A Physical Assessment of the Opportunities for Improved Management of the Water Resources of the Bi-National Rio Grande/Rio Bravo Basin

Workshop to Design the Information Management System

Workshop on Rio Conchos Environmental Flow Restoration

Results

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This is a summary of the results of the two project workshops, held at the Universidad Autonoma de Ciudad Juarez on June 19-20. It should not be surprising that the discussions did not crystallize all aspects of the project, since we are navigating uncharted waters (literally, in some respects). However, NHI and ITESM are very pleased with the level and quality of the expertise that was brought to bear, and found the workshops quite useful in illuminating the next downstream reach of this project. All participants are requested to give us your feedback on this document. We want to be sure that it accurately captures the workshop discussions and reflects the appropriate action items and assignments. These will form the basis for the partner-specific workplans and funding commitments that will be developed as the very next step in the project.

Workshop to Design the Information Management System
June 19

1. Build an Integrated Master Database Using ARC-HYDRO

The "Physical Assessment" project envisions the creation of a basin-wide hydrological planning model, capable of evaluating the hydrologic feasibility of a suite of scenarios for improving the management of the limited water available in this system, particularly those opportunities that bridge across management units and jurisdictional boundaries. By hydrologic feasibility, we mean both physical viability and the ability to provide mutual benefits to stakeholders throughout the system.

However, the workshop and discussions with some of the modeling teams working on individual segments of the basin revealed that the Physical Assessment project need not rush to adopt and begin populating a hydrologic model of the basin. Indeed, attempting to standardize the segment specific modeling efforts in this way may cause them to retreat from our project. Instead, we need to create enticements for these efforts to provide their data cooperatively. We can do this by creating a data set that they value and can utilize, by generating trans-segment and trans-model water management scenarios that they can use their model to evaluate, by linking the models together through a process of utilizing the outputs of upstream models as inputs into downstream models, and by convening the many segment-specific modeling teams into a "consortium" or "counsel" that would begin a process of

exploring how these models can be most effectively linked and serving as a source of advice and guidance for the Physical Assessment project.

To create this basin-wide master data set, we need to first survey and gather all of the extant data sets that are organized or can be organized in GIS/ArcHydro format, and are relevant to hydrologic planning. These data can then be used to construct the basin-wide model to serve the following **Modeling Objective**:

> ***"To evaluate the physical viability of scenarios for management options in the basin (taking into consideration the physical hydrology of the basin). Physical viability includes both hydrologic feasibility and potential to provide mutual net benefits to water user communities throughout the basin. Feasibility will be evaluated at both the planning level (monthly time steps) and operational level (daily time steps), depending on the scenario."***

After a presentation by David Maidment of the University of Texas on the application of the new ArcHydro data model as part of the Water Availability Program under way in Texas, the participants engaged in a discussion of how the project should construct a shared database for the Rio Grande Basin. Consensus was reached around the following points:

- *Use ArcHydro as a data model for the project.*
- *Make the database both bi-lingual and bi-metric.*
- *Package data in the database according to HUCs for U.S. data and according to sub-*cuenca *for Mexican data.*
- *Use the Albers Equal Area Projection with Lambert Parameters*
- *Use only data with a resolution of 1:250,000 or better.*
- *Develop and use a common metadata format.*

The group also identified several themes that should be included in the database:

- *Topography*
- *Climate (station locations and time-series)*
- *Soils*
- *Geology*
- *Land use/land cover (with changes over time if possible)*
- *Stream network*
- *Streamflow (station locations and time-series)*
- *Critical habitat*
- *Hydraulic infrastructure (physical characteristics and operating rules)*

- *Aquifers (physical characteristics including groundwater quality)*
- *Water Quality*
- *Administrative units (cities, states, irrigation districts)*

To integrate the data, the project will need to pre-process some of the U.S. and Mexican data sets to make them compatible. In assembling the database, we will establish priorities with respect to both the data packages and data themes. For instance, we will give a priority to those HUCs and sub-cuencas where water is stored, diverted and delivered. As such, gathering data for areas downstream of reservoirs will be a higher priority than for upstream areas. We will give a higher priority to data themes that are most relevant to the modeling objective stated above.

