BENEFITS OF THE SALINITY CONTROL PROGRAM IN THE UPPER COLORADO RIVER BASIN

Photo Credit: Brent Draper, NRCS, Duchesne County, Utah

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SUMMARY OF BENEFITS IN THE UPPER COLORADO RIVER BASIN FROM THE COLORADO RIVER BASIN SALINITY CONTROL PROGRAM

Overview

This report, prepared for the Colorado River Basin Salinity Control Forum (Forum) by the Forum's Work Group, identifies benefits that have occurred in the Upper Colorado River Basin (Upper Basin) since the inception of the Colorado River Basin Salinity Control Program (Program) in 1974. The Basin States and agencies of the federal government recognized decades ago that the salinity of the Colorado River adversely affected the quality of the water in the Lower Colorado River Basin (which includes the states of Arizona, California and Nevada). It was also recognized that as the Upper Basin States (Colorado, New Mexico, Utah and Wyoming) developed their Colorado River Compact apportioned water, the salinity of the River would increase. Figure 1 is a map of the Colorado River Basin and of areas where Colorado River water is used, as well as the boundary between the Upper and Lower Colorado River Basins. In 1974 the state-supported Colorado River Basin Salinity Control Act was passed by Congress. The Act provided a path forward for the salinity of the river to be reduced while not impacting the rights of the Upper Basin States outlined in the Upper Colorado River Basin Compact of 1948.

With the Department of Interior's Bureau of Reclamation (Reclamation) in the lead, it was soon determined that the potential impacts of future increased salinity would be in the Lower Basin and that salinity increases, for the most part, would originate in the Upper Basin. Impacts to water users in the Lower Colorado River Basin as a result of using water from the River with elevated salinity levels were termed "economic damages." Reclamation conducted studies that quantified these economic damages, and a model was developed which estimates future damages for increased salinity levels.

The Program seeks to reduce salinity in the water delivered to users in the United States and Mexico while helping to increase the efficiency of water use in the Upper Basin. Because most salinity sources are of Upper Basin origin, this area of the Program has been the most instrumental. Most of the salinity control measures involve either improving irrigation water delivery systems (i.e., lining canals) or improving on-farm irrigation (i.e., reducing deep percolation). These measures result in less water seeping into the ground and into salt rich shale; therefore, less salt is leached into the river system.

Figure 1. The Colorado River Basin supports 35 to 40 million people in the seven Basin States. Although most salinity impacts are exhibited in the Lower Basin, most salinity control efforts are focused in the Upper Basin where the primary salt sources are located. (2012 Colorado River Basin Water Supply and Demand Study)

The states and communities forming the Upper Basin have benefited directly and indirectly from the Program in many forms. With the original intent to enable Upper Basin states to develop their Compact-apportioned waters while minimizing salinity impacts associated with higher water use, the Program allowed more efficient use of water supplies. This had the effect of protecting riparian and other vital habitat, improving water quality and reducing sediment transport. Streams are protected through the construction of projects designed to reduce groundwater and surface water coming into contact with geologic formations rich in salt. These programs also reduce selenium contributions which are known to have adverse effects on wildlife.

Farmers receive technical and financial assistance to improve their farming operations, allowing an extended, more profitable farming season across the Upper Basin. In addition to on-farm improvements, water conveyance facilities have been improved to prevent seepage and water loss. These projects help farmers conserve water, allowing storage for future on-farm use or conserved water which may remain in the stream for wildlife or other beneficial uses.

With increases in crop yield come economic multipliers in the form of new farm equipment, increased transportation of products, conversion to higher value crops, new storage facilities, packing houses, better housing, and support to other industries that are related to agriculture and these communities. Positive economic effects also occur in the form of employment from construction contracts and the business local companies receive to support the construction.

All these economic inputs manifest in a social value in the Upper Basin. One can notice that communities in these agricultural areas receiving benefits from the Program have well-kept homes, new schools, green fields and a healthy industry.

In over four decades of the Program, no attempt has been made to describe or even identify these benefits. The Forum requested the Work Group to prepare a report describing in general terms the benefits of the Program to the Upper Basin communities. This is the Work Group's report to the Forum.

The Work Group is very appreciative of the assistance it has received from its partners in the Program as this report was prepared. Those partners include the following federal agencies: the Bureau of Reclamation (Reclamation), Natural Resources Conservation Service (NRCS), Bureau of Land Management (BLM), U.S. Geological Survey (USGS), Fish and Wildlife Service (FWS) and Environmental Protection Agency (EPA). The Work Group was also assisted by state and local agencies in the Upper Basin. Local participants, such as irrigation and canal companies and irrigators, were also of assistance. However, the Work Group is solely responsible for this report. For purposes of discussion, the Work Group has classified the identified benefits into hydrologic, environmental and socio-economic categories, as detailed in the following sections.

Introduction

The Clean Water Act (Public Law 92-500) was enacted in 1972 and required development of water quality standards for salinity in the Colorado River Basin (Basin). The Basin States formed the Colorado River Basin Salinity Control Forum (Forum) in 1973 to develop these standards, including numeric salinity standards and a plan of implementation for salinity control that were subsequently approved by the EPA. The Forum is composed of representatives from each of the seven Basin States appointed by the governors of the respective states. The Salinity Control Program (Program) in its infancy was discussed and advocated by the seven states which share the water resources of the Colorado River. The United States Congress passed the legislation that created the Program, and now affected federal agencies are implementing the Program. The Program reduces salinity in the Colorado River by preventing salts from dissolving and mixing with the River's flow. Irrigation improvements and landscape management reduce water available to transport salts vertically, laterally and on the soil surface. Point sources, such as saline springs, are also controlled. Implementation of the Program occurs principally through off-farm irrigation water delivery improvements implemented through Reclamation's Basinwide Program or through on-farm irrigation improvement practices implemented through NRCS's Environmental Quality Incentives Program (EQIP). A long term, interstate and interagency public/private partnership effort is being carried out to reduce the amount of salts in the River and its associated impacts in the Basin.

In 1973, representatives of the International Boundary and Water Commission, the United States and Mexico signed Minute 242, which addressed issues with the salinity in Colorado River water delivered to Mexico. Minute 242 requires that water deliveries to Mexico at the Northerly International Boundary, pursuant to the Mexico Water Treaty of 1944, have a salinity concentration of no more than 115 ± 30 mg/l greater than the average annual salinity of Colorado River water arriving at Imperial Dam. However, the United States could not honor the commitments made in Minute 242 without an act of Congress and congressional appropriation. In 1974 Congress enacted the Colorado River Basin Salinity Control Act (Act) to address these salinity issues and ensure the United States could meet its obligation to Mexico, and it authorized the construction, operation and maintenance of salinity control works in the Colorado River Basin.

Title I of the Act addressed the United States' obligation to Mexico by authorizing the Yuma Desalting Plant, the Wellton-Mohawk Irrigation drainage reduction program, concrete lining of the Coachella Canal in California (allowing the United States to use the conserved water to replace drainage water bypassed to Mexico), and a well field in Arizona known as the Protective and Regulatory Pumping Unit (Minute 242 wells).

