiltration from distribution canals in the Mexicali Valley irrigation area
- 121,600 AF/y from underground flows on the California-Baja California and Arizona-Baja California borders (including the AAC, whose underground flow also has a predominant vertical component)
- 40,540 AF/y from Mesa de San Luis Río Colorado in Sonora

Additionally, derived from the rehabilitation of Irrigation District 014, the La Mesa Drain was built with the initial purpose of intercepting infiltrated waters from the AAC to keep the elevated watertable levels that prevailed in the area—particularly in surrounding towns such as Algodones—under control.

Lining the All-American Canal: Competition or Cooperation for the Water in the U.S.-Mexican Border?

With regard to water quality, several studies on the dissolved salt balance at the La Mesa Drain show it is made up of a 1,000 liter per second inflow from the AAC with an average salinity of 900 ppm, plus another similar volume from irrigation returns from the Mexicali Valley with a median salinity of 3,500 ppm. The greatest inflow of low-salinity water comes from the first section of the drain because this area has the highest permeability in the aquifer and is where infiltration from the AAC takes place (CNA 1991).

This information shows various qualitative and quantitative factors of the potential affects on the Mexican portion of the Mexicali Valley over different time periods, should the construction of the lined canal go forward. Despite the AAC issue having been discussed intensely since 1988, there is still no clear solution to “the new controversy,” at least not a joint one. This is because, on the one hand, the U.S. government declares its intention to line the AAC and says it complied with public comment requirements under the 1944 Water Treaty, and on the other, the Mexican government simply expresses its disagreement, which achieves nothing in real terms. Meanwhile, the risk remains and the negative effects would, according to the available studies, be felt mainly in Mexican territory⁷.

Therefore, it is worthwhile to analyze scenarios that could lead to successful negotiations between both countries to share this water, which is in high demand. It is not about holding back urban development or allowing agriculture to continue using the great majority of the region’s available water inefficiently—one cannot hold back the development of one sector at the expense of another, nor maximize the growth of one region while minimizing the other.

ALTERNATIVES FOR IMPROVING NEGOTIATION STRATEGIES AND BINATIONAL MANAGEMENT OF WATER: STATIC MARKET EQUILIBRIUM OR NASH EQUILIBRIUM?

Reaching viable alternatives lies not in technical solutions but in negotiation, conflict management, and “game” strategy, as well as with the role of and benefit for the players. The Game Theory perspective was introduced by Mumme and Lybecker in the previous

Opposing Approaches to Managing Shared Water Resources:
The Lining of the All-American Canal and the Valley of
Mexicali—Static Market Equilibrium or Nash Equilibrium?

chapter. The authors see that theoretical framework as one of the potential alternatives that might help to reach a bilateral solution to the AAC conflict. The authors, based on the findings of Frisvold and Caswell (2000), argue that in order to overcome the inherent constraints of this approach (non-cooperative choice game), issue linkages should be considered in the scenario.

In addition to the ideas developed by Mumme and Lybecker in this volume, this chapter explores two theoretical concepts that illustrate solutions to a complex situation: Sharing water when there is competition over this priority resource, which is strategic to regional development but also scarce, dwindling in supply, and increasingly in demand from various sectors in two countries.

What is the correct approach to analyze the All-American Canal conflict? Is it a Static Market Equilibrium—defined as the process that “optimizes” the allocation and use of resources, in this case, water? Or is it a Nash Equilibrium—a strategy that seeks a shared benefit, previously discussed and reached by consensus? Which ought to be the basis of negotiation to resolve this difference, Adam Smith’s Price Theory⁸ or the Equilibrium Theory of John Forbes Nash?⁹

Smith’s is the predominant approach upon which water management in the United States, and particularly in the Lower Colorado River Basin, is based. This chapter argues that this theory has led to conflict among the different water users when attempting to achieve social efficiency. Although this mechanism works adequately on the U.S. side, thanks to its organizational conditions and available infrastructure, and especially the nature of its legal framework with regard to water property rights, it would be inappropriate for Mexico to enter into the water markets arena today, mainly because of the characteristics that property rights should possess. They should be:

- Clearly defined
- Reasonably complete
- Certain
- Transferable

Lining the All-American Canal: Competition or Cooperation for the Water in the U.S.-Mexican Border?

