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Rio Grande Salinity Management - First Steps Toward Interstate Solutions

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Good afternoon, I am Dale Doremus with the New Mexico Environment Department, Surface Water Quality Bureau. I am part of an interagency group that focuses on Rio Grande salinity issues and includes the Interstate Stream Commission (ISC), Office of the State Engineer (OSE), and the Environment Department. Dr Michelson and I will share this time slot to talk about an interstate salinity management program for the reach of the Rio Grande from San Acacia to Ft Quitman, TX.

Figure 1 shows the area of interest, from San Acacia to Ft Quitman. The study area includes the Rio Grande Project area. Initially we were focused only on the Rio Grande Project area (Elephant Butte to Ft. Quitman) but research from NM Tech and the USGS indicated significant salinity inputs in the San Acacia region, so we expanded the study area to include that reach.

As most of you know, there has been long-term concern and contention over the elevated Rio Grande salinity in the Texas-New Mexico border region. Salinity increases in the reach from Elephant Butte Reservoir to Ft. Quitman, TX have been documented for more than 100 years. Evaluation of historical data shows that Rio Grande salinization predates the construction of the reservoirs, canals, and drains of the federal Rio Grande Project. Recent research by NM Tech, NMSU, SAHRA, (SAHRA is a consortium of universities in Arizona, New Mexico, and California funded by the National Science Foundation) has identified natural upwelling of sedimentary brine and geothermal waters as principal salinity contributors in the region. The research also shows natural salinity inputs appear to be localized at the terminus of sedimentary basins in the region. In addition to these natural sources, anthropogenic sources such as municipal wastewater discharges and agricultural return flows also contribute, but to a lesser degree. Many of you have seen presentations on

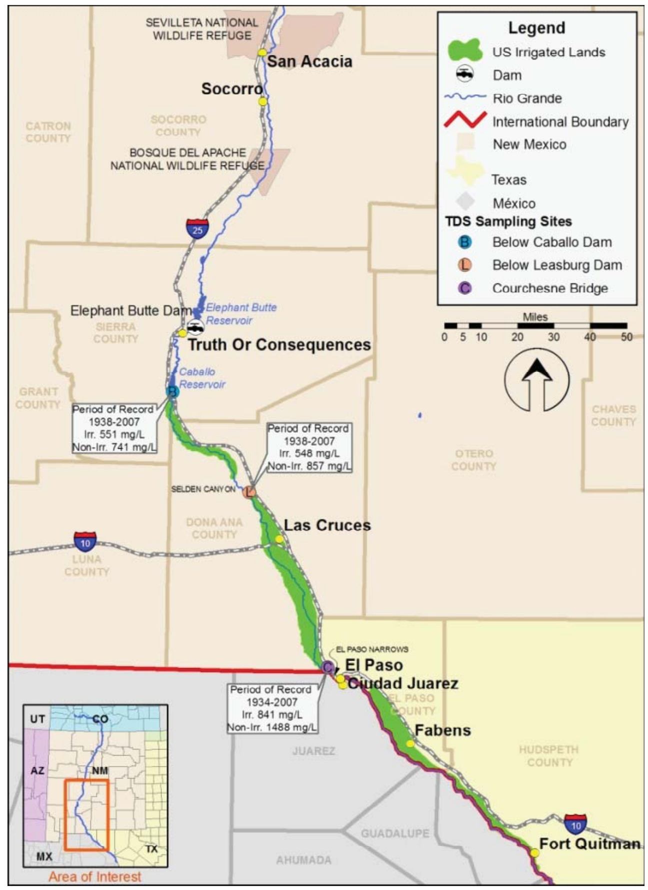

Figure 1. Rio Grande Salinity Management Study Area

this Rio Grande salinity research by Dr. Fred Phillips of NM Tech and others, so I won't get into the technical details, but I will give an example of an area at the southern terminus of the Mesilla Basin where sedimentary brine inputs have affected Rio Grande water quality.