Title II of the Act created the Colorado River Basin Salinity Control Program and directed the U.S. Department of the Interior (DOI), the U.S. Department of Agriculture (USDA) and the Environmental Protection Agency "to cooperate and coordinate their activities effectively to carry out the objective of this title", i.e. "to control the salinity of water delivered to users in the United States and Mexico." Title II authorized the Secretary of the Interior to construct several salinity control projects, most of which are located in Colorado, Utah and Wyoming.

Figure 2. Salinity damages to municipal water pipe

In the 1974 Salinity Control Act, Congress authorized Reclamation, as the acting agency of the DOI, to construct salinity control features in a few areas where studies had already been initiated. Examples of this are the Grand Valley canal work and the Paradox salt disposal effort. Congress also authorized Reclamation to study other areas. Once a study reached a point where a feasible Reclamation project had been identified, Congress could act to authorize a new project.

The 1974 Act also recognized the Federal responsibility for the Colorado River as an interstate stream, its obligation to Mexico, and the Federal ownership of much of the land that contributes dissolved salts to the River. Therefore, the majority of the costs for these projects would be the responsibility of the Federal government. However, the states and water users receive a benefit of these programs, and part of the funding was reimbursed to the Federal government through a Basin States' cost-share program. The majority of these costs are covered by the Lower Basin States since they experience the majority of the reduction in economic damages due to the reduced salinity in the River.

Since 1974 there have been several congressional actions that have modified the 1974 Act. To understand the Program's authority today and to understand how salinity project areas came to be identified, one needs to review the legislative history. The following paragraphs are a summary of this history, and the history is depicted in Figure 3, "Colorado River Basin Salinity Control Program Legislative History."

The 1974 Act did not authorize any specific salinity control work to be done by the Department of Agriculture. With time it was recognized that much valuable cost-effective salinity control work could be accomplished by improving on-farm irrigation projects. In 1984 Congress amended the Act to authorize the USDA to conduct on-farm salinity control efforts. These were efforts in which producers could volunteer to participate by contributing to the cost of the project. This salinity control work was to be done only in areas approved by Congress. This approval was to be accomplished by USDA submitting a required report to a committee of Congress. In this way, six USDA salinity control areas were established.

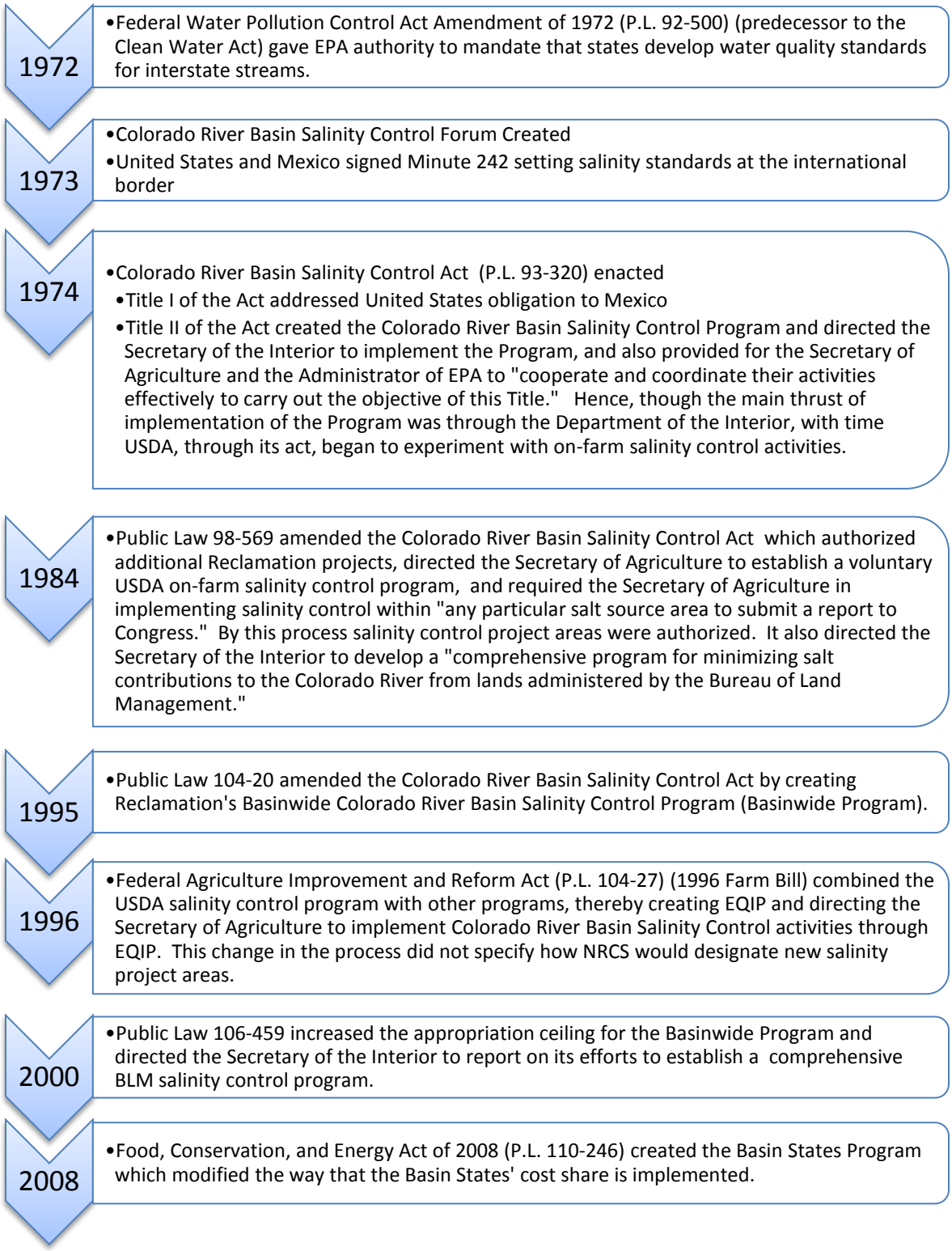

Figure 3. Colorado River Basin Salinity Control Program Legislative History

Amendments to the Act in 1984 also authorized additional projects for Reclamation and instructed BLM to study salinity control opportunities on lands it manages and to identify and implement a salinity control program.

Title II of the Act was amended in 1995 to direct Reclamation to conduct a basin-wide salinity control program. The Basinwide Program uses a competitive process that has greatly increased the federal cost effectiveness of salinity control. Reclamation may implement a variety of effective salinity control measures, but most projects concentrate on improving the efficiency of off-farm irrigation delivery systems. The agency solicits applications through a Funding Opportunity Announcement (FOA) for projects that will reduce the salinity of the Colorado River. Project proposals may come from any location in the Colorado River Basin. Reclamation evaluates and ranks each application and awards funding grants to the highest ranking applications. Cost effectiveness is the prime criterion in the evaluation. The timing of the FOA is based on the need and the amount of federal appropriations received to implement its portion of the Program. The Basinwide Program has demonstrated significantly improved cost-effectiveness, as computed on a dollar per ton of salt basis, as compared to earlier Reclamation-funded projects.

