2017 Review

Water Quality Standards for Salinity Colorado River System

October 2017

Colorado River Basin Salinity Control Forum

2017 Review

WATER QUALITY STANDARDS FOR SALINITY
COLORADO RIVER SYSTEM

October 2017

Prepared by

Colorado River Basin Salinity Control Forum

COLORADO RIVER BASIN SALINITY CONTROL FORUM

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The Colorado River Basin
(2012 Colorado River Basin Water Supply and Demand Study)

TRANSMITTAL LETTERS

The Federal Water Pollution Control Act requires that at least once every three years the Basin States review water quality standards relating to the salinity of the Colorado River. The states collectively initiated this review under direction of the Forum. The Forum prepared a draft review and, after providing an opportunity for public comment, prepared this final 2017 Review.

With the adoption of this final review, copies are being sent to the Colorado River Basin State Governors listed below for inclusion within their individual state water quality standards.

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LIST OF ABBREVIATIONS

208 Plan	Section 208 of the Clean Water Act amendments of 1972 and 1977 requiring integrated area-wide plans and programs for dealing with water pollution problems
Act	The Colorado River Basin Salinity Control Act (P.L. 93-320) (1974), as amended by P.L. 98-569 (1984), P.L. 104-20 (1995), P.L. 104-127 (1996), P.L. 106-459 (2000), P.L. 107-171 (2002) and P.L. 110-246 (2008)
Basin	Colorado River Basin
Basin Funds	Lower Colorado River Basin Development Fund and Upper Colorado River Basin Fund
Basin States	Arizona, California, Colorado, Nevada, New Mexico, Utah, Wyoming
BSP	Basin States Program
Basinwide Program	Basinwide Salinity Control Program
BLM	United States Bureau of Land Management
Clean Water Act	P.L. 92-500
Congress	United States Congress
CRSS	Colorado River Simulation System
EQIP	Environmental Quality Incentives Program
EPA	United States Environmental Protection Agency
Forum	Colorado River Basin Salinity Control Forum
Ktons	Thousand tons of salt
maf	million acre-feet
mgd	million gallons per day
mg/L	milligrams per liter
Mtons	Million tons of salt
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
Program	Colorado River Basin Salinity Control Program
Reclamation	United States Bureau of Reclamation
Review	2017 Review, *Water Quality Standards for Salinity, Colorado River System*
TDS	Total Dissolved Solids
TMDL	Total Maximum Daily Load
USDA	United States Department of Agriculture
WWTP	Waste Water Treatment Plant

TABLE OF CONTENTS

COLORADO RIVER BASIN SALINITY CONTROL FORUM MEMBERS i

COLORADO RIVER BASIN MAP ii

TRANSMITTAL LETTERS iii

LIST OF ABBREVIATIONS iv

TABLE OF CONTENTS v

SUMMARY 1

PURPOSE OF THE REVIEW 3

HISTORY AND BACKGROUND 4

UNDERSTANDING THE SALINITY OF THE COLORADO RIVER 7

PROVISION FOR REVIEWING AND REVISING THE STANDARD 10

NUMERIC CRITERIA 10

PLAN OF IMPLEMENTATION 11
- General 11
- Constructed Measures 12
- Accomplishments and Future Control 13
- Forum Policies and NPDES Permits 19
- State Water Quality Management Plans 19

CONCLUSION AND ADOPTION OF THE STANDARDS 28

FUTURE PROGRAM 29

TABLES

Table 1 Control Measures in Place through 2017 15

Table 2 Additional Controls – Plan of Implementation 2020 16

Table 3 Remaining Potential Salinity Control (2018-2035) 17

Table 4 Plan of Implementation Levels Modeled by CRSS 30

Table 5 Annual Damages and Damage Reductions 32

FIGURES

Figure 1 2015 (Calendar Year) Generalized Flow and Salinity Concentrations Across the Colorado River Basin 8
Figure 2 Flow Weighted Average Annual Salt Concentrations at Numeric Criteria Stations 9
Figure 3 Salinity Control Program Impact below Hoover Dam 14
Figure 4 Salinity Control Program Impact below Parker Dam 14
Figure 5 Salinity Control Program Impact at Imperial Dam 15
Figure 6 Colorado River Basin Salinity Control Forum Project Areas 18
Figure 7 Projected Annual Average Salinity Concentration below Hoover Dam 30
Figure 8 Projected Annual Average Salinity Concentration below Parker Dam 31
Figure 9 Projected Annual Average Salinity Concentration at Imperial Dam 31

APPENDICES

Appendix A Flow Weighted Salinity Values at the Three Numeric Criteria Stations A-1

Appendix B Forum Policies
Policy for Implementation of Colorado River Salinity Standards Through the NPDES Permit Program B-1
NPDES Permit Program Policy for Implementation of Colorado River Salinity Standards B-5
Attachment 1 - Guidance on New Construction Determination B-15
Policy for Use of Brackish and/or Saline Waters for Industrial Purposes B-16
Policy for Implementation of Colorado River Salinity Standards Through the NPDES Permit Program for Intercepted Groundwater B-18
Policy for Implementation of Colorado River Salinity Standards Through the NPDES Permit Program for Fish Hatcheries B-21

Appendix C States NPDES Permits List
Legend C-1
List of NPDES Permits C-3

Appendix D EPA PDES Permits List
Legend D-1
List of NPDES Permits D-3

Appendix E Colorado River Simulation System Model Description E-1

Appendix F Salinity Economic Impact Model Executive Summary F-1

SUMMARY

This document is a review of the water quality standards for salinity in the Colorado River. Section 303 of the Clean Water Act amendments to the Federal Water Pollution Control Act require that water quality standards are reviewed every three years. Accordingly, the seven-state Colorado River Basin Salinity Control Forum has reviewed the existing state-adopted and EPA-approved water quality standards for salinity consisting of numeric criteria and a Plan of Implementation. Upon adoption by the Forum, this Review will be submitted to the governors of each of the Basin States for inclusion in their state water quality standards.

The Forum recommends no change in the numeric salinity criteria at the three stations located on the lower main stem of the Colorado River. The numeric criteria at these stations will remain:

Station	Salinity in mg/L[1]
Below Hoover Dam	723
Below Parker Dam	747
At Imperial Dam	879

The Plan of Implementation is intended to maintain the salinity concentrations at or below the numeric criteria while the Basin States continue to develop their compact-apportioned waters. The U.S. Bureau of Reclamation's (Reclamation) computer modeling indicates less than 5 percent probability of exceeding the numeric criteria in the next three years. The Colorado River Basin Salinity Control Act requires the implementation of salinity control programs to reduce the salinity of the Colorado River. Reducing the salinity of the Colorado River water reduces economic impacts to its users. While the Plan of Implementation included in this Review ensures the numeric criteria will not be exceeded during the review period, the Forum will continue to evaluate opportunities for additional salinity control that will (1) increase the economic benefits realized in the Lower Basin, and (2) provide additional direct and indirect benefits to the Upper Basin.

The Forum's Plan of Implementation includes:

1. Construction of salinity control measures by Reclamation, USDA, the Basin States Program and BLM to the extent that those measures remain viable and appropriately cost-effective.