ISC-4 is a well just above El Paso Narrows and the city of El Paso that has been completed at the top of the bedrock. Figure 2 shows a series of deep nested piezometers and shallow wells that span from Anthony to El Paso. The wells were installed by USGS in cooperation with ISC and the Elephant Butte Irrigation District to measure water elevations and water quality. Cross section shows ISC-4 at the southern end of the Mesilla Basin is less than 200 ft deep and is completed at the top of bedrock at the terminus of the basin (Fig. 3). Investigations by the NM Environment Department and the Interstate Stream Commission identified extremely saline groundwater in this area, with concentrations at ISC-4 as high as 31,000 mg/L total dissolved solids and14,000 mg/l of chloride. This investigation points to the possibility of managing salinity inputs to the Rio Grande. Intercepting saline point sources such as that encountered by ISC-4 has potential to result in significant freshening of river water in the winter non-release season.

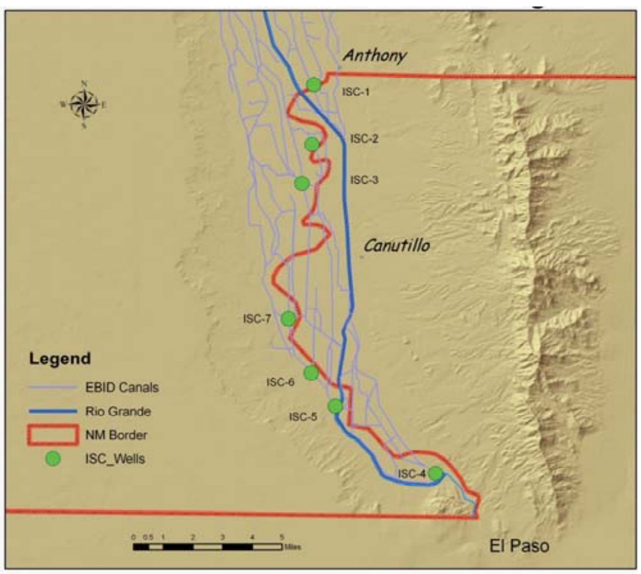

Figure 2. ISC Wells in the NM-TX Border Region

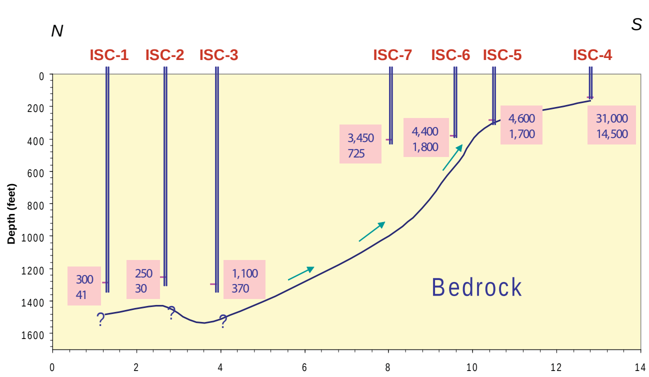

Figure 3. TDS and Cl concentration Cross Section

What steps have been taken toward interstate management of Rio Grande salinity? In 2006-2007 the Rio Grande Compact Commission, in collaboration with local water management entities, initiated a multi-state effort to create a Rio Grande salinity management program. The Commissioners hosted a salinity workshop, held in El Paso in May of 2007 with the goal of identifying ways to improve Rio Grande water quality by reducing salinity in the New Mexico -Texas border region. The participants formed what is now known as Rio Grande Project Salinity Management Coalition. Who are these folks who are so interested in salinity management? In addition to the Rio Grande Compact Commissioners, the group includes state water management agencies from TX, NM, and CO, including the Texas Commission on Environmental Quality, Texas Water Development Board, the Interstate Stream Commission, Office of State Engineer, New Mexico Environment Department as well as the Colorado Division of Water Resources. The local water utilities and irrigation districts are key players including the City of Las Cruces and El Paso Water Utilities, Elephant Butte Irrigation District, El Paso County Water Improvement District #1, and Hudspeth County Conservation and Reclamation District #1). University research organizations in the area that have been involved include NMWRRI, Texas Agri-life Research and Extension Center in El Paso, and UTEP Center for Environmental Resource Management. The Rio Grande Salinity Management Coalition met three times in 2008, and developed objectives and a plan to move forward with a salinity management program for the area from San Acacia, NM to Ft. Quitman, TX. The group's primary goal is to develop a plan to fund and implement target salinity reduction projects that will increase the useable water supplies and improve Rio Grande water quality.