Figure 4. Salinity damages to crop land in the Upper Colorado River Basin

Further congressional action changed how additional salinity areas were identified. In 1996, the Federal Agriculture Improvement and Reform Act (1996 Farm Bill) created the EQIP Program for USDA, to be implemented nationwide by the NRCS, providing the authority for future Colorado River salinity control work to be accomplished. No longer were reports back to Congress required for work to begin in new areas. However, state NRCS leadership thought it appropriate to conduct studies consistent with National Environmental Policy Act (NEPA) policy when contemplating salinity control efforts in select areas. Once those studies were completed and public input considered, the State Conservationist could designate a new salinity control area. Since 1996, six additional project areas in three states have been adopted by NRCS.

The Forum has concurred in the addition of these six areas. The twelve current project areas are identified in Figure 5. The NRCS EQIP generally concentrates on improving on-farm water

delivery systems, and NRCS salinity activities fall mainly under the authorities of EQIP. NRCS solicits EQIP applications from producers and evaluates, ranks and selects those applications that best meet the goals of EQIP and the Salinity Control Program in the defined salinity control areas. Based on successful applications, NRCS provides technical and financial assistance to agricultural producers. The 1996 Farm Bill also authorized the Basin States to cost share with NRCS on salinity control activities in lieu of repayment. Now both the NRCS and Reclamation programs require a 30 percent up-front cost sharing from the Basin States Funds. This means that each dollar appropriated by Congress is matched by $0.43 in cost sharing by the Basin States.

P.L. 106-459 (2000) increased the appropriation ceiling for Reclamation's Basinwide Program, allowing Reclamation to continue to request additional proposals under the Basinwide Program. The Farm Security and Rural Investment Act (2002) continued the authorization of EQIP. The Food, Conservation, and Energy Act of 2008 (2008 Farm Bill) created the Basin States Program (BSP), which modified the way that the Basin States' cost sharing was implemented.

The twelve NRCS-designated and Forum-approved salinity control areas, which are located and named on the map included as Figure 5, vary greatly as to size and maturity, some quite large and well-seasoned and others small and more recent. It is true that some USDA and Reclamation Basinwide salinity control efforts now take place outside of these designated areas. However, the great preponderance of salinity control effectuated by USDA, Reclamation and the Basin States Program is accomplished in these designated areas. Considerable funds have been spent on the Program and approximately 1 million tons of salt have been controlled. Appendix A reports the current total of expenditures by these partners and the tons of salt controlled by area.

By all measures, the four-decade-old Program has been very successful in accomplishing its primary objective. The NRCS and Reclamation have formed a federal partnership in this salinity control effort. Water users in the Lower Basin States of Arizona, California and Nevada are using water lower in salt concentration than they would have been using today if it were not for the Program. Also, waters delivered to Mexico by the United States are of better quality than they would have been were it not for the Program. While these are laudable facts, this paper addresses the benefits that have accrued to water users and the associated communities in the Upper Basin States of Colorado, New Mexico, Utah and Wyoming. For a short write-up of what has been accomplished in some of these areas, see Appendix B. These write-ups are included in this report as samples of the work accomplished.

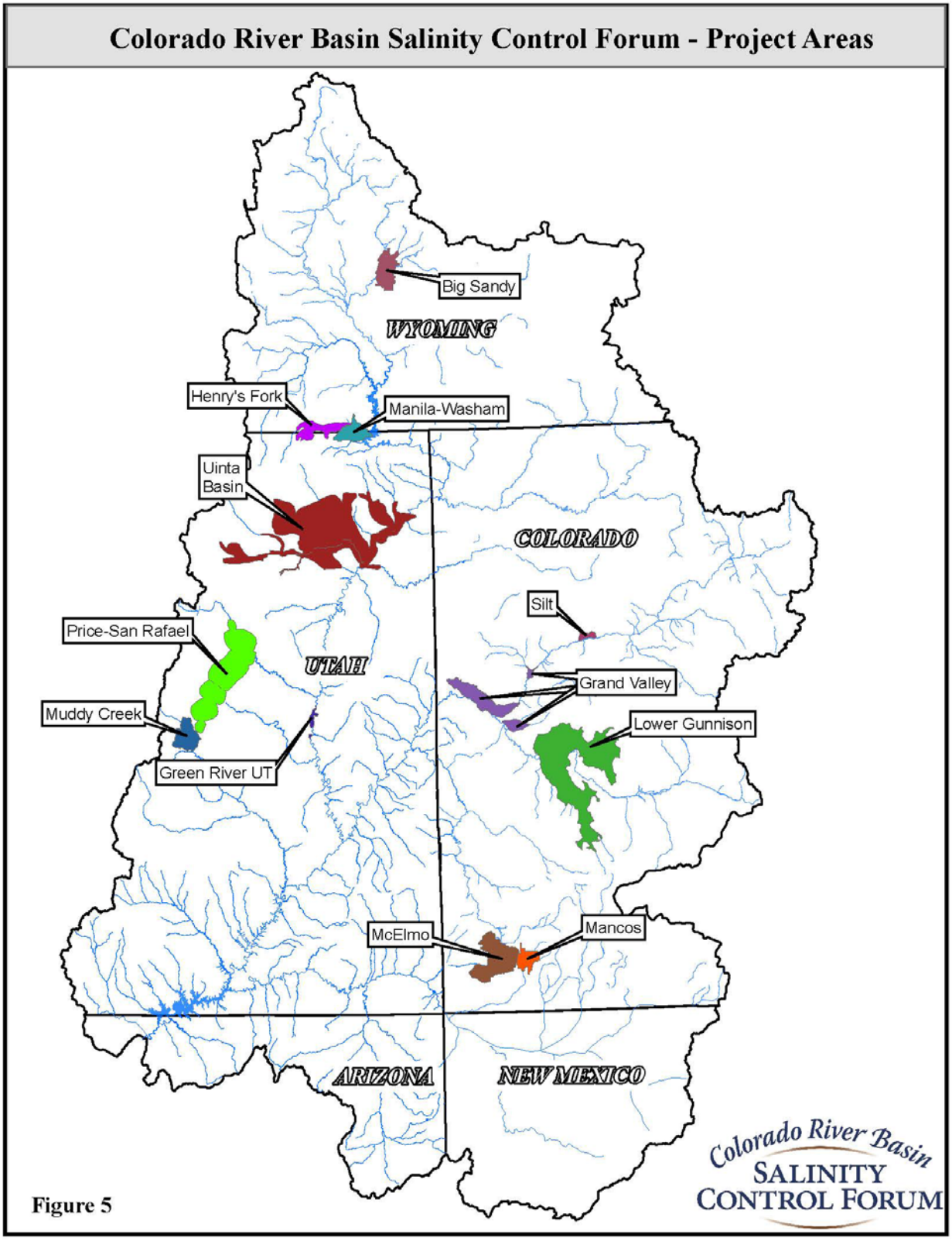

Figure 5. Salinity control project areas in the Upper Colorado River Basin (Colorado, Utah, Wyoming and New Mexico)

Hydrologic Benefits

The Program over the last few decades has reduced the salinity of the water diverted from the River by U.S. users as the use of water has increased in the Upper Basin. This has also resulted in better quality of water being delivered to Mexico. The Program is able to conserve water resources while reducing salt loads through funding and incentivizing the application of more efficient irrigation, water application and water conveyance systems.