2. State implementation of the Forum's adopted policies for effluent limitations under the National Pollutant Discharge Elimination System (Appendix B of this Review).

3. Implementation of non-point source management plans developed by the states and approved by EPA.

[1] Flow-weighted average annual salinity

Item 1 of the plan listed above is to be implemented by federal agencies in conjunction with state, local and private participants. The Forum works jointly with federal agencies on developing measures to be implemented. Items 2 and 3 are primarily implemented by the Colorado River Basin states.

The current Plan of Implementation approved by the Forum anticipates an additional 63,500 tons of annual salinity control over the next three years. The program to date has controlled over 1.33 million tons of salt annually and the current program funding levels would control 1.66 million tons annually by 2035. Reclamation's numerical modeling indicates that there is less than 5 percent probability of exceeding the numerical criteria over the next three years with the current and planned salinity control projects. The Salinity Control Program continues to be a successful federal and state partnership that has environmental and economic benefits for users of Colorado River water.

PURPOSE OF THE REVIEW

The 2017 Review: *Water Quality Standards for Salinity, Colorado River System* (Review) is prepared and submitted in response to Section 303(c) of Public Law (P.L.) 92-500 (Clean Water Act) by the seven-state Colorado River Basin Salinity Control Forum (Forum) on behalf of the governors of their respective states. This review of the water quality standards includes the numeric criteria and the Plan of Implementation developed and adopted by the Forum. This is the 14th review conducted by the Forum. Section 303(c)(1) of the Clean Water Act requires that:

> The governor of a state or the state water pollution control agency of such state shall from time to time (but at least once each three-year period beginning with the date of enactment of the Federal Water Pollution Control Act Amendments of 1972) hold public hearings for the purpose of reviewing applicable water quality standards and, as appropriate, modifying and adopting standards. Results of such review shall be made available to the Administrator [of the Environmental Protection Agency].

The scope of this Review is limited to the portion of the Colorado River Basin (Basin) above Imperial Dam and how this area of the Basin is in compliance with the water quality standards approved by the United States Environmental Protection Agency (EPA) in 1975 (Standards). This Review focuses on the 2018 to 2020 period (review period) and evaluates the appropriateness of the Standards in the Basin. Background information and activities regarding historical actions relative to the development and adoption of salinity standards are contained in the Forum report, *Water Quality Standards for Salinity, Including Numeric Criteria and Plan of Implementation for Salinity Control, Colorado River System*, Colorado River Basin Salinity Control Forum, June 1975.

Below Imperial Dam, salinity is controlled as a federal responsibility to meet the terms of the agreement with Mexico contained within Minute No. 242 of the International Boundary and Water Commission entitled "Permanent and Definitive Solution to the International Problem of the Salinity of the Colorado River." Minute No. 242 requires that measures be taken to assure that Colorado River water delivered to Mexico upstream from Morelos Dam will have an average annual salinity concentration of no more than 115 ± 30 parts per million total dissolved solids (TDS) higher than the average annual flow-weighted salinity concentration of the Colorado River water arriving at Imperial Dam.

Nothing in this Review shall be construed to alter, amend, repeal, interpret, modify or be in conflict with the provisions of the Boulder Canyon Project Act (45 Stat. 1057), the Boulder Canyon Project Adjustment Act (54 Stat. 774), the Colorado River Basin Project Act (82 Stat. 885), the Colorado River Compact, the Colorado River Storage Project Act (70 Stat. 105), the Upper Colorado River Basin Compact, or the Treaty with the United Mexican States (Treaty Series 994).

HISTORY AND BACKGROUND

The Colorado River Basin Salinity Control Program (Program) is a unique cooperative watershed effort between several federal agencies and seven states designated to meet national, international and state water quality objectives. The Forum participates with federal, state, local agencies and private participants to ensure the successful execution of the triennial Plan of Implementation through on-the-ground activities and encouraging legislative support for federal funding.

The Basin is 242,000 square miles[2] (approximately 155 million acres) of the western United States and a small portion of northern Mexico. Currently, about 40 million[3] people in the seven western states of Arizona, California, Nevada (Lower Basin States) and Colorado, New Mexico, Utah, and Wyoming (Upper Basin States), collectively referred to as the Basin States, rely on the Colorado River and its tributaries to provide some, if not all, of their municipal water needs. Additionally, water from the Colorado River system is utilized to irrigate nearly 5.5 million acres of land[4] in the Basin, producing some 15 percent of the nation's crops and about 13 percent of its livestock, which combined generate many billions of dollars a year in agricultural benefits.

The Colorado River also serves as the lifeblood for at least twenty-two federally recognized Native American Indian tribes, seven National Wildlife Refuges, four National Recreation Areas, and eleven National Park units. Hydropower facilities along the Colorado River supply more than 4,200 megawatts of electrical capacity to help meet the power needs of the West and reduce the use of fossil fuels. Finally, the Colorado River is vital to Mexico, supporting a thriving agricultural industry in the San Luis and Mexicali Valleys and providing municipal water supplies for communities in the Mexican States of Sonora and Baja California.

The Colorado River system is operated in accordance with the Law of the River[5]. Currently, apportioned water in the Basin exceeds the 109-year record (1906 through 2014) basinwide average long-term historical natural flow[6] of about 16.1 million acre-feet (maf). However, the Upper Basin States have not fully developed use of their 7.5 maf apportionment, and total consumptive use and losses in the Basin have averaged approximately 15.3 maf[7].

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[2] Colorado River System, Consumptive Uses and Losses Report, 1996-2000, Bureau of Reclamation.

[3] About 40 million people were estimated to be within the hydrologic boundaries of the Basin in the United States, as well as in the adjacent areas of the Basin States that receive Colorado River water, in 2015. See Colorado River Basin Water Supply and Demand Study - Technical Report C, U.S. Bureau of Reclamation, 2012.

[4] It is estimated that there were 5.5 million irrigated acres in the hydrologic boundaries of the Basin in the United States, as well as in the adjacent areas of the Basin States that receive Colorado River water, in 2015 based on interpolated acreage data from Scenario A Current Projections. See Colorado River Basin Water Supply and Demand Study - Technical Report C, U.S. Bureau of Reclamation, 2012.

[5] The treaties, compacts, decrees, statutes, regulations, contracts and other legal documents and agreements applicable to the allocation, appropriation, development, exportation and management of the waters of the Colorado River Basin are often collectively referred to as the "Law of the River."

[6] Natural flow represents the flow that would have occurred at the location had depletions and reservoir regulation not been present upstream of that location.

[7] Basinwide consumptive use and losses estimated over the period 2002-2011, including the 1944 Treaty delivery to Mexico, reservoir evaporation, and other losses due to operational inefficiencies.

Salinity-caused impacts have long been a major concern in the United States and Mexico. The salinity in the river generally increases as it flows downstream. The Colorado River has carried an average salt load of approximately 9 million tons annually past Hoover Dam, the uppermost location at which numeric criteria have been established.

The salts in the Colorado River system are naturally occurring and pervasive. Many of the saline sediments of the Basin were deposited in prehistoric marine environments. Salts contained within the sedimentary rocks are easily eroded, dissolved, and transported into the river system.