The coalition envisions the plan in four phases. The first phase is the Rio Grande Project Salinity Assessment, which is basically to pull together existing information and establish the current state of knowledge today about this study area. This will be used as a basis for Phase 2, which is to develop salinity management alternatives. Phase 3 will be to implement actual projects on the ground, Pilot-Scale Testing, and Phase 4 will evaluate project effectiveness.

At the first coalition meeting in early 2008, the NM State Engineer and NM ISC offered the Coalition $250,000 for the first phase of salinity management work. This is the non-federal cost share for US Army Corps of Engineers (USACE) WRDA (Water Resources Development Act) §729 project that has 75% federal match, which results in $1M total budget. The

USACE has contracted with researchers from USGS in Albuquerque and Austin offices, Texas Agri-Life Research and Extension Service, NMWRRI, NM Tech and other SAHRA researchers to implement the Phase 1 workplan developed by the Coalition.

The first phase that I mentioned earlier is the Rio Grande Salinity Assessment, which consists of four tasks. The first is to document and integrate salinity data and information. This includes a geospatial salinity database that will be developed by the USGS Water Science Center in Ausitn. The second task is to develop a baseline salinity budget. This is a synthesis of current state of knowledge regarding dissolved solids loads and includes development of a dissolved solids budget for defined reaches along Rio Grande. The third task is a preliminary economic damage analysis for residential, agricultural, municipal and industrial uses which Ari will discuss in more detail. Task 4 will identify critical data gaps based on information from the first three tasks. These are the key issues which will direct future study for the development of salinity management alternatives.

Phase 2 is the development of the actual salinity management alternatives. In this phase of the project we will attempt to fill critical data gaps; conduct an environmental and economic assessment; and, based on stakeholder needs and priorities, identify the most promising locations for salinity control projects, including conducting feasibility and cost analysis for specific projects. The third phase is the design and implementation actual pilot scale testing of salinity control projects. Part of the pilot projects will include quantifing salinity reductions and potential increase to usable water supplies. The fourth and final phase is to evaluate the project effectiveness. Here again we will monitor and document improvements in water quality and quantify associated benefits of reduced salinity.

So with that, I will turn this over to Ari to talk about economic damages and benefits of a salinity management program.

Ari Michelsen

Why do we care about salinity? We go out of our way to put salt on our food, but salinity is an economic burden, there are huge cost increases, reductions in income, and there are other impacts such as environmental impacts.

What do we need to know about salinity? A lot. For a salinity program or even a study, we need to know who is affected, what are the impacts, are the impacts large or small, and how the economic impacts are related to changes in salinity. If we are able to control salinity, and reduce it by 100, 200, 500 parts per million, what are the benefits? How do damages decrease if salinity is reduced? Is investment in salinity control warranted? How much investment is warranted? These are all essential questions. An economic assessment is needed when we begin to talk about any salinity investments.

There are many different types of economic impacts due to water salinity. While I won't go into all of the economic impacts shown on Figure 4, what I am going to do in this presentation is summarize what has been done in other areas. There has been very little work on salinity economic impacts in the Rio Grande Basin with some minor exceptions. We need to look at lessons learned from other areas and also look at the differences in the Rio Grande Basin to set up the framework for salinity assessment here. Examples of economic impacts include increased costs, such as equipment replacement costs, shorter lives, salinity tolerant equipment, added cost of alternative sources such as desalination, and higher water use costs, for example leaching to get salts out of the soil profile so plants and crops can survive. Other impacts are reductions in income from reduced crop yields and less profitable industries – for example, why don't we have microchip manufacturing plants in El Paso? Well salinity is one reason, why did manufacturers move to Albuquerque - because of a good clean water supply. Other types of damages include lower value and less desirable landscapes, damages to the environment, impacts on recreation, and long term non-sustainable productivity in water use. You can't just keep irrigating with elevated salinity in the water.