It is anticipated that the categories of water management improvements to be evaluated will include:

1) *Strategies to reduces losses to the system from evaporation, deep percolation (especially to saline groundwater), and evapo-transpiration*
2) *Conjunctive management of surface and groundwater for enhanced storage and more flexible delivery (and reduction in evaporation)*
3) *Re-operation of existing infrastructure*
4) *Expanded water trading*
5) *Desalinization of saline aquifers*

For initiatives of this sort, data themes of lesser relative importance may include water quality and demographics.

All partners will be involved in this activity, with specific HUC/sub-cuenca and specific data theme assignments. This effort will be directed by the partners who have already developed GIS products in the priority HUCs/sub-cuencas on the priority data themes. This includes **ITESM, UACJ, and HARC** on the Mexican side, and several current and prospective partners on the U.S. side. **UT, UTEP, TAMU, SNL, SAHRA and USGS** could all be valuable contributors. **ITESM and NHI** will construct a matrix of the data units ("HUCs" and subcuencas) and the data requirements. For each square, they will then indicate the institution with the best expertise to undertake the data compilation for that unit and data type. They will also develop a timeline for the assembly of relevant data and a strategy for allocating resources.

2. Form a Consortium of Modeling Teams

Stand-alone GIS products are not the only source of information for the shared database. Models represent another valuable source of data. Groups that have developed water resources models for specific regions of the basin hold much of the data needed to assemble a master database. The ideal strategy for building the database would involve convening the many segment-specific modeling teams into a **"consortium"** or **"counsel"** that would begin a process of exploring which data can be contributed to the master database. This would be of value to the various modeling teams as the data set could be used to evaluate trans-segment and trans-model water management scenarios that they cannot currently consider with their existing models. When combined with the information available in stand-along GIS products, harvesting all available data from existing models may move the project a long way towards the development of a comprehensive shared database.

The modeling consortium can also explore linking their models together through a process of utilizing the outputs of upstream models as inputs into downstream models. This would allow for exploration of how these models can be most effectively linked to serve as a source of advice and guidance for the Physical Assessment project. This guidance would help the Physical Assessment project determine how it can best add value to the process of improving the understanding of the physical processes that dominate the basin and the management options that are likely to be most robust.

NHI will take a leading role in attempting to develop this consortium, with key help from some of the other partners and other modeling teams. We may want to call specifically upon the government research units such as **IMTA, USGS**, and **SNL** in this venture.

3. Develop Scenarios for the Rio Conchos Basin (and downstream) and Request IMTA to Evaluate Them Using its Stella-Based Model

The IMTA model of the Mexican portion of the Rio Bravo basin appears to have the potential to immediately assist in evaluating management options in that portion of the system, primarily in the Conchos basin. The project has already outlined several concepts for broad-scale improvements in water management for the Conchos basin (see the Rio Conchos Workplan) that could be developed into scenarios that may have substantial benefit for a number of interests in the basin. Indeed, since modernization of the Conchos basin has become an urgent priority for the Mexican (and U.S.) government(s), it would seem that early progress in this area would be most relevant for government decision-makers. In this effort, IMTA would benefit from further testing of the utility of its model to explore alternative management scenarios.

NHI, ITESM, UACJ, **WWF** and **Biodesert,** in consultation with the other partners with specific experience in the Rio Conchos basin, will draft the initial set of scenarios which IMTA would be funded to model. The results will be used to help shape the basin-wide modeling effort. **IMTA** will be asked to perform the modeling, with participation by **NHI** and **ITESM.**

4. Further Evaluation of Hydrologic Modeling Software Options

While we may not begin to build the system wide water resources model immediately, it is important to continue a push towards the choice of a software package at this stage for two reasons. First, the requirements of that software may influence how we go about assembling the master data set. Second, in the event that the regional modeling efforts in the basin invited to form the consortium cannot link together their individual models so that basin-wide initiative can be rigorously evaluated, we will need to create an over-arching system-wide model that can provide an integrated analytical framework for more site specific analysis accomplished using existing discrete model.