Though a substantial portion of the Upper Basin is irrigated (Reclamation estimates 1.8million acres in 2011)[1], many of the irrigated areas in the Upper Basin are subject to water shortages. This results in insufficient water to meet the crop water demands or the irrigation water requirement. By reducing water loss through conveyance or application, water resources can be conserved, stored in upstream reservoirs for future use, used for other projects/functions or remain in the stream for in-stream values or downstream uses.

The water efficiency elements of the Basinwide Program, EQIP and the BSP have particularly been helpful to Upper Basin producers during the recurring short water supply and extreme drought years. Salinity reduction practices that increase water use efficiency and reduce losses, such as from deep percolation, allow limited water supplies to be stretched further. In water-short years water supplies can go farther, potentially increasing crop yields, and may also allow irrigation of acres which have been historically under-served.

Examples of water conservation include lining or enclosing earthen canals (e.g., installing membrane lining, piping, concrete lining and/or application of low permeable materials) and converting to highly efficient irrigation practices (e.g., installing center pivots in previously flood irrigated fields). For example, the Uncompahgre River Valley (approximately 70,000 irrigated acres) and the Grand Valley (approximately 60,000 irrigated acres) in Western Colorado are salt-rich areas that have historically relied upon extensive network of earthen canals to distribute large volumes of water over long distances. With federal, state and local financial assistance, these irrigation systems have begun to modernize. Piping of irrigation laterals is considered to be approximately 90-100 percent effective in reducing water loss to deep percolation from the conveyance systems.

As demonstrated by several studies, reduction of deep percolation results in reduction of salt loading to the river systems. A project in the Uncompahgre River Basin near Montrose, Colorado, was conducted in 1998–2000 to determine the effects on salt loads in a small drainage basin by replacing 8.5 miles of open-ditch irrigation laterals with 7.5 miles of pipe. Due to deep percolation at the outflow site, the salt load was approximately 1,980 tons per year (~11 percent reduction). When surface water impacts are considered, the salt load reduction was estimated to be 2,900 tons per year (~16 percent reduction)[2].

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[1] Quality of Water, Colorado River Basin, Progress Report No. 23, (2011) Bureau of Reclamation, Department of the Interior, accessed at http://www.usbr.gov/uc/progact/salinity/pdfs/PR23final.pdf, p. 16.

[2] Kanzer and Merritt, 2008, "The salinity control story of the Upper Colorado River Basin illustrated by case studies" 2nd International Salinity Forum, citing Butler, D.L., 2001, Effects of piping irrigation laterals on selenium and salt loads, Montrose Arroyo Basin, western Colorado: U.S. Geological Water-Resources Investigation Report 01–4204.

Additional consumptive use of the waters of the Colorado River is projected to increase the salinity of the River through concentrating effects. The Program offsets those impacts by investing in water use efficiency projects. Recent examples of such water development projects that could impact salinity consumptive concentration are the Central Utah Project, the Animas-LaPlata project in Colorado and the Navajo-Gallup project currently being constructed in New Mexico.

Environmental Benefits

Water Quality

The primary constituents of total dissolved solids (TDS, i.e. salinity) include positively charged ions (cations) of calcium, magnesium, sodium, potassium and, to a lesser extent, boron, iron, manganese and trace metals like selenium. TDS also includes negatively charged ions (anions) of carbonate, bicarbonate, chloride, sulfate and rarely nitrate and fluoride anions. Inefficient water use practices have enabled different combinations of these cations and anions to enter the water and form salt. At high concentrations these salts can produce detrimental effects to beneficial uses of the water in agriculture such as irrigation, stock watering and other agricultural uses, as well as wildlife impacts and municipal and industrial impacts.

Headwater streams and reservoirs of the Upper Basin are generally of very good quality with low concentrations of salinity. As water travels through the Basin, it picks up naturally occurring salts, mostly found in salt bearing formations (e.g., marine shales). In the irrigated valleys, return flows can be moderately high in salts. As water reaches the main stem of the Green, San Juan and Colorado Rivers, it may carry millions of tons of accumulated salt. Since salt moves and accumulates downstream, high salinity concentrations are typically not a significant problem for water users in the Upper Basin.

In some areas of the Upper Basin, ground and surface water comes into contact with salt rich formations that can increase salinity enough to impact the use of the stream for irrigation and stock watering. In these stream reaches, salinity control efforts by the Program have improved water quality. A good example is the Program's efforts in the Ashley Valley drainage of Vernal, Utah. Ashley Creek was listed as impaired in 2002, due to the high concentrations of salts and selenium being leached from wastewater treatment. The Program cost shared the replacement of the lagoons with a mechanical sewage treatment facility. The water quality data record shows that concentrations of salinity and selenium in Ashley Creek have been reduced (see Figure 6).

In several areas of the Upper Basin, selenium exceeds water quality standards that are protective of aquatic life. Specifically, selenium enters the food web via benthic organisms and eventually bioaccumulates in higher trophic levels (e.g., birds and fish). Toxicological effects of selenium include embryo mortality and offspring deformity. The Lower Gunnison and Colorado River Basins in western Colorado are the most notable examples of locations where high concentrations of selenium are being addressed by the Program. The effect of the Salinity Control Program is to not only reduce salinity, but also to control selenium.

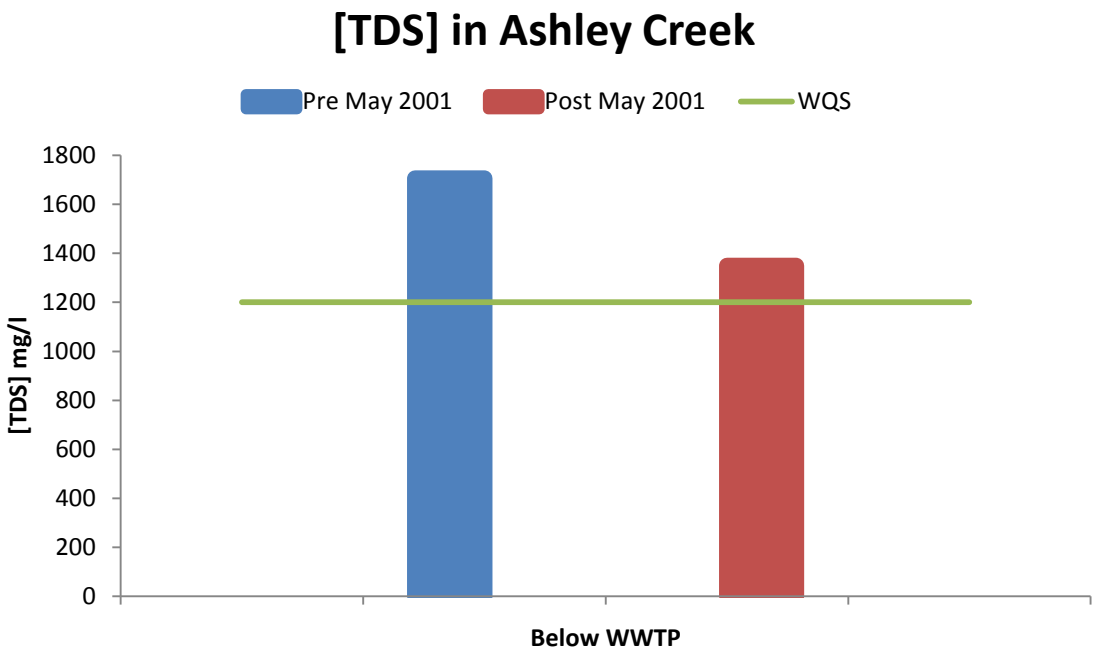

Figure 6. New waste water treatment plant (WWTP) was completed in May 2001. Data shows a decrease in TDS below the WWTP after construction was completed.