Increased costs due to higher salinity
Higher equipment replacement costs (shorter life)
Higher cost of salinity tolerant equipment
Added treatment cost/higher alternative source (desalination)
Higher water use/cost to avoid damages (leaching)

Reductions in income and other benefits
Reduced crop yields
Restricted to less profitable industries and crops
Lower value/less desirable landscape/riparian/recreation/environment
Non-sustainable (long term) productivity and water use

Figure 4 Economic Impact Examples

One of the things that is critical for doing any kind of economic impact assessment is knowing the relationship between the levels of salinity and the damages. How do they change as you move from 500 parts per million to 1000 parts per million to 1500 parts per million? In the El Paso area there is shallow groundwater that is 2000, 3000, 5000 parts per million. This was used for agricultural irrigation during drought, but this water quality was having a detrimental impact on crop yields and soils and is not sustainable in the long term.

There have been a few economic studies nationally or internationally on salinity impacts. One of the major studies was conducted in 1988, and results from this study are the basis for almost all the other studies in the U.S. What they did is estimate damage coefficients for different types of water use and salinity levels. What these coefficients basically said is when you have a specified concentration of salinity, you have X amount of damage to equipment, to residential fixtures, to industry, and they went through each of the water use categories shown earlier. That study was the basis for the 1998 study in southern California with the Metropolitan Water District and the US Bureau of Reclamation. They used the same 1988 Milliken-Chapman coefficients, and estimated damages for the Metropolitan Water District. A more recent study in 2003 also used the same damage functions. In this more recent study they tweaked some of these damage functions but didn't make much of a change overall. And we will look at some of the damage estimates from these studies. They are very significant, but vary from location to location, depending on the industries, number of residents, types of appliances, the salinity level, soil conditions and crops. The results are very location specific. Again, all of the above studies used the same damage functions.

Let's briefly look at summary results of a more recent study in the United States, the Central Arizona Salinity Study. In this study, impacts in five categories were considered: residential, commercial, industrial, agriculture, and water utilities. There are other impacts too, for example environmental, but they didn't consider those impacts. Residential damages estimated included reduced life of appliances, and as somebody mentioned earlier, damage to faucet fixtures, and damage avoidance costs such as bottled water or use of softeners. Water usage was categorized as cooling, irrigation, kitchen, laundry, and so on. Impacts to irrigation and residential landscape irrigation were assumed to be zero. We know that is not the case and in El Paso we have evidence that if you don't manage your water correctly, water with elevated salinity will damage your landscape and golf courses and so on. But there are also ways to avoid those damages through management and landscape plant selection. The Central Arizona Salinity Study used local data for population, the number of household appliances, and for water demand. An important point, population growth, is not considered in their damage estimates. If there is population growth, these future damages should be taken into account in making current water quality investment decisions. Under the Central Arizona Salinity Study, base residential water quality for Tucson at that time was 316 mg/L TDS. For comparison, in El Paso typical delivered M&I water has 600 to 700 mg/L TDS, so we are already double the concentration analyzed for the impact damages in Tucson. In Arizona they had a drinking water TDS standard at that time of 500 mg/L. While they are looking at changing that standard, in El Paso the current standard is 1000 mg/L, so you really have to look at all the conditions and differences. In Arizona the agriculture base TDS water quality was 907 mg/L. One of the critical things for irrigation of plants is soil condition, and soil conditions really vary. While farmers are very aware of the importance of soil, urban landscape developers are beginning to use soil maps in terms of irrigation and salinity to look at where we should be placing schools, parks, golf courses, and how you manage your urban landscapes. Figure 5 is an example where there were a lot of problems resulting from poor land use placement on areas that don't leech or drain well. You can see what happens if you do not have good drainage through the soil profile, you see turf damage and bare spots because of higher salinity concentrations where the salts just stay in the soil and accumulate.