In a 1971 study[8], EPA analyzed salt loading in the Basin and divided it into two categories, naturally occurring and human-caused. EPA concluded that about half (47 percent) of the salinity concentration measured in water arriving at Hoover Dam is from natural sources, including salt contributions from saline springs, groundwater discharge into the river system (excluding irrigation return flows), erosion and dissolution of sediments, and the concentrating effects of evaporation and transpiration. Other natural sources include salt contributions from non-point (excluding irrigated agriculture) or unidentified sources or from the vast, sparsely populated regions of the Basin, many of which are administered by the United States Bureau of Land Management (BLM) or other governmental agencies. Of the land within the Basin, about 75 percent is owned and administered by the federal government or held in trust for Indian tribes. The greatest portion of the naturally occurring salt load originates on these federally owned and administered lands.

Human activities, including livestock grazing, wildlife management, logging, mining, oil exploration, road building, recreation and urbanization can influence the rate of natural salt movement from rock formations and soils to the river system. EPA estimated that out-of-Basin exports (3 percent), agricultural irrigation (37 percent), reservoir evaporation and phreatophyte use (12 percent), and municipal and industrial uses (1 percent) account for 53 percent of the salinity concentration in water arriving at Hoover Dam. Much of the salt load contribution from irrigated agriculture is from federally developed irrigation projects.

In 1972, the federal government enacted the Clean Water Act that mandated efforts to develop and maintain water quality standards in the United States. At the same time, Mexico and the United States engaged in discussions to address the issue of increasing salinity in the Colorado River water being delivered to Mexico. The Basin States established the Forum in 1973. The Forum is composed of representatives from each of the Basin States appointed by the governors of the respective states. The Forum was created for interstate cooperation and to provide the states with the information necessary to comply with Section 303(a) and (b) of the Clean Water Act.

EPA promulgated a regulation in December 1974 which set forth a basinwide salinity control policy for the Basin. The regulation specifically stated that salinity control was to be implemented while the Basin States continue to develop their compact-apportioned water. This regulation also established a standards procedure and required the Basin States to adopt and submit for approval to EPA water quality standards for salinity, including numeric criteria and a Plan of Implementation, consistent with the policy stated in the regulation. In compliance with

[8] The Mineral Quality Problem in the Colorado River, Summary Report, Environmental Protection Agency, Regions VIII and IX, 65pp., 1971

the regulation, the Forum selected three numeric criteria stations on the main stem of the lower Colorado River as being appropriate points to measure the salinity concentrations of the river. These stations are located at the following points: (1) below Hoover Dam, (2) below Parker Dam, and (3) at Imperial Dam. The Forum also adopted a water quality standard for the Colorado River Basin including both a Plan of Implementation and numeric criteria.

With the Plan of Implementation as proposed in this Review in place, the probability of exceeding the numeric criteria during the review period is very low based on Reclamation computer model simulations. The analysis indicates the probability of exceeding the numeric criteria with the Plan of Implementation in place in any of the next three years at the Hoover Dam, Parker Dam and Imperial Dam stations is 5 percent or less. This low probability of exceedance was an important factor in the Forum's decision to adopt the Plan of Implementation accompanying this Review.

The Colorado River Basin Salinity Control Act (P.L. 93-320) (1974) (Act), established the Colorado River Basin Salinity Control Program under Title II to address the concerns raised by EPA. The Act also created the Colorado River Basin Salinity Control Advisory Council to advise the federal agencies regarding administration of the Program. P.L. 93-320 has been amended several times since its original enactment. P.L. 98-569 (1984) authorized the United States Department of Agriculture's (USDA) on-farm program. P.L. 104-20 (1995) created the United States Bureau of Reclamation's (Reclamation) Basinwide Salinity Control Program (Basinwide Program). The Federal Agriculture Improvement and Reform Act (P.L. 104-127) (1996) (1996 Farm Bill) authorized up-front cost sharing by the Basin States and modified the USDA authorities, including the use of the Environmental Quality Incentives Program (EQIP). P.L. 106-459 (2000) increased the appropriation ceiling. The Food, Conservation, and Energy Act of 2008 (P.L. 110-246) (2008 Farm Bill) created the Basin States Program (BSP). The Agricultural Act of 2014 (P.L. 113-79) (2014) continued the authorization of EQIP.

UNDERSTANDING THE SALINITY OF THE COLORADO RIVER

As with most large rivers, the natural flow of the Colorado River increases from its headwaters to its terminus. Today, however, the flow of the Colorado River decreases below Hoover Dam due to diversions. Imperial Dam is the last major diversion point for uses in the United States. In normal years, 1.5 maf is scheduled to pass Imperial Dam for deliveries to Mexico.

In general, the salinity concentration of the water in the Colorado River increases from the headwaters to the terminus. Much of the salt is picked up in the Upper Basin, and some of the tributary streams average higher concentrations of salt than the main stem.

Reclamation has developed a map of the Basin reflecting the relative flows and the corresponding salinity concentrations of the water across the Basin in calendar year 2015. This map is provided for general illustrative purposes as Figure 1. The average flow of the Colorado River and its important tributaries are indicated by the width of the line, and the salinity concentrations are illustrated by colors coded to ranges in TDS.