The water-rights trade model based on Smith's theory generally states that, while buyers and sellers seek benefits for themselves or their group, the "invisible hand" of the market will distribute the goods efficiently. However, there are plenty of examples in which this "invisible hand" does not efficiently distribute resources and which this theory does not explain. One example is the California water markets and their resulting crossborder effects on water supply, as have been seen in recent years in the Lower Colorado Basin and the Imperial-Mexicali region. This development model leaves one of the parties—the Mexican agricultural sector—unprotected.

Thus, continuing to base crossborder water management (including water-saving and optimization projects, such as the AAC's lining) on Smith's theory would lead to marked conflicts when sharing a common resource like water (Ingram 1992). Therefore, it would be difficult to make predictions of the results of bilateral, multisectorial negotiations. In this context, a posture derived from a weighted negotiation could provide favorable solutions for all the stakeholders of these shared—and in fact over-allocated—waters of the Lower Colorado and/or for specific issues, such as in the case of the AAC lining project.

Nash's Equilibrium Theory and its derived Game Theory, though, fit the particular case of bilateral relations or conflicts, such as in the AAC lining. Essentially, it proposes the idea that every "game" (conflict or negotiation) of an economic nature has a point of equilibrium through which the "players" (political, financial, societal, and other stakeholders) can ensure ending up in a better position than before, even when it is not the ideal position for which they would have wished.

According to Nash, market system inefficiencies are due to the fact that the parties in a negotiation tend to look for the point where the decision or agreement reaches the optimum solution in the system, even if it is not beneficial or the most efficient for all players. Therefore, proposing common benefit strategies for dealing with a common resource like water could be a more appropriate approach.

The theoretical alternative suggested by Nash improves the situation when compared with that of Smith. However, Nash's alternative, which considers the dominant non-cooperative choice, would

Opposing Approaches to Managing Shared Water Resources:
The Lining of the All-American Canal and the Valley of
Mexicali—Static Market Equilibrium or Nash Equilibrium?

still lead the participants to a low level equilibrium that is not attractive to them. Nash equilibrium is defined as where no player can improve their position by acting alone if others stick to their positions (Schmid 2004). This has been described as a social trap (Platt 1973).

Nash's theory could be considered a theoretical basis on which to analyze issues related to shared water resources. Addressing cross-border water conflicts in a binational context, such as the AAC lining project, by using Nash's proposal could lead in new and better directions because it would be possible to ensure, with great accuracy, that all parties involved come out ahead, instead of just the one party that controls or dominates, as occurs in the market system.

Considering that the water seeping from the AAC toward Mexico could, on an institutional level, be categorized as an asset with a high exclusion cost, the Theory of Equilibrium, in which no player or participant can improve his position in the negotiation by acting unilaterally or individually, suggests that the best solution could be obtained by acting collectively and promoting the values of trust and cooperation with others (Schmid 2004). The issue is that trust is learned over time through successful transactions (human interrelations), including the learning of legal and behavioral norms. With regard to legal norms, which should be based on such interrelations, there are limited precepts. Although the international groundwater regulations between the United States and Mexico, as set forth in Minute 242, state that there must be "coordination for extraction and also consultation and exchange of information on the aquifer," it is precisely these elements of cooperation that have not been achieved. This gap in cooperative behavior could be closed using Nash's Equilibrium model.

The Nash's equilibrium model could be improved with Schmid's suggestion. Schmid states that the only way out of the social trap (do not cooperate) is by fostering trust and being confident in the cooperation of others. This can be achieved through intensive and permanent dialogue and repeated games between the parties involved—that is, through several negotiations sessions.

An in-depth review of available data (Navarro 1998; Cortez Lara 1999; Cortez Lara, Whiteford, and García Acevedo 2000) on actual events surrounding the lining the of the AAC indicate there is no

Lining the All-American Canal: Competition or Cooperation for the Water in the U.S.-Mexican Border?

formal evidence of proposed solutions that have been fully discussed among the stakeholders. Only in a few cases has this discussion taken place at the level of the authorities of both countries related to this issue, namely, IBWC and its Mexican counterpart, Comisión Internacional de Límites y Aguas (CILA).