Figure 5. Clayey Enntisols and Petro-calcic Aridisols are poor for salt leaching

Industrial and commercial damages: the Central Arizona Project used economic census data (a five- year census) to identify local industries, the categorized uses by process, boiling, cooling, and so on, and used the 1988 damage functions applied by water use category. They didn't make changes to the original coefficients.

For agricultural damages two major areas were considered: reduced yield using University of California Riverside salinity lab equations and estimates, and the added cost of leeching salts. In order to get the salts out, you have to use more water and there is a cost for the additional irrigation needed.

Studies acknowledged that the estimated values were approximate, because different crops have different tolerances for salinity. Well this is good and bad, you can shift crops to a certain degree, but as you shift to more salt-resistant crops, they are usually lower income crops. These impacts, while real, were not included in the damage estimates.

In one of the few studies on salinity damages in the El Paso area, Ejeta, McGuckin and others published in 2004, the authors estimated returns from EBID farmers on the New Mexico portion of the Rio Grande with better water quality averaged $258 per acre and returns to farmers on the Texas side in the El Paso County Water Improvement District were almost $50 less per acre. This was largely attributed to the reduction in water quality (salinity). These are significant impacts. In this case there are about 50,000 acres of irrigated crops impacted, and, this doesn't include the switches already made to salt-resistant, lower income crops.

Figure 6 is just an example, on the left you see pecan leaves from salt impacted soil and water that are much smaller and on the right a typical healthy much larger pecan leaf. The leaves are what produces the quantity, size, and quality of pecans and determines farmer profits.

Figure 6. Pecan leaves impacted by salty soil (Miyamoto)

Figure 7 shows onions, and you can see in this salt affected field in El Paso there is much lower germination, much less viability of plants, and lower yields and growth. You can really see how spotty the onion crop is across the field. These are just examples of the various salinity impacts and how you have to consider local conditions in estimated damages.

Figure 7. Onion field in El Paso affected by salty soil

Figure 8 is a photo of an irrigation head gate. I included this because it gives an indication of salt affects and damage most people wouldn't necessarily notice. This is on the Mexican side. Irrigation district head gates are typically made out of metal. Well why is this one made out of plastic? It is because of the salt corrosion and damage, so they are trying plastic head gates to reduce the damages. But the replacement of damaged head gates and plastic require additional money to be spent – that is economic damages.

Figure 8. Irrigation head gate damage by salt

Water utility costs of salinity vary with location and utility, but there can be shorter equipment life that needs to be considered. In the case of the Central Arizona Study, no costs for utility corrosion were assumed because other studies had indicated that in this system, salinity was not the reason for corrosion, there were other factors. But there are utility and consumer associated costs of salinity such as the need for alternative supplies. For example, if you can't take the water from the river, you need to look for other sources. That may be desalination or it may be importing water.

Figure 9 is an example of a reverse osmosis desalination unit in El Paso installed because of elevated salinity and other reasons (arsenic).

Figure 9. Reverse osmosis desalination unit in El Paso

Figure 10 is an example of a change and impact to environmental conditions - everyone's favorite plant, salt cedar. Salt cedar does well under higher salt concentrations, replaces native vegetation and consumes large quantities of water. There is also a question of whether salt cedar plants contribute salt to the soil surface.

Figure 10. Salt cedar grows well under higher salt concentrations, replacing native vegetation

So what were some of the economic impact results for other areas? The impacts in the Central Arizona Study were estimated to be $30 million per year for each 100 mg/L change in salinity. These values are in year 2000 dollars, and when adjusted for inflation over the last eight years, the damage estimates would be higher, even without considering increases in population.Who is suffering these damages? In the Arizona area, the burden on residents, that is individual homeowners, was estimated to be 45 percent of the total damages.

The Metropolitan Water District study of 1998 estimated annual urban damage costs (not agricultural) of $.50 per acre-foot of water for each 1 mg/L change over a threshold of 100mg/L. In El Paso, the typical urban water supply, the salinity concentration is 600 to 700 mg/L, which is substantially above the California damage threshold of 100 mg/L.