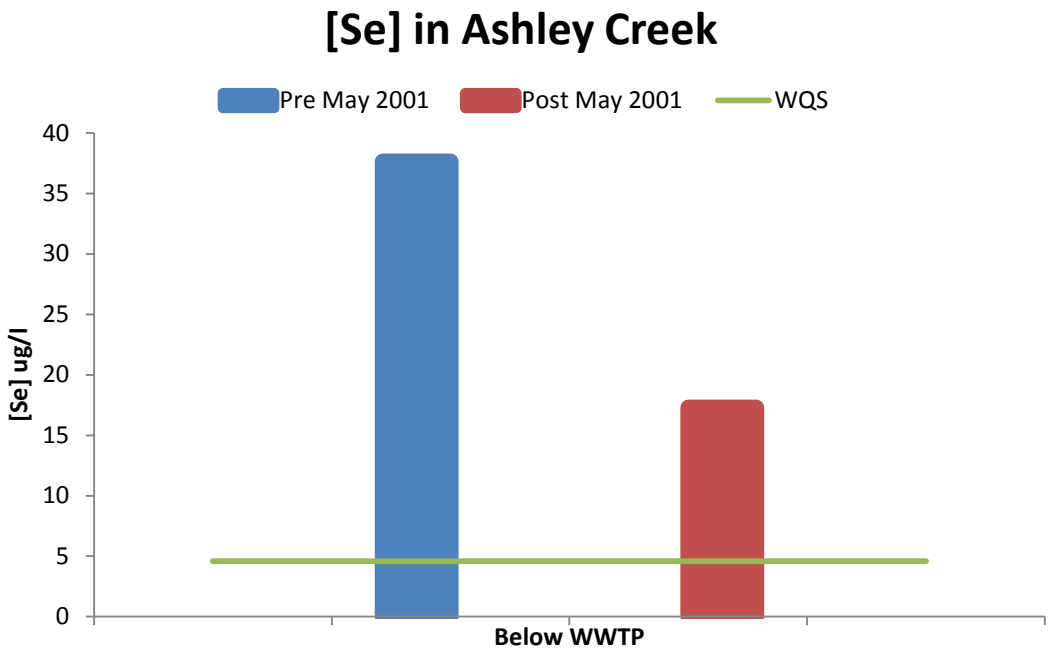

Figure 7. New WWTP was completed in May 2001. Data shows a decrease in [Se] below the WWTP after construction was completed

Projects endorsed and co-sponsored by the Program have been effective in reducing not only the TDS concentrations, but have also been effective in reducing selenium in the area. USGS reported that "the annual selenium load for the Gunnison River site was estimated to be 23,196 pounds for water year 1986 and 16,560 pounds for water year 2008, a 28.6 percent decrease."[3] In the previous Ashley Creek example, replacing old, leaky sewage lagoons with a new sewage treatment facility reduced selenium loads as well as salinity in the creek (see Figure 7).

Sediment Loading

Sediment loading and transport can be reduced by improved delivery and irrigation systems. Sediments can transport salts; therefore, the reduction of the mobility of soils has a direct salinity control benefit. Lining of canals, improved water control systems and sprinkler systems that replace flood irrigation significantly reduce the mobilization of sediments.

In 2012, the Monitoring and Evaluation Progress Update Report from the USDA for the Big Sandy Unit in Wyoming provided evidence of salinity mitigation as a result of sediment reduction. The report states in part:

"Although the gauging stations that were once in place have now been removed or are no longer functioning, one interesting aspect is the decrease in sediment load from the Big Sandy to the Green River. According to the people working at the water treatment plant in the City of Green River, Wyoming, there have been substantial decreases in the amount of sediments being removed by the water treatment plant. Although in the original EIS this concern was not addressed, it is interesting to see it as a positive effect from going from flood to sprinkler systems. One can speculate from the decrease in sediment that there is also a decrease in salt, which was the intent of the project[4]."

Although these types of Program benefits are difficult to quantify, indirect and direct benefits from such enhanced environments have been observed by landowners, land management agencies and the public alike.

Habitat Replacement

Over many decades, irrigation and the subsequent saturating of soils has resulted in widespread habitat alteration and the introduction of invasive species across the landscape. As part of the Program, fish and wildlife values that are lost due to implementation of the Program are compensated via federal appropriations (e.g., the Reclamation Basinwide Program) and financial assistance (e.g., EQIP under NRCS) for replacement of fish and wildlife values forgone. The Basin States Program provides cost-share funding for both of these efforts. Examples of "wildlife only" projects include constructed and managed wetlands and/or permanent wildlife areas along stream corridors.

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[3]Mayo, J.W., and Leib, K.J., 2012, Flow-adjusted trends in dissolved selenium load and concentration in the Gunnison and Colorado Rivers near Grand Junction, Colorado, water years 1986-2008: U.S. Geological Survey Scientific Investigations Report 2012-5088, pg 33. Accessed at: http://pubs.usgs.gov/sir/2012/5088/SIR12-5088.pdf

[4]*2012 M & E Progress Update Report*, Big Sandy Unit, USDA Colorado River Salinity Control Program, 2012 accessed at: http://www.usbr.gov/uc/progact/salinity/pdfs/MonEval/2011/BigSandy2011.pdf, pp. 7-8.

Replacing poor quality, irrigation-created habitats with planned wildlife enhancement projects is preferred and can result in better quality managed wildlife resources. The unintended habitats created by leakage and seepage are often haphazard and poorly support wildlife. Invasive exotic plants such as Salt Cedar (tamarisk) or Russian Olive can dominate these wetland areas. These wetted, unmanaged areas can be long strings of vegetation on saline soils with an elevated level of contaminates from local leaching. Planned habitat replacement projects often result in better quality forage and water for fish, wildlife and livestock. An added benefit is better management and oversight of the habitats by FWS and/or state and local management agencies.

In all of the Program's salinity control areas, Reclamation wildlife habitat replacement projects follow current and implemented salinity control measures. Most of the voluntary replacement projects have occurred concurrently with NRCS projects by landowners/producers; however, some wildlife replacement projects remain to be implemented.

Socio-Economic Benefits

Where there is water, there is the potential for life and, in an anthropogenic context, social and economic value. Accordingly, water shortages and/or inadequate water delivery systems have a direct impact on socio-economic benefits. For example, some of the irrigation systems can be more than a century old with earthen delivery systems that may lose 40 to 60 percent of the deliverable water. Preventing the loss of available water could improve the harvest yields by 30 to 50 percent, increasing financial returns.