To bring this selection process to closure, **NHI** will perform some further evaluations of the current candidates, looking specifically at which are being most broadly used by others in the basin, and looking at the relative time and dollar costs associated with learning how to use the models. Ease of use was considered important by some workshop participants. This evaluation will lead to the identification of a tool that can rapidly be used to begin the process of screening the planning level feasibility of basin-wide management scenarios.

5. Develop a Tool to "Game" Basin-Wide Scenarios

Using gaming, a technique that has proved useful in screening management options in California, we can begin to understand at a basin-wide level how some of the categories of water management options listed in Section 1.) above might perform if employed at a basin-wide level. For instance, it would be interesting to see how a vigorous effort at groundwater banking in the dewatered aquifers might benefit users throughout the system. It would also be interesting to see what the benefits might be of a vigorous program of agricultural water conservation in the areas that now use water most inefficiently, and how these benefits might be distributed throughout the system. Or we might want to look at how delivering conservation services *in lieu* of water might work. Or how reservoir releases that emulate more natural flow regimes might affect the entire system. Actually, there are many such

"thought experiments" that could be run using a simple hydrological accounting system for the sole purpose of seeing which of these appear to be sufficiently promising to warrant the expenditure of larger amounts of time and effort to develop them at a more refined and definitive level.

NHI will take the lead in figuring out how to set up a similar "gaming experiment" for the Physical Assessment Project. Members of the modeling consortium (see action item # 2 above) and representatives of stakeholder communities in the basin will be asked to participate by posing the broad-scale management changes that will be "gamed". Of course, these games are data dependent. Accordingly, it may not be possible to begin playing the actual games until the integrated database is further along. But we can at this stage at least determine what would be required to enable such gaming to be done eventually. The ability to play this early screening role will be an important consideration in the selection of a system-wide modeling system. Early results of this sort would also graphically demonstrate the potential value of the Physical Assessment project to outside interests in the government and within the water user communities.

Institutional Environment

The workshop also discussed several issues regarding the custody and maintenance of the data system and models. Presumably, all of the partners will play a role in the process of building the data system and hydrologic model, operating out of their own institutional base. But one or more institutions will need to assume responsibility for actually housing and maintaining the database and the system-wide model, albeit with remote access for the other partners and, indeed, the world at large. The database and model will, of course, be dynamic and will grow, evolve and improve as new data becomes available. But not all data are "created equal". There will be great variation in quality, completeness, and currency of data. One of the key functions in maintaining the database will be exercising judgment regarding the quality of the data that is admitted into the system and regarding when new information should replace old information. We could call this the "gatekeeper" function.

Several tentative conclusions emerged:

- *All of these issues arise only when we integrate the data sets that individual partners will be collecting and processing. Thus, we do not need to resolve these issues at this stage. However, it is important to start the dialog at this early stage.*

- *It is important to retain the bilateral and symmetric character of this collaboration, even if only for optical reasons. Thus, two mirror institutions within the basin; one on each side of the border should perform the custodial and maintenance functions. This will facilitate participation by government agencies and research centers and the attraction of governmental funds. Such redundancy is not hard to maintain with existing software, and will also provide a "disaster recovery" benefit, assuring that if data is lost in one institution, the other can replace it.*

- *These two mirror systems will maintain a web site at which all data and project documents will be accessible. Every collaborator will store their information on this site through an access code. However, we will create an internal network that will make posted information available only to project partners until the decision is made that it is ready to be posted for general consumption.*

- *The data should carry a "quality designation". Some data will be regarded as sufficiently reliable that the project will "adopt" it as such. Some data may be useful to post and utilize even though there are questions about its accuracy. This data should be posted with an appropriate disclaimer. Some data may have additional credibility because it has been officially sanctioned and released by government agencies (e.g. C.N.A.). In sum, the data system should be completely transparent as to both source and quality of data, and should be labeled accordingly.*