Since 1988 the subject has been raised intermittently by U.S. authorities and the Mexican side has reacted, albeit without any cohesion that would support a uniform proposal and that could be seen as a negotiation position that could bring a balanced solution to the conflict. In this sense, for example, at the federal level, CILA does not have consistent studies such as those IBWC has and uses for binational negotiation and consultation with Mexico (for example, the Final Environmental Impact Statement and the Final Environmental Impact Report for the AAC lining project). This speaks to the need to strengthen technical aspects on the Mexican side so they can lay a solid basis for negotiation and put leaders in a position to give solid, sustainable answers to IBWC.¹⁰

With Mexican society perceiving the response from their representative authorities as lukewarm, isolated, and generally unsatisfactory, undoubtedly different stakeholders will voice their concerns, though probably in the same manner as the government has. Such was the case with the recent technical recommendation (Cortez, et al. 2002) that the Baja California state government requested in order to develop its position before authorities in both Mexico and the United States.¹¹

Other government stakeholders have also tried to get involved with the canal's lining. Starting in 1998, the various administrations of the municipal government in Mexicali, together with Imperial County, discussed compensation alternatives—referring to the possibility of having water from the Colorado River delivered through the AAC under the following guidelines:

- A portion of the water allotted under the 1944 Water Treaty (Lindero Norte/Morelos Dam) would be delivered at a point near the Mexicali urban area
- Mexico would build the structure to convey the water from the point of delivery to the city of Mexicali
- A volume of up to 500,200 AF/y would be conveyed

Opposing Approaches to Managing Shared Water Resources: The Lining of the All-American Canal and the Valley of Mexicali—Static Market Equilibrium or Nash Equilibrium?

- Mexico would not be charged for conveyance losses along the 31-mile route
- The quality of the water delivered to Mexico would be similar to that of the water conveyed through the AAC
- Mexico would cover all costs incurred

This proposal was deemed infeasible by CNA for technical contradictions. Among them were the fact that water salinity concentrations at the original point of delivery set forth in the treaty would result in negative consequences for the rural population and agriculture in northeastern Mexicali Valley.

Other alternatives in addition to this one have been proposed, including modifying the original project,¹² using the Yuma desalination plant, and delivering water from the Colorado into Tijuana. Still other alternatives may be proposed, but stakeholders must attempt to establish a conflict-management strategy based on equilibrium of the solutions and, as a result, of shared benefits.

The example of the alternative of delivering water to the city of Mexicali through the AAC makes it clear that the efforts of one of the stakeholders (the municipal government, in this case) to attract a benefit for the city of Mexicali did not succeed, or at least has not yet, because it did not take into account the negative effects on third parties (in this case, the rural stakeholders or agricultural producers). It once again fell prey to playing with the conflict without including all the stakeholders involved. This, in the end, makes it more difficult to reach a weighted solution that benefits both countries.

CONCLUSIONS

While the condition of the aquifer has been determined by CNA, Mexico lacks the necessary technical and environmental impact studies that would allow for a fair negotiation with its counterparts. Information exists that creates enough suspicion to respond negatively to the project, but a formalized answer is extremely advisable. The pending environmental impact studies do not necessarily have to be conducted by government agencies, but what they would need is a great deal of public participation. This is where integration should be sought, first as a Mexican region, including social stake-

Lining the All-American Canal: Competition or Cooperation for the Water in the U.S.-Mexican Border?

holders such as Sociedad del Distrito de Riego (Irrigation District Society), which represents the nearly 14,000 agricultural users; the five irrigation districts or user associations that could be directly and immediately affected (districts 4, 5, 6, 7, and 16); the residents of surrounding communities; the business sector; environmental groups; academia; and the corresponding agencies from the different levels of government.

On another front, the challenge is to bring U.S. and Mexican stakeholders together, especially to exchange information, homogenize criteria, and discuss both technical and socioeconomic issues that unquestionably affect both sides because of their degree of regional interdependence. The goal of benefiting more than one party should be promoted in both nations. By incorporating an equilibrium approach like the one proposed by Nash, the potential for reaching a solution with a positive net value that includes every stakeholder and that, as a result, minimizes affectation of third-parties, would be increased.

A short- or medium-term solution resulting from the implementation of a cooperative model could include actions aimed at making the binational regulatory framework for the management of cross-border groundwater more suitable. Given the existing interdependence and competition for a resource with a high exclusion cost, Nash's negotiator/conciliator model can address the conflict over the AAC, if suggestions made by Schmid are included to develop an intensive and iterative dialogue negotiation process.