As an example, the planning report for the Price-San Rafael River Project in Utah anticipated that total dollar benefits from project implementation would generate between $9.3 million and $10.3 million per year[5]. Increased income will help stimulate labor demand and local economies, as seen in Carbon and Emery Counties of Utah (Table 1).

[5] Huntington-Cleveland Program Chronicle Socioeconomics. (2008, October 2). Retrieved October 6, 2015 (http://www.usbr.gov/uc/progact/salinity/hc/aboutHC/se.html.

Table 1. Employment multiplier for every dollar created by federal cost-share spending in Carbon and Emery Counties of Utah[6]

Categories and Industry Sectors	Multipliers
Output	
Agriculture and Forestry Support Activities	NA
Manufacturing and Industrial Buildings	1.59
Other New Construction	1.68
Water, Sewer, and Pipeline Construction	1.6
Total Value Added	
Agriculture and Forestry Support Activities	NA
Manufacturing and Industrial Buildings	1.84
Other New Construction	1.76
Water, Sewer, and Pipeline Construction	2.09
Average (Mean) Output Multiplier	1.76
Employment	
Agriculture and Forestry Support Activities	NA
Manufacturing and Industrial Buildings	1.66
Other New Construction	1.65
Water, Sewer, and Pipeline Construction	1.89
Average (Mean) Employment Multiplier	1.73

Coordination of Reclamation's Basinwide Program with NRCS's EQIP has significant economic advantages: salt can be controlled at a lower cost per ton, energy costs can be reduced or eliminated, crop production can be increased and water management can be improved. The improved water efficiency of irrigation projects on saline soils is the single most effective salinity control measure found in the past 30 years of investigations. Where topography permits, pressure from piped delivery systems may be used to operate irrigation systems at efficiency rates far better than those normally obtained by flood systems. In addition, this Program provides Reclamation with much greater flexibility (in both timing and funding) to work with NRCS to develop such successful projects.

[6] Huntington-Cleveland Program Chronicle Socioeconomics. (2008, October 2). Retrieved October 6, 2015 (http://www.usbr.gov/uc/progact/salinity/hc/aboutHC/se.html).

An excellent example of an integrated irrigation approach is the Ferron area within the Price-San Rafael project located in the San Rafael River drainage of Utah. The small community of Ferron relies almost completely on irrigated agriculture. However, the upstream reservoir typically cannot meet demand in the latter portion of the growing season. In an attempt to preclude the effects of water shortages, spring stream flows were flooded over farm fields in order to saturate the soils before the dry season. This type of over-irrigation, combined with seepage water from the earthen canals, would percolate into the ground, dissolve and transport salts from the underlying Mancos Shale and discharge at lower elevations in stream channels. Lower fields would "salt up" because of induced high water tables, rendering them useless, and contribute heavy salt loads to the natural stream channels.

Figure 8. Aerial view of Ferron, Utah, after much of the salinity control work was completed

The community of Ferron came together to consider the potential opportunity to participate in the Program. In order to participate, a canal company contracted by Reclamation would have to guarantee successful completion of piping canals and provide a pressurized hookup to every farm field. Under contracts with NRCS, individual irrigators (i.e., consumers) would then volunteer to improve on-farm irrigation systems. However, in order for the project to operate successfully, a minimum number of volunteers would be required (~70% participation) and volunteers would be expected to share costs incurred by the pressurized turnout.

When the work was successfully completed it provided new insights on efficient irrigation practices. For example, if fertilizer was applied effectively, more water would be available in the reservoir later in the growing season. Further, if water was uniformly distributed, there would be less "salting up" and reduced impacts to the water table. Finally, less labor was required to produce a greater crop yield. Though crop mix in the area is very limited, alfalfa and hay production saw an increase in tonnage and therefore monetary gain (as much as a $300 per acre increase). Considering the total acreage within the project area of Ferron, estimated gains are as high as $4.5 million. Using a conservative estimate of increased crop production ($50 per acre)

and the total acreage enhanced by the Program (about 370,000 acres), the projected total benefits of irrigated areas in the Upper Basin would be upwards of $18.5 million a year.

The potential increased annual economic value of irrigated agriculture to the Upper Basin is significant. Visible and anecdotal indicators of increased agricultural profitability can be observed in the agricultural communities in the Upper Basin. Trucks are busy transporting hay locally and regionally. Acreage of higher value crops such as potatoes, onions, orchards and vineyards seem to be expanding and new on-farm facilities such as grain storage or packaging houses are being constructed. It certainly looks like a multiplier effect is occurring in the local communities.

Another example of community-wide beneficial impacts is in the Huntington-Cleveland Project in Emery County Utah. The small rural community of Huntington is at the center of a large, recently constructed and almost completed salinity project funded by Reclamation, NRCS and the Basin States Program. Over the last five years, the Huntington-Cleveland Irrigation Company (HCIC), with a local contractor and on-farm work being done by local farmers, assisted by the EQIP program, has constructed hundreds of miles of pipe, thousands of sprinklers, yards of concrete, etc. using a local labor force. All told, an estimated expenditure of ~$100 million had a favorable impact on the local community.

An additional economic benefit is that the various salinity control programs, collectively, have helped prevent productive agricultural acreage from being forced out of production due to excessive accumulations of salts in the soil and irrigation waters. Also once "salted-up fields" are being reclaimed.

When the Colorado River Compact was agreed to in 1922, a framework was set up to enable orderly water development and which provides the basis for what we now commonly refer to as the "Law of the River," a compendium of agreements that control how, where and what volumes of water may be utilized and consumed. Those who negotiated the Compact and subsequent agreements made some rather far-reaching decisions that have allowed for the orderly growth, development and population of the region. However, it is highly unlikely that these authors could fathom what role the River would play in the socio-economic fiber of the region now populated by over 40 million people in the United States and Mexico. Over the last 40 years, new water quality laws and Salinity Control Program efforts have allowed the Upper Colorado River Region to grow and prosper while minimizing the harmful impacts of salinity in the Upper or Lower Basins. The Salinity Control Program now looks to the future of continued growth and economic development, realizing that additional salinity control will need to be implemented to meet the continued objectives of the Program.

Conclusion

Over the last four decades the main benefits of the Salinity Control Program have been to allow the Upper Basin to develop Compact apportioned water while water users in the Lower Basin and Mexico have received water with improved water quality. This cost-effective and multiple-benefit Program will need to be continued with significant investment well into the future.

The most apparent benefit of the Program is the economic gains in the Upper Basin. Though these gains have not been formally quantified, their positive impact is obvious and substantial throughout local communities. However, water and the way it is used can be better managed. Conserved water may be better applied or, in some cases, saved for late irrigation season use in water-short areas. This enhanced water management results in improved crop production which translates to better profitability for the water users. Improved delivery and on-farm systems often also require less labor to manage.

The prosperity of these agricultural communities has added social values. The tax base is increased, public services are enhanced, funds are available for improved schools, and employment opportunities appear so that young adults can remain and work in their communities.

The quality of the water being diverted for use in the Upper Basin is generally acceptable, yet reaches of tributary streams below irrigation projects experience higher salinity and, therefore, may have reduced value for future use in the area. For example, increased selenium concentrations in some reaches are harmful to some aquatic fauna, including endangered fish species. The Program has been very effective in reducing selenium in return flows.