- *Where judgments regarding quality or appropriate labeling of data are needed, the project partners should serve as a "technical jury" in making those judgments. However, to make this process efficient, it may be best to designate one or more partners as the lead for particular types of data, where they have the requisite expertise. That (those) partners would then make recommendations as to quality designation that would stand unless others dissent.*

- *NHI will research whether there are useful precedents for setting up a shared database that may provide some useful structural lessons.*

Workshop on Rio Conchos Environmental Flow Restoration
June 20

This workshop was convened "back-to-back" with the "Design" workshop to conserve resources, since many of the experts were needed for both. It was also appropriate because of the priority that we wish to give to the Rio Conchos basin in terms of the first year of effort on the Mexican side of the border. Finally, it was useful to focus on the environmental dimension early because it has been comparatively neglected in the work that is being done by other projects in the basin.

The following "Working Hypothesis" were presented at the workshop for critical review:

- *For the river channels downstream of La Boquilla and Francisco I. Madero reservoirs (and perhaps also San Gabriel), it is feasible to restore a semblance of natural flow patterns by relocating the point of diversion of the main irrigation canals from their current location at the base of the dams to a point downstream where the elevation of the river is sufficient to permit the water to be delivered to the irrigation command areas by gravity. It should be possible to do this without adverse impacts on the irrigators who divert from the canal above the new diversion point by providing an alternative water supply, either out of the natural channel or from groundwater recharged by the increased infiltration from the natural channel.*
- *Luis Leon reservoir is operated primarily for flood control, with these releases credited to meet Mexico's obligation to deliver water to the U.S. under the 1944 treaty. A relatively small portion of these releases are used for irrigation in the lower Rio Conchos basin. The treaty obligation is specified in terms of a total annual volume of water, but does not specify the schedule or magnitude of the water deliveries (a minimum of 350,000 acre feet per year, averaged over 5 year cycles). It appears that San Gabriel reservoir, on the Rio Florido tributary in the State of Durango, is also operated largely for flood control purposes. Therefore, it should be possible to reoperate both of these reservoirs to release water to meet the treaty obligations in a pattern that more closely resembles natural flows.*

- *Re-establishing more natural flows will produce biological benefits in terms of both instream fisheries and riparian habitats.*
- *The use of natural channels to deliver irrigation water in a configuration that will restore fluvial processes can be done without adverse impact on irrigation agriculture by providing a substitute water supply for those irrigators that would be "stranded" by the change in point of diversion. The substitute water supply could come from either enhanced groundwater recharge (due to the increased infiltration from the stream channel) or siphons out of the natural channel.*

Five "tracks" of research and analysis were identified as necessary to test the feasibility of these restoration hypotheses. These include:

1. *Engineering feasibility (i.e., identifying the options for new points of diversion for the La Boquilla and Francisco I. Madero Reservoirs).*
2. *Analyzing the irrigation areas served by La Boquilla and Francisco I. Madero Reservoirs that would need a substitute water supply in the event that the existing points of diversion are modified and the best option for providing same.*
3. *Land use compatibility (i.e., identifying the agricultural and residential development in the floodplain that would either constrain the magnitude of peak flows that could be re-established, or that would need to be relocated the Luis Leon and San Gabriel Reservoirs).*
4. *Estimating the biological benefits that would result from the changed flow regime below La Boquilla, Francisco I. Madero, Luis Leon and San Gabriel Reservoirs*
5. *Estimating the economic costs and benefits of these changes.*

It appears the current approach to ecosystem restoration in Mexico will dictate that restoration projects in the Conchos Basin can go forward only if they are physically possible **and** biologically compelling. Therefore, the following immediate work items emerged to be pursued along parallel tracks. We envision that the project will draw substantially upon the expertise of **WWF** and **NHI** in environmental restoration to guide these efforts. It is likely that the technical tasks can be completed in advance of bio-hydrologic analysis.