Cases such as the AAC could occur more frequently along the U.S.-Mexican border given the demographic and economic dynamics that exist in the region, as well as the growing water demand. Therefore, and with the understanding that development cannot be stopped and that the economic growth of one region generally has positive effects on the other, it is essential to adjust the rules of the game for crossborder groundwater management so that an efficient, equitable, and sustainable use of the resource may be achieved.

Opposing Approaches to Managing Shared Water Resources:
The Lining of the All-American Canal and the Valley of
Mexicali—Static Market Equilibrium or Nash Equilibrium?

ENDNOTES

¹ The Colorado River is divided into the upper and lower basins at Lee's Ferry, which is located a few miles south of Lake Powell and its respective Glenn Canyon Dam. This dam supplies, downriver, parts of Nevada, Arizona, New Mexico, and California, whose normal allocation is 7.5 MAF/y, as set forth in the Colorado River Compact approved by the U.S. government in the early 1900s.

² Population estimated based on 4.2% average population growth projected for 2000 to 2010 (IID 2001).

³ Note that on a watershed level, 85% of the water volume used is still allocated to agriculture. In more arid regions, such as California, this percentage is 92%.

⁴ By the reduction of underground volumetric availability alone, caused by keeping the waters of the AAC from seeping into the Mexicali Valley aquifer, the surface area for agriculture would be reduced by 9,149 ha. However, because of indirect effects due to the volume-quality ratio of these waters, the damage could potentially expand gradually to 33,400 ha.

⁵ Data to June 30, 2001, considering a 2.3% average annual growth rate observed from 1995 to 2000 (Consejo Estatal de Población 2004).

⁶ The environmental impact assessments made in these years started out with the initial position, in 1988, of not disclosing results about potential crossborder impacts for Mexico. In 1994 it was done more openly but without including opinions from the Mexican section. In the recent National Environmental Protection Act process in 2002, which produced the new Environmental Impact Review and Environmental Impact Statement for the AAC lining project, it was opened to public comment in Mexico. Yet, there was no opposition to the project, other than CILA's official position expressing disagreement. However, this statement was made without any technical documents to support it.

⁷ The most recent and strong reaction opposing to the AAC initiative is the legal action against the U.S. government by a few local non-governmental organizations established on both sides of the border, including Consejo de Desarrollo Económico de Mexicali

Lining the All-American Canal: Competition or Cooperation
for the Water in the U.S.-Mexican Border?

(CDEM), United Citizens for the Natural Resources and the Environment (CURE), and Citizens of the Desert Against Pollution (CDAP).

⁸ The idea presented in this chapter regarding the model universally spread by classical economists such as Adam Smith, neo-classical economists like Alfred Marshall, and new institutionalists like Oliver Williamson, is that the government should play only a regulatory role and impose as few restrictions as possible on trade and pricing.

⁹ The four mathematical principles behind the modern “Game Theory” are developed at length in the four documents published by its author, John Forbes Nash. In his essays, Nash makes basic, valuable contributions both to Uncooperative Game Theory and to Fair Bargaining Theory (*Essays on Game Theory*, John Forbes Nash, 1997).

¹⁰ According to Official Document LAE 01012/00, drafted in Ciudad Juárez, Chihuahua, on May 22, 2000, the Mexican commissioner extends a Diplomatic Note to his American counterpart expressing his disagreement with the AAC lining project, citing the potential negative effects it could have on the Mexicali Valley.

¹¹ This recommendation, based on a series of technical documents prepared by agencies from both countries, essentially establishes that the Mexican government should oppose lining the AAC until they have:

- A complete study on the socioeconomic and environmental impacts of the canal lining on the Mexicali Valley
- Alternatives to mitigate the effects lining the canal would have in Mexico

¹² It is important to stress that this alternative is more of a recommendation borne of the environmental study conducted in the United States, which was then translated into Spanish and presented as a negotiable option for Mexico. In fact, the project was modified due to pressures from U.S. environmental non-governmental organizations.

Opposing Approaches to Managing Shared Water Resources:
The Lining of the All-American Canal and the Valley of
Mexicali—Static Market Equilibrium or Nash Equilibrium?

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Lining the All-American Canal: Competition or Cooperation
for the Water in the U.S.-Mexican Border?

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