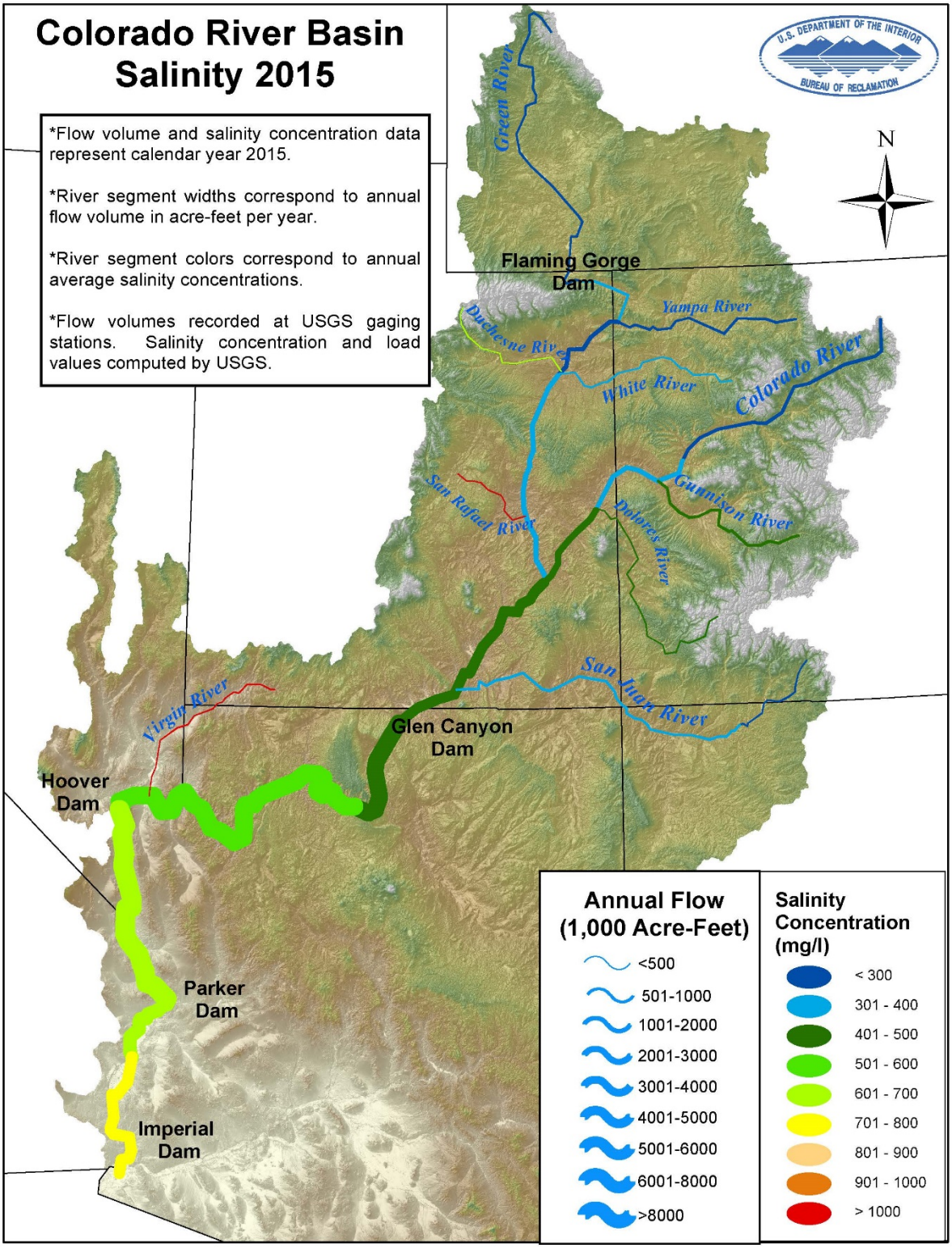

Figure 1 – 2015 (Calendar Year) Generalized Flow and Salinity Concentrations across the Colorado River Basin

In general, over the last thirty years the salinity concentrations have decreased at all three of the numeric criteria stations (see Figure 2). The values for the Observed Flow-Weighted Average Salinity at the Numeric Criteria Stations are provided in Appendix A. In this Review, the terms "salinity," "TDS" and "concentration," each in mg/L, are used interchangeably.

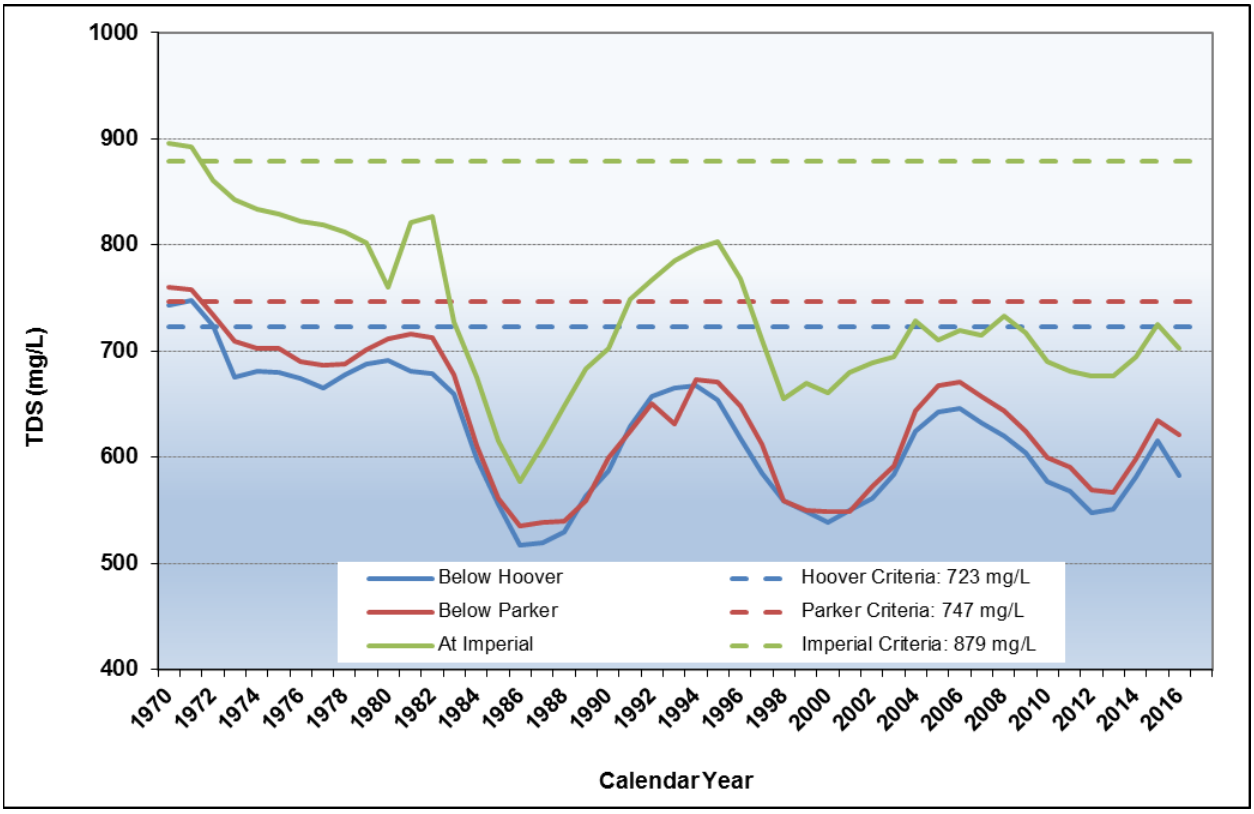

Figure 2 – Flow Weighted Average Annual Salt Concentrations at Numeric Criteria Stations

PROVISION FOR REVIEWING AND REVISING THE STANDARD

The Colorado River water quality standards for salinity and the approach taken by the Basin States in complying with the standards are unique. The salinity concentrations that are projected in the future have not been shown to have adverse effects on human health or wildlife. Thus, the Program is different from most other water quality standard compliance programs. The standards adopted by the Forum and the Basin States and approved by EPA consist of the numeric criteria and the Plan of Implementation. The numeric criteria portion of the water quality standards is established to protect against increases in economic damages to infrastructure and crop production. The Plan of Implementation is designed to maintain the flow-weighted average annual salinity at or below the numeric criteria while the Basin States continue to develop their compact-apportioned water supply.

The Program is a basinwide coordinated effort among federal, state and local agencies and participants to control salt loading. The Forum, in its statement of "Principles and Assumptions for Development of Colorado River Salinity Standards and Implementation Plan," approved by the Forum on September 20, 1974, stated under Principle 7:

> The Plan of Implementation shall be reviewed and modified as appropriate from time to time, but at least once every three years. At the same time, the (numeric) standards, as required by Section 303 (c) (1) of P.L. 92-500 shall be reviewed for the purpose of modifying and adopting standards consistent with the plan so that the Basin States may continue to develop their compact-apportioned waters while providing the best practicable water quality in the Colorado River Basin.[9]

NUMERIC CRITERIA

EPA promulgated a regulation that set forth a salinity control policy for the Basin. This policy required that the flow-weighted average annual salinity in the lower main stem of the Colorado River be maintained at or below the 1972 levels. The points in the lower main stem of the Colorado River where the flow-weighted average annual salinity is measured are at the following three stations: 1) below Hoover Dam, 2) below Parker Dam, and 3) at Imperial Dam. The basis for selecting these stations is their proximity to key diversion facilities on the lower Colorado River. Nevada diverts main stem water from Lake Mead for use in the Las Vegas area. The Metropolitan Water District of Southern California and the Central Arizona Project divert water from Lake Havasu, impounded behind Parker Dam, for millions of water users in southern California and central Arizona, respectively. The large agricultural areas in the Imperial and Coachella Valleys in California and the Yuma area in Arizona are served by diversions at Imperial Dam.