1. Assess the Engineering Feasibility of Moving Points of Diversion of Irrigation Canals Downstream of La Boquilla and Francisco I. Madero Reservoirs

Much of the analysis that needs to be conducted on this strategy depends on the location of the new diversion point. As a first step, engineering feasibility is a function of two things: 1) the distance over which a new connector canal would have to be built; and 2) the "lift" required to pump water from the natural channel into the new canal in order to allow for gravity feed. As a first cut, the most desirable points of diversion will be those with the minimum distance and minimum lift. If a viable alternative can be identified other engineering considerations, such as existing land use, the feasibility of constructing afterbays, and the identification of irrigation areas that would require a substitute water supply, may arise.

This can be determined by superimposing stream channel and canal axis data themes on topographic data themes of the areas. **UACJ** has the information necessary to do this analysis although the site-specific data on stream channels and canal axes need to be geo-rectified.

2. Document the Existing Land Uses in the Floodplain and the Existing Agricultural Uses of Water that Might be "Stranded"

Satellite imagery at a sufficiently accurate resolution can quickly tell us what crops are being grown in the floodplains immediately below these four dams. It can also tell us the cropping that is reliant on out-takes from the irrigation canals that are fed by La Boquilla and Madero that might lose water supply if the canal diversion is relocated further downstream. **HARC** will acquire these images for all four reservoirs from "QuickBird" and interpret them. **ITESM** will investigate other options for remote sensing data.

3. Understand Naturalized and Impaired Flows Immediately Above and Below the Four Reservoirs

To define the desired environmental flow regime, the Indicators of Hydrologic Alteration method can be used to evaluate 32 "Indicators of Hydrologic Integrity" that can be used to understand how much the flow regime has changed from "natural" conditions relative to the more recent altered state. For the Rio Conchos, we can get data on how flows have changed as a result of the construction of the four dams of interest by assuming that the reservoir inflow is a representative proxy for the natural flow. The reservoir outflow would then be considered to be the altered flow regime. **NHI** and **UACJ** will make a request for these data. **NHI** will coordinate the IHA analysis to assess which of the 32 indicators has been most dramatically altered due to the construction of the dams on the Rio Conchos.

4. Monitor Fish Abundance Trends Below the Four Reservoirs

Changes in native fish abundance (19 species) before and after the construction of these dams is also available for comparison. It will show a sharp decline in native species in the river segments immediately below these dams. Dr. Salvador Contreras (**Bioconservación**) will provide those data and analyses.

It would also be useful to document the current abundance levels of native fishes in the potential restoration areas below the four dams to provide a baseline against which to evaluate the success of the restoration strategy. This will require field work. However, it is not necessary that this work proceed immediately (under the project's currently limited funding) and, indeed, is best done when we know with greater precision which of the potential segments will prove most feasible for restoration and their downstream extent. For instance, it is not clear that the San Pedro tributary below Madero dam will prove to be feasible from an engineering standpoint (see work item # 1 above). If and when the field work is needed, again, Dr. Salvador Contreras (**Bioconservación**) will undertake it, using his graduate students from **UANL**.

5. Link Indicators of Hydrologic Integrity and Ecosystem Change

Declines in abundance levels alone will not tell us much about what portions of the natural hydrograph need to be restored to allow these fish to recover. For that, much more detailed study of the critical life stages of particular species, and their water-dependent physical requirements, would be necessary. Thus, we must also look for other indicators that can correlate flow conditions to biological benefits. **NHI** (David Purkey) will investigate which of the 32 IHA indicators can best account for the observed biological changes in the system. **ITESM** (Lozano) will conduct a literature search of reports on bio-sampling in the Rio Conchos basin to see if other species groups besides native fish can be used to define restoration flow targets. Then, **Bioconservacion, Profauna, Pronatura Noreste, and WWF** will conduct the research and analysis required to develop the most salient indicators.

6. Description of Riparian Habitat Benefits

In addition to instream benefits, improved flow conditions can be expected to substantially improve geomorphic processes with resultant improvements in the mix of riparian habitats that existed prior to development. That is not to say that we can hope to re-establish those conditions. But, it may be possible to move a substantial degree in that direction.

These riparian benefits need to be described to give this restoration strategy the credibility and appeal that it deserves. This work will be undertaken by **Profauna.**