Water from the Colorado River was separately estimated to result in damages of $.68 per acre ft per 1 mg/L change. This emphasizes the importance of considering local sources and conditions.

As Dale Doremus described in the first part of this presentation, the Rio Grande Salinity Management Coalition has developed a multi-phase work plan and acquired initial funding for a first phase of hydrologic studies and preliminary economic impact assessment. The preliminary economic assessment will use existing data and adjust it to the extent possible within the study's resources and time frame. In this first phase, the objective will be to develop first-cut estimates of the types and magnitudes of impacts, who is getting impacted and the approximate value of impacts. This will help determine the worth of investing funds for further study and measures to control salinity. The plan is to provide a good big picture image of the conditions and impacts by building on work from previous studies.

As noted earlier, local conditions vary such as concentrations, chemical composition, types of use and residential appliances and industrial equipment, and are important in developing accurate damage estimates. Other factors that should be addressed in subsequent studies include area specific damage functions and population growth. These population projections for the El Paso/Juarez area illustrate why population growth is an important factor in estimating damages (Fig. 11). The top growth projection line is not cumulative, this is for just the city of Juarez, and you have to add all these up for the total growth and population. In considering salinity impacts, you can't just say, here we are in 2008 and these are the damages. You need to look ahead and consider, with elevated salinity, how much should we be investing to reduce the salt concentrations with the impacts of increasing population?

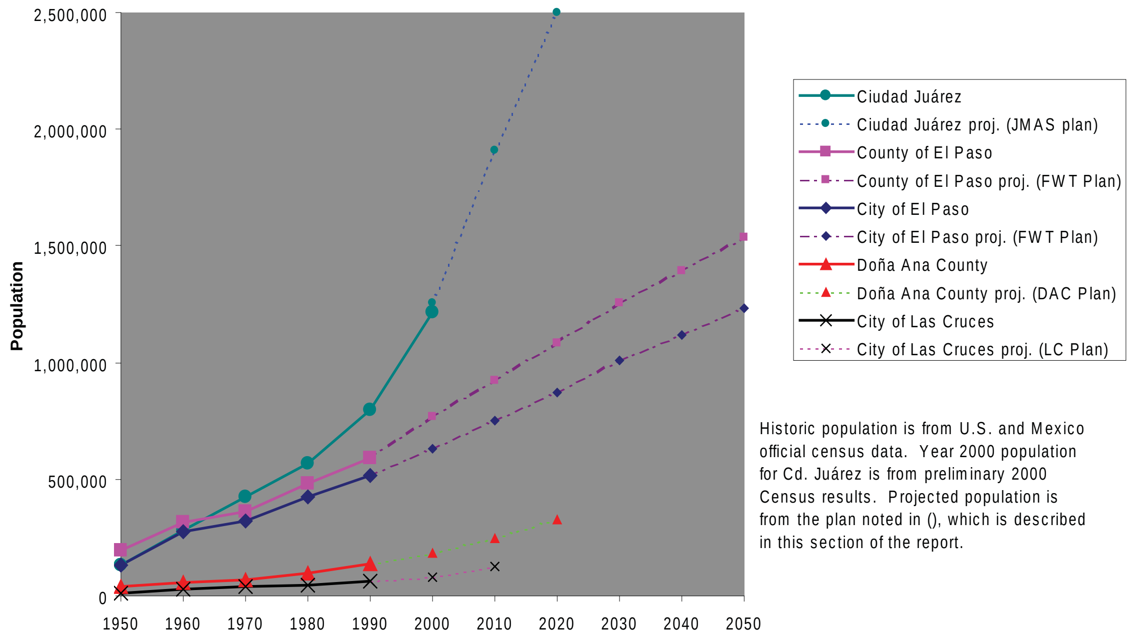

Figure 11. Historic and Projected Population in the Paso del Norte 1950-2050

This is the framework for the assessment that we will be conducting. Thank you and if you have any questions I would be glad to answer them.