The numeric criteria for each of those stations as established in 1972 are as follows:

Below Hoover Dam	723 mg/L
Below Parker Dam	747 mg/L
At Imperial Dam	879 mg/L

[9] Water Quality Standards for Salinity Including Numeric Criteria and Plan of Implementation for Salinity Control, Colorado River System, Colorado River Basin Salinity Control Forum, 1975 Review, p. 133.

While the federal regulations provide for temporary increases above the numeric criteria levels if sufficient control measures are included in the Plan of Implementation, no temporary increases are anticipated during this review period.

The Forum believes the Review is the appropriate setting to recommend any changes to the numeric criteria. The Forum finds the current numeric criteria are adequate for the next three years and recommends no changes at this time. Because of the potential economic benefit to the Basin, the Forum believes there is justification to maintain salinity levels below the numeric criteria and remove additional salt from the Colorado River, thus saving several hundred million dollars in annual damages.

PLAN OF IMPLEMENTATION

General

The Plan of Implementation goal is designed to keep the flow-weighted average annual salinity concentrations at or below the 1972 numeric criteria levels while the Basin States continue to develop their compact-apportioned water supply. Measures in place are controlling 1.33 million tons of salt annually. The Plan of Implementation would implement practices to control an additional 63,500 tons of salt per year by 2020. Based on this level of control, Reclamation estimates there is less than a 5 percent probability that the numeric criteria will be exceeded in any year during the review period.

The Plan of Implementation is composed of many actions contemplated by the federal and state agencies and includes projects that remove the required salt tonnage to meet the Plan goal. This will principally be accomplished by reducing the salt contributions to the Colorado River from existing sources and minimizing future increases in salt load caused by human activities. For this Review, the Plan of Implementation can be briefly summarized as follows:

1. Implementation of salinity control measures by Reclamation, Natural Resources Conservation Service (NRCS), the BSP and BLM to the extent that those measures remain viable and appropriately cost effective.

2. Application of the Forum-adopted policies by each of the states. (The texts of the policies are included in Appendix B, and a list of National Pollutant Discharge Elimination System (NPDES) permits issued pursuant to these policies is found in Appendices C and D of this Review.)

3. Implementation of non-point source management plans developed by the states and approved by EPA (see the State Water Quality Management Plans section of this Review).

The Forum participates with federal, state and local agencies and private participants to ensure the Plan of Implementation is executed. The Forum also urges Congress to appropriate the funds needed for implementation and recommends legislative changes when necessary.

Constructed Measures

Congress enacted Public Law 93-320 in June of 1974 with the Forum's support. Title II of the Public Law created a water quality program for addressing salinity in the Colorado River in the United States above Imperial Dam. Primary responsibility for Title II was given to the Secretary of the Interior, with Reclamation being instructed to investigate and build the Paradox Valley, Grand Valley, Las Vegas Wash and Crystal Geyser salinity control units. The Secretary of Agriculture was also instructed to support the effort within existing authorities.

Public Law 93-320 has been amended several times. The amendments directed the Secretary of the Interior and the Secretary of Agriculture to give preference to the salinity control units with the least cost per unit of salinity reduction. The amendments established a BLM program, a voluntary on-farm salinity control program to be implemented by USDA (including the voluntary replacement of incidental fish and wildlife values foregone as a result of the on-farm measures) and the Basin States Program. Through implementation of these programs, many cost-effective salt-load reducing activities have been accomplished.

USDOI-Reclamation

The Act was amended by P.L. 104-20 to authorize the Basinwide 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. Reclamation solicits applications through a Funding Opportunity Announcement (FOA) for projects that will reduce the salinity of the Colorado River. Reclamation evaluates and ranks each application and awards grants to the highest ranking applications. Cost effectiveness is the prime criteria in the evaluation. The timing of the FOA is based on the need for more salinity control projects, and it relates to the amount of federal appropriation Reclamation receives to implement its portion of the Program. P.L. 104-20 and P.L. 106-459 increased the authorization ceiling for Reclamation’s salinity control program.

USDA-NRCS

The NRCS program generally concentrates on improving on-farm systems. NRCS salinity activities fall mainly under the authorities of EQIP. EQIP for Colorado River salinity control was authorized and initially funded under the 1996 Farm Bill and recently reauthorized by the 2014 Farm Bill. NRCS accepts applications under EQIP and evaluates, ranks and selects those applications that best meet the goals of the salinity control program. Based on the applications, NRCS provides technical and financial assistance to the producers. NRCS also offers financial assistance for voluntary replacement of fish and wildlife values forgone.

USDOI - BLM

The goal of the BLM program is to reduce the mobilization of salts to the Colorado River from BLM administered public lands. Salt reduction is achieved by controlling both point and non-point sources of salt contributions, recognizing that the majority of salt derived from public lands is of non-point source origin. Salt loading from non-point sources is mainly reduced by minimizing soil erosion.

Basin States Program

Public Law 110-246 amended the Act and created the BSP through which money from the Lower Colorado River Basin Development Fund and the Upper Colorado River Basin Fund (Basin Funds) is used for cost sharing in Reclamation and NRCS salinity control programs. These are administered by Reclamation in consultation with the Colorado River Basin Salinity Control Advisory Council. Cost share on federal appropriations expended by both Reclamation and NRCS for salinity control in the Basin is required by the Act. The money for the Basin Funds comes from levies assessed on users of power generated within the Basin. The required cost share on the original salinity control units of Paradox, Grand Valley and Las Vegas Wash is 25 percent of the project cost. Salinity control units and programs implemented subsequent to the original units require a 30 percent cost share from the Basin Funds.

For cost-share dollars generated by the federal expenditures under the Basinwide Program, Reclamation expends the required cost-share funding, together with appropriated funds in the Basinwide Program, through a public grant process. BSP funding generated by federal appropriations expended in EQIP is managed by Reclamation to administer the BSP and to enter into the following agreements: (1) NRCS for technical assistance, (2) other federal agencies for studies and research, (3) the states of Colorado, Utah and Wyoming to fund approved salinity control activities and projects, and (4) other entities for approved salinity control activities and salinity control projects. Each of the state agencies has the same goal of providing salinity control in the most cost-effective manner. The cost-share aspects of the BSP have proven very useful as a means of achieving additional cost effective salinity control. The BSP complements the NRCS and Reclamation programs in a comprehensive manner and facilitates local water user participation.