As the Program pursues areas of greatest potential and benefit, other areas may be left to return to natural conditions. However, language within Program guidelines requires “the replacement of incidental fish and wildlife values forgone.” Hence, the Program is responsible for replacing these values which often results in larger, better managed habitat areas.

Formal quantification of the benefits of the Program is beyond the scope of this report. However, the many examples of Program efforts attribute to the overarching benefits experienced throughout the Upper Basin.

Appendix A

Federal Partners

Table A.1. Federal dollars expended and tons of salt controlled for identified Salinity Control Project Areas.

State	Project	Tons Controlled	Dollars ($) Expended
Colorado			
	Grand Valley	153,689	69,963,889
	Lower Gunnison	171,467	126,368,781
	McElmo Creek	29,353	26,045,268
	Mancos River	4,400	6,977,000
	Silt	2,200	4,302,000
	Total	**361,109**	**233,656,938**
Utah			
	Uintah Basin	314,998	200,526,868
	Price-San Rafael	158,733	119,657,227
	Manila-Washam	18,926	19,262,785
	Muddy Creek	100	186,000
	Green River	700	273,000
	Tropic & East Fork*	1,829	1,060,000
	Total	**495,286**	**340,965,880**
Wyoming			
	Big Sandy River	69,450	22,500,640
	Henrys Fork	0	0
	Total	**69,450**	**22,500,640**
New Mexico			
	San Juan*	48,329	14,344,011
	Total	**48,329**	**14,344,011**

*These projects are USBR Basinwide projects, but are not within the defined project areas (shown in Figure 5) as set forth in this report.

Appendix B

Examples of Salinity Control Projects in the Upper Basin

There are 12 identified salinity control project areas in the Upper Basin as identified in the text of this report and in Figure 5. Also included are brief summaries of six of these project areas.

1. Big Sandy, Wyoming *
2. Lower Gunnison, Colorado*
3. Grand Valley, Colorado *△
4. Green River, Utah
5. Mancos Valley, Colorado
6. Manila-Washam, Utah/Wyoming *
7. McElmo, Colorado
8. Muddy Creek, Utah
9. Uinta Basin, Utah*
10. Price-San Rafael, Utah *
11. Silt, Colorado
12. Henrys Fork, Utah/Wyoming

*See summaries of these salinity control projects below

△ Includes the addition of the Whitewater and DeBeque areas to this project area

Big Sandy

The Big Sandy area of Wyoming has been a most successful salinity project. The Big Sandy Project was constructed by Reclamation and NRCS in the 1950's and 1960's. Originally these systems were used for flood irrigation with an average of 35% efficiency. When the Big Sandy Salinity Project area was established by the USDA in1988, farmers were able to make major improvements to irrigation system efficiencies, most notably through the use of center pivots. Eden Valley Irrigation District estimates that approximately 11,034 acres have been brought under improved irrigation systems from the Salinity Control Program. On-farm upgrades are not the only improvements, as many earthen canals have been lined or converted into pipes. These improvements help decrease canal seepage, move water more efficiently, allow for better control of water allocations throughout the system and improve water quality throughout the area (i.e., less seepage through saline soils).

By improving on-farm irrigation systems in the Big Sandy area, almost 69,945 tons of salt have been prevented each year from entering the Colorado River system at a very low cost of $21.55 per ton of "salt saved." In addition, many miles of canal lining have occurred. Now conserved water can be stored in the Big Sandy Reservoir (outlet structure pictured above) and can be used to provide needed water to the crops late in the irrigation season.

Lower Gunnison

Although the Lower Gunnison Unit of the Salinity Control Program, located in western Colorado, has been identified as the largest "untapped" source of salt control in the Upper Colorado River Basin by the Salinity Control Forum's Work Group, many salt control projects have already been implemented. It is estimated that 227,100 tons[7] of salt per year have been controlled by numerous on-farm projects with thousands of participating agricultural producers and numerous off-farm projects.

In addition, numerous off-farm projects have been implemented by the Program. It is estimated that nearly 80,000 tons[8] of salt have been controlled via a series of projects that are focused upon reducing deep percolation of seepage water that can transport salts to the river system. In the Uncompahgre Valley, almost 150 miles of open canal have been replaced by closed piped systems in the last 20 years or so.

These improvements are welcomed by many hard-working agricultural producers in the Lower Gunnison Basin as salinity control investments have resulted in improved water quality and, in some areas, better water availability. In turn, these salt control projects can provide benefits such as better irrigation water management and even increased agricultural productivity, as well as helping to create new agricultural opportunities.

This is true for folks like Randy Meaker, who has been farming with his family in the Uncompahgre Valley for three generations. He explains, "The funding support I received through the Salinity Control Program has provided me with the opportunity to advance to high efficiency sprinkler irrigation and has since proven to be a great savings to my farming operation. In addition, sprinkler irrigation has given me a lot more freedom to experiment with different crops, cover crops and farming techniques, like minimum till, which have made significant improvements to my soil health."

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[7] Comprehensive Planning Studies for Salinity Control Measures in the Upper Colorado River Basin, Final Findings and Strategies, Lower Gunnison Basin, Colorado, U.S. Bureau of Reclamation, December 2013, page 1-5.
[8] Ibid, page 4-1.

Salinity control efforts have brought about additional benefits to farmers, ranchers and water managers within the Lower Gunnison and, in particular, within the Uncompahgre Project area. Water users are receiving cleaner, more consistent water deliveries, pressurized in some areas, due to piping / lining projects that bring water from distant off-farm locations.

In addition to piping and lining canals and laterals, water managers are investing in water delivery improvements like flow controls and measurements that are being installed concurrently with salinity control projects. Altogether, such improvements have helped irrigation water suppliers more efficiently manage critical water supplies. Steve Fletcher, Manager of the Uncompahgre Valley Water Users Association, has found this out first hand. "Our manual labor and, therefore, costs of delivering water have been reduced as we spend less time on operation and maintenance efforts. Our water is cleaner with less sediment and less debris. In addition, as we put our canals into pipes, we have fewer issues with ditch bank stability and safety and less maintenance related to weeds, algae and cleaning."

Along with these salinity control projects, the Lower Gunnison Unit has benefitted from numerous wildlife habitat improvement projects through Program activities. Ongoing efforts have created wildlife habitat replacement projects that include approximately 1,238 acres of permanent, managed, high quality habitat.

These projects include constructed and enhanced wetlands and open water habitats that are free of invasive species. "It has been very rewarding to work with farmers, water providers and wildlife interests to bring these wildlife projects forward," said Jim Currier, formerly with the Colorado State Conservation Board.

Barb Osmundson with the U.S. Fish & Wildlife Service agrees: "The wildlife habitat replacement projects tend to provide more desirable wetland and riparian habitat than what was lost due to salinity control projects."

Even with these projects in place, there are significant potential salinity control opportunities available in the Lower Gunnison area. It is estimated that about 185,000 tons of salt per year have been controlled to date by both the on-farm and off-farm efforts.[9] Salt loading estimates from these two sources are 840,000 tons[10], so it appears much more salinity reduction work can be accomplished in this area.