Accomplishments and Future Control

The Plan of Implementation recognizes that the Forum, participating federal agencies and the Basin States each have specific responsibilities for addressing salinity on the Colorado River. The Forum, in conjunction with the Colorado River Basin Salinity Control Advisory Council, will continue to provide overall coordination and a continuing review of salinity conditions and program effectiveness, and advise the participating federal agencies accordingly.

To date, it is estimated that the Program has reduced the annual salt loading in the Colorado River by approximately 1,330,000 tons, resulting in over 100 mg/L reduction in salinity concentrations in the Lower Basin. Figures 3 – 5 show the comparison of measured salinity levels as compared to what salinity levels would have been without implementation of the Program at the three numeric criteria stations. Table 1 gives a brief summary of the measures that have been implemented to date, the areas where those measures have occurred and the tons of salt controlled per year associated with each area.

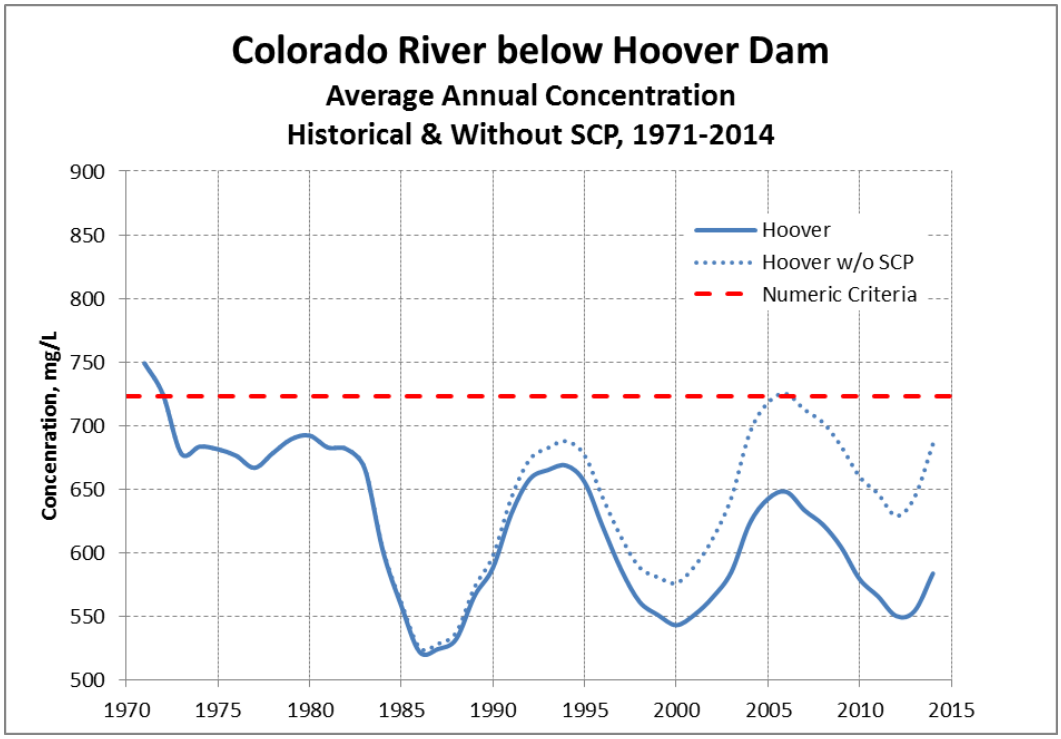

Figure 3 – Salinity Control Program Impact below Hoover Dam

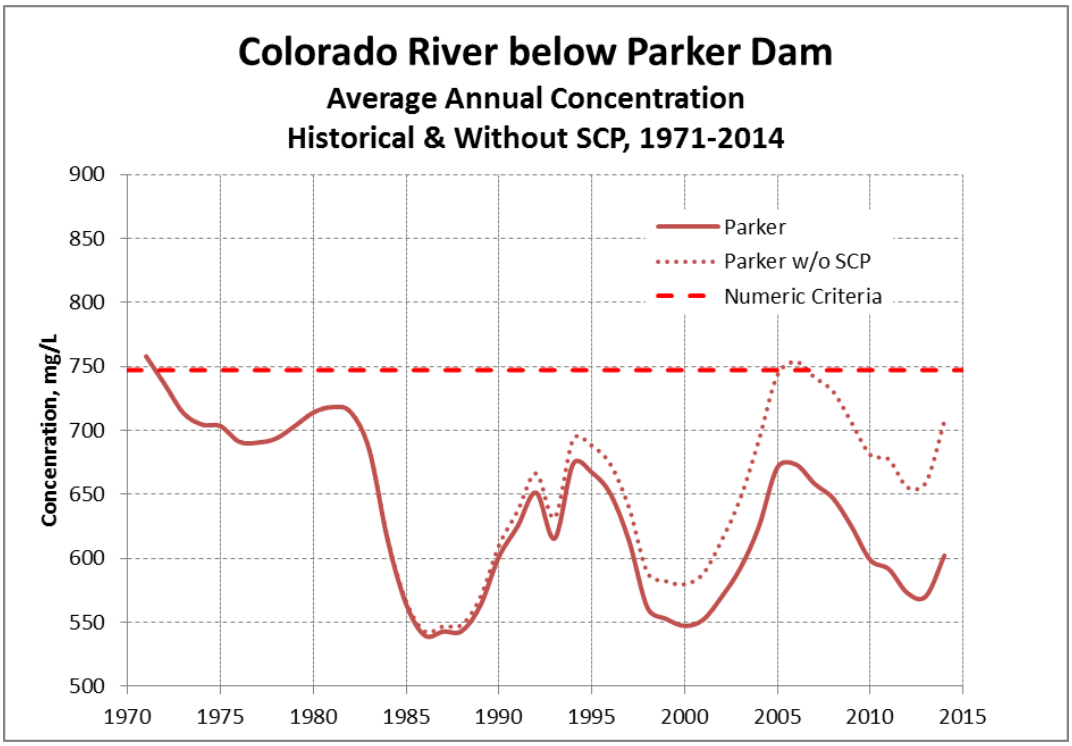

Figure 4 – Salinity Control Program Impact below Parker Dam

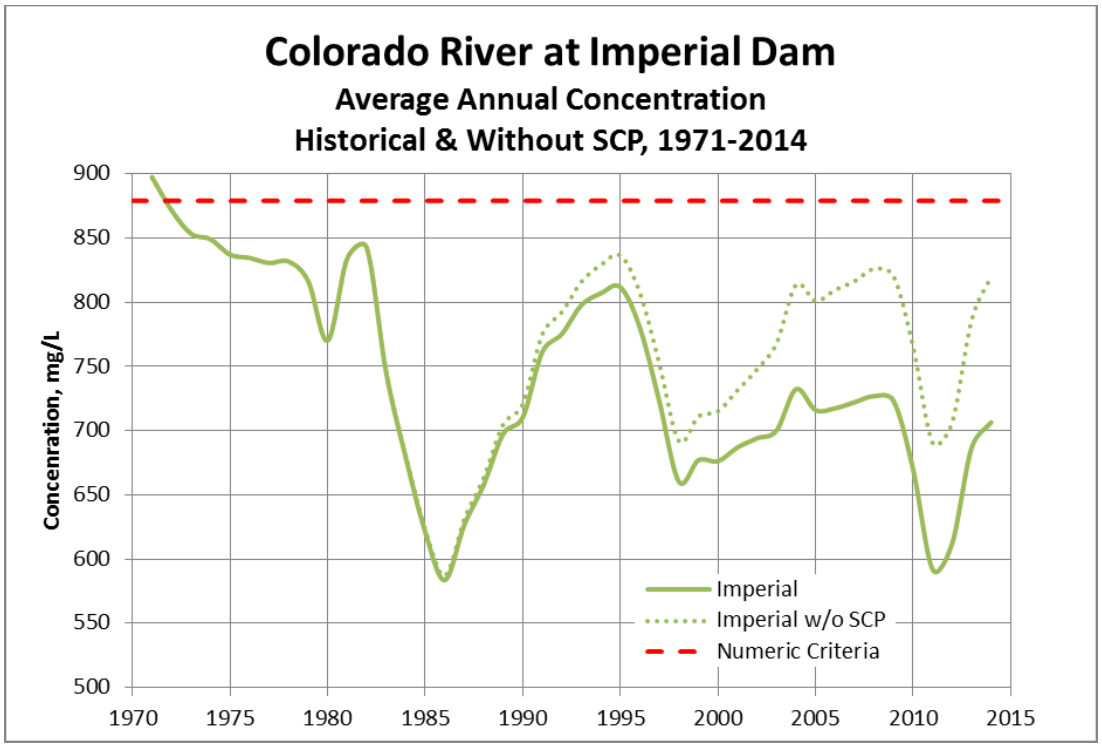

Figure 5 – Salinity Control Program Impact at Imperial Dam

Table 1
Control Measures in Place through 2017

Tons/Year		Tons/Year	
Agricultural Measures	**1,040,200**	**Non-Agricultural Measures**	**289,800**
Big Sandy	72,900	Paradox Valley Unit	100,900
Blacks Fork	1,100	Meeker Dome	48,000
Grand Valley	277,400	Las Vegas Wash	3,800
Green River	1,600	Ashley Valley WWTP	9,100
Henrys Fork	400	BLM	128,000
Lower Gunnison	218,300		
Mancos	4,700		
Manila	19,400		
McElmo (Dolores)	54,500		
Muddy Creek	600		
Paria	1,800		
Price-San Rafael	142,800		
San Juan	49,400		
Silt	2,400		
Uinta	183,700		
USDA Tier 2	7,500		
Unspecified Projects (USBR & BSP)	1,700		
TOTAL			**1,330,000**

The Plan of Implementation assumes that measures currently in place continue to operate through the 2017 Review period and beyond. Improved water delivery and irrigation systems will need to be continually maintained and efficiently operated to provide reliable salinity control. Much of the financial burden of O&M and replacement of irrigation systems falls to salinity program participants, who are the agricultural producers in the basin. The Forum acknowledges the need for producers to maintain their improved irrigation practices through continued efforts and financial investment. The same is true for the non-agricultural measures as well. The best example may be the Paradox Valley Unit (PVU). The expected life and continued effectiveness of the PVU project is a matter of study by Reclamation and the Forum. The current EIS process and corresponding alternatives studies need to be completed, and an alternative implemented, in order to maintain the levels of salt control currently in place for the PVU.

The Plan of Implementation anticipates the continuation of the Program through the period of the Review. As presented in Table 2, it is anticipated that an additional 63,500 tons annually will be controlled by the Program as set forth in the 2017 Plan of Implementation, resulting in a total of 1,393,500 tons of annual reduction by 2020.

Table 2
Additional Controls - Plan of Implementation 2020

Funding Source	Tons/Year as of 2020
RECLAMATION (Basinwide Program)*	27,400
USDA NRCS (EQIP)	26,100
BLM	5,400
BASIN STATES PROGRAM (BSP)	4,600
TOTAL	**63,500**

*Includes cost-share dollars from Basin States Program

This Plan of Implementation mainly focuses on the improvement of agricultural practices in the Upper Colorado River Basin. These improvements include both on-farm and off-farm activities. The majority of the salt reduction will occur in established salinity project areas, but some will occur outside those areas. Table 3 provides the salinity control project areas and an estimate of the potential salt reductions for both on- and off-farm projects that could occur in those areas. Figure 6 shows the established project areas.

Table 3

Remaining Potential Salinity Control (2018-2035)

Project Area	Total Tons/year
Big Sandy	34,264
Black's Fork	26,900
Grand Valley	207,036
Green River	12,100
Henrys Fork	17,720
Lower Gunnison	533,700
Mancos	19,000
Manila	15,200
McElmo (Dolores)	33,852
Muddy Creek	12,457
Paria	29
Price-San Rafael	66,064
San Juan	13,130
Silt	19,336
Uinta	102,796
USDA Tier 2	8,500
Saline Groundwater Sources	150,000
Nonpoint Sources*	
TOTAL	**1,272,100**

*BLM is reviewing non-point source control potential.

The potential additional controllable salt remaining in all of the identified areas is estimated to be 1,272,100 tons annually, and thus the potential available tons exceed the 63,500 tons of additional annual salinity control identified by the Plan of Implementation.