[9] Ibid, page 4-1.
[10] Ibid, page 1-5.

Grand Valley

The Grand Valley Unit of Colorado is one of the largest and most successful of the salinity control areas. Over the past 40 years, the NRCS program has successfully treated 99% of the acreage goal (44,000 acres). In addition, a total of 142,007 tons per year of salt (108% of the projected goal) have been controlled. Although much of the wild flood irrigation has been replaced with gated pipe to better utilize water, a smaller sub-area called Palisade has turned to very advanced water efficiency practices. Here micro-jet irrigation is controlled by computer programs to irrigate under grape vines and fruit trees.

In the Grand Valley, the overall reduction in water use has led to decreases in water delivery fees. Other efficient practices include: flow meters, which have helped users better manage water deliveries; canal lining, which has reduced water loss; improved canal management from diversion improvements; and drainage efforts are reduced as cleaner water reaches the fields. Also there have been “squared-up” fields, fewer weeds, and more even distribution of water on the field. This has resulted in increased crop yield, better management of nutrients and, in some cases, extended irrigation/crop growing seasons.

Clarence Wood, a long-time agriculturist in this area, stated, “Not only do we have a better and more efficient system, our labor costs are down by 40 percent compared to the way we had to irrigate with dirt ditches, and our crop values are up.”

Jim Currier, formerly with the Colorado State Conservation Board, has noted that in the Grand Valley “less water is used, reducing associated water delivery fees; flow meters have helped users better manage water; much seepage is eliminated and hence, less water lost; canals are better managed because of diversion improvements; drainage efforts are reduced and cleaner water reaches the fields.

Manila-Washam

The Manila-Washam Unit that straddles the Utah/Wyoming border north of the Uinta Mountains is a newer project where the combined efforts of Reclamation and NRCS have been embraced by the local water users. Here an advanced surface-water-quality computer model (SPARROW) created by the USGS was used to predict the potential salt savings. On-farm interest is expected to increase in the area with the treatment of over 4,000 acres of irrigated land, as well as three new pipeline projects. Due to irregular topography, irrigation delivery and application is difficult. The piping of canals has prevented water degradation, reduced salt seeps in the area and has allowed for extended control over water usage. Ned Brady, a local farmer and canal president, beams as he declares: “We are able to deliver the right amount of water to the rightful owner at the proper time – something we had only dreamed of in the past!”

Uintah Basin

The Uintah Basin Unit (UBU) is comprised of 224,800 acres of irrigated agricultural land lying south of the Uinta Mountains in eastern Utah. The area was cited as a study area in the original 1975 Salinity Control Act (PL-93-320). USDA Salinity control funding started in 1980, two years before the original Environmental Impact Statement (EIS) was approved in April 1982. A second EIS was approved in 1993, expanding projected irrigation improvements from 122,200 acres to 137,000 acres.

The pre-project on-farm agricultural salt load was estimated to be 208,120 tons/year or 1.04 tons/actively irrigated acre/year. As of the end of FY2014, USDA had funded 157,200 acres of irrigation improvements and about 300 miles of off-farm canal and lateral replacements, controlling 155,200 tons/year of on-farm and off-farm salt load to the Colorado River System. About 63,000 acres have never been planned for federally funded irrigation improvements, representing about 58,000 tons/year of salt loading. Many acres have been treated with no federal involvement. A 2014 engineering study ties the bulk of future salt control potential to the Ute Indian Irrigation Project, which has had little or no interest in treatment.

In the same timeframe, USBR has funded replacement of 684 miles of canals and laterals, controlling about 42,000 tons/year of salt loading to the river system. One thousand, seventy-seven miles of canals (63% of pre-project assets) have not been treated, including eight hundred miles of Ute Indian Irrigation Project operated canals or private canals crossing Tribal lands.

Kent Nelson, a local irrigator, is the second-generation manager of a farming operation with several salinity funded sprinkler projects. Kent indicates that salinity projects and USDA technical assistance with irrigation water management have greatly increased the productivity and efficiency of his operation while sharply reducing wasted water and deep percolation. Sprinkler systems give the irrigator much greater control over water application, allowing more even irrigation of high and low spots in the field. The Salinity Control Program has positively affected the local economy and is a win-win program for irrigators and downstream water users.

Price-San Rafael

The Price-San Rafael Rivers project in Utah is below the eastern margin of the Book Cliffs of the Wasatch Plateau from Price south to Ferron. The Ferron sub-unit is a major success story; here the local canal company and all irrigators in the area worked cooperatively.

The Huntington Cleveland Irrigation Company (HCIC) System reorganization has been a major milestone toward completing the Price-San Rafael Project. The entire off-farm infrastructure has been installed and the on-farm irrigation improvements are nearing 90 percent completion.

Sherrel Ward, former President of the HCIC, has stated that the improvements rescued his farm during a recent drought. Ward installed six wheel lines (side roll sprinklers) and four full or partial center pivots. Ward can now irrigate all his fields with one third less water and therefore estimates he is producing an average of 1.5 tons of hay per acre more. The increase in forage production means he no longer needs to use public range lands to provide winter grazing for his 170 cow/calf herd of beef cattle. His herd has also realized a better conception and birth rate due to the improved condition of the cattle.

The Cottonwood Creek Irrigation Company (CCIC) is the last large remaining service area in the Price-San Rafael Project to become involved in the Salinity Control Program. This project is about 75 per cent “built out” and should be completed within five years.

Lee Moss, a long-time science and math teacher in the local school system and a water user in the CCIC, is very enthusiastic about the improvements. This season will be the fourth under the

new sprinklers and the forage stand is steadily improving. The alkali patches have disappeared from his fields and his soil tilth is improving. He feels his production has doubled. If fact, he was able to carry over 1100 small hay bales for the first time this winter. Mr. Moss says the system operated exactly as it was designed and he greatly benefited from the Irrigation Water Management classes that he attended.

J. Mark Humphries, Manager of the Emery Water Conservancy District who oversees water deliveries in the area, was also very enthusiastic about the Salinity Control Program. He says the various projects have provided much better control options for the water supplies. Much of the water delivery is now metered, allowing for more precise water management.

J. Mark says that improved water management has allowed the irrigation season to be extend both in the spring and in late summer/early fall. In addition to better crop production and crop diversification, the soils are improving as the alkali areas are disappearing. Furthermore, there is less conflict among water users and less need for pesticide application as the old brushy ditches and waste areas are eliminated. Many of the communities in the area now have pressurized secondary water systems for more efficient landscape irrigation. As the old, large canals, siphons, and crossings are eliminated, many safety hazards have been reduced.

Modernizing these large systems is not without challenges. These systems, both off-farm and on-farm, require a much higher level of management and the learning curve is comparatively steep. There are increased costs for new irrigation, tillage and harvesting equipment. Installation of wheel lines, in particular, requires a significant labor commitment as these systems are often moved twice each day. Mr. Humphries has also observed some losses of small acreage farms as many small parcels are being consolidated into larger farms. He also notes that, although wildlife numbers in general are increasing, specific types of habitat such as large trees or cottonwood galleries, have significantly decreased.