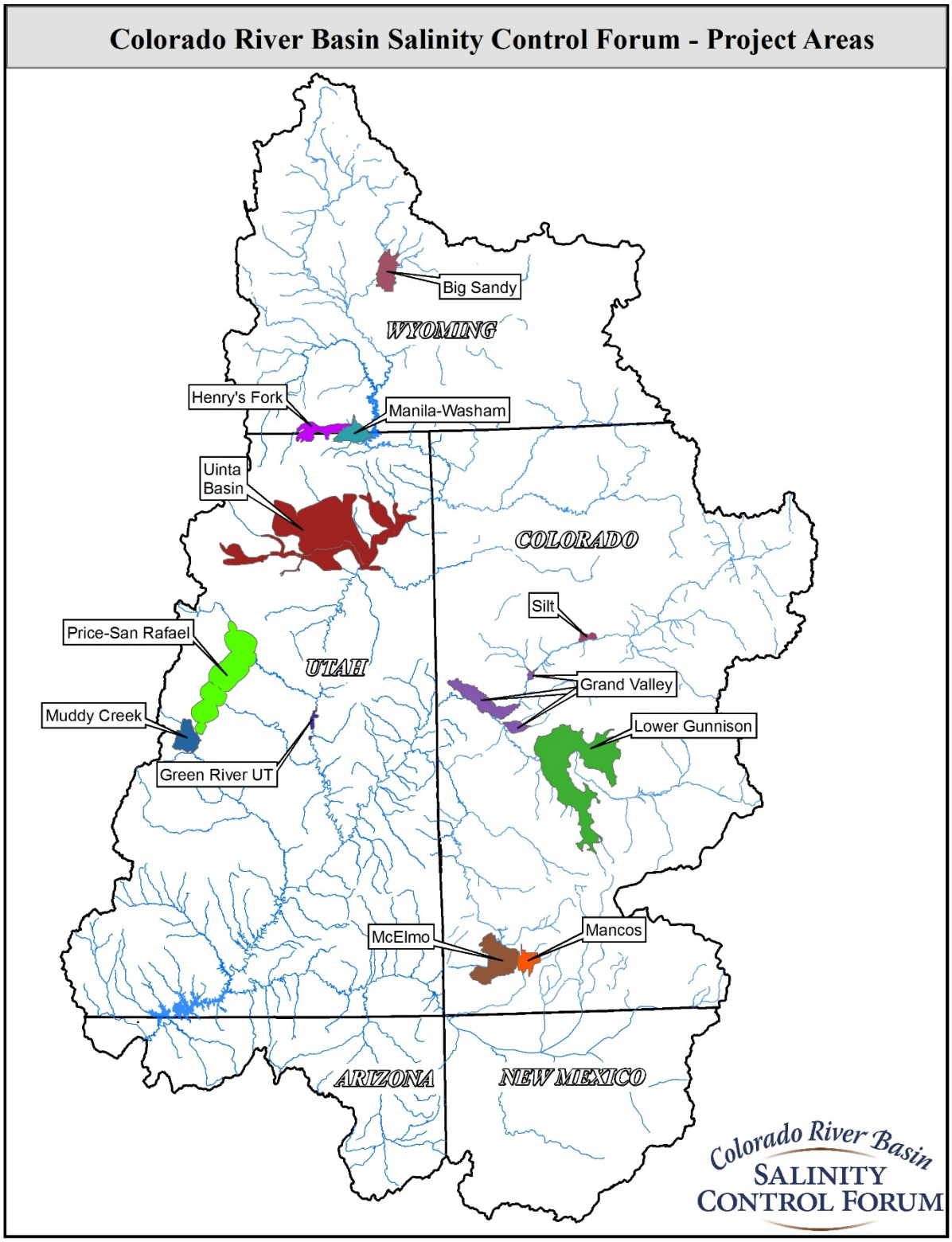

Figure 6 – Colorado River Basin Salinity Control Forum Project Areas

Forum Policies and NPDES Permits

Important components of the Plan of Implementation are the Forum policies and NPDES permits which guide Basin States activities associated with the control of salt discharge to the Colorado River. In 1977, the Forum adopted the Policy for Implementation of Colorado River Salinity Standards through the NPDES Permit Program. This policy provides guidance for the regulation of municipal and industrial point source discharges of saline water. In 1980, the Forum adopted a policy to encourage the use of brackish and/or saline waters for industrial purposes where it is environmentally sound and economically feasible. A third policy dealing with intercepted groundwater was adopted by the Forum in 1982. In 1988, the Forum adopted a fourth policy which addresses the salinity of water discharges from fish hatcheries. The Forum subsequently updated its NPDES policy in 2002 to clarify the Forum policies for consistent implementation among the Basin States. In 2015, a Forum sub-committee found that the States are consistently implementing the policies. These policies are found in Appendix B of this report.

Each of the states has adopted the Forum policies presented in Appendix B. Salinity discharge requirements for these permits are evaluated and practicable controls are required during the permit process. A listing of NPDES permits and level of compliance of discharge facilities within the Basin are presented in Appendix C. Some NPDES permits are issued by EPA for federal facilities and on Indian reservations. The EPA also issues NPDES permits for the state of New Mexico, which are then adopted by the New Mexico Environment Department. Forum policies also apply to EPA-issued NPDES permits and hence, become a part of the Plan of Implementation. The NPDES permits issued by EPA can be found in Appendix D of this report. During the period of this Review, the status of implementation of NPDES permits and water quality management plans in each of the states is as follows:

State Water Quality Management Plans

ARIZONA

Scope

The Colorado River enters Arizona and the Lower Basin near Page and travels through the Grand Canyon before turning southward at Lake Mead (Hoover Dam) and flowing to the Gulf of California. There are four major drainages in Arizona's portion of the Basin: 1) the Little Colorado River; 2) the Virgin River; 3) the Bill Williams River, formed by the Big Sandy and the Santa Maria Rivers at Alamo Lake, which empties into the Colorado River above Parker Dam; and 4) the Gila River, which joins the Colorado River below Imperial Dam. Because the Gila River is below Imperial Dam, facilities that discharge to the Gila River or its tributaries do not require conformance with the Forum policies.

NPDES Permitting

The Water Quality Division of the Arizona Department of Environmental Quality (ADEQ) administers the Arizona Pollutant Discharge Elimination System (AZPDES) program on non-Indian country lands. All permits for domestic wastewater and industrial discharges, with direct river discharges, are written in conformance with associated Forum policies. ADEQ continues to evaluate and revise other discharge permits as information becomes available.

Currently there are 26 active individual discharge permit holders and one minor wastewater treatment plant with general permit coverage in Arizona's non-tribal portion of the Colorado River system. Of these, 21 permits are for municipal or domestic wastewater discharges. The other 5 permits are for industrial discharges related to fish hatcheries, mines, water treatment or water delivery. A specific listing of the individual permits and the status of compliance with Forum policies is contained in Appendix C.

There are currently 10 stream segments in the Basin that are listed in the state's 2016 Section 303(d) list as impaired (2 – Bill Williams, 5 – Colorado River Grand Canyon, 2 – Colorado River Lower Gila, 1 – Little Colorado River). No waters are currently listed for salinity, which only applies to the Colorado River. The primary causes of impairment are selenium (7), suspended sediment (3), *E. Coli* (3), copper (1) and ammonia (1). Complete assessment information can be found on ADEQ's website.

Watershed Planning

ADEQ's TMDL Program and the Water Quality Improvement Grant Program utilize comprehensive watershed-based plans, which contain EPA's required nine elements, to help focus funding to those areas and projects that have the greatest chance for improving water quality. These plans contain implementation strategies for many of the impaired waters, as well as Best Management Practices to address existing and potential issues in the watershed. Recent activities within the Basin have been focused on reducing sediment in the Little Colorado River and the Colorado Grand Canyon.

Work plans are developed to secure grant funding under the Clean Water Act, Section 319(h) for watershed level planning and implementation. The work plans identify and coordinate efforts by state, federal and local agencies, along with watershed groups and private citizens, to reduce or prevent nonpoint source pollution through the use of Best Management Practices and "on-the-ground" projects.

CALIFORNIA

Water Quality Management Planning

The Water Quality Control Plan for the Colorado River Basin (Basin Plan) was adopted by the California Regional Water Quality Control Board, Colorado River Basin (Regional Water Board) in November 1993 and approved by the State Water Resources Control Board (State Water Board) in February 1994. The revised plan became effective upon approval by the Office of Administrative Law (OAL) in August 1994. Subsequent Basin Plan updates include amendments adopted by the State and Regional Water Boards and approved by OAL through March 2017. The salinity control component of the Basin Plan is consistent with the Forum's Plan of Implementation for salinity control. The Regional Water Board collaborates with local entities and the Colorado River Board of California to ensure that implementation of the water quality plan is achieved.

Salinity control in ground and surface waters is a high priority for the State and Regional Water Boards and a very significant concern in arid areas like the Colorado River Basin Region, which relies heavily on water from the lower Colorado River for municipal and agricultural supply. To address rising salinities in groundwater, the State Water Board adopted a *Recycled Water Policy*

in February 2009 which requires the development of Salt and Nutrient Management Plans for groundwater basins throughout California. The plans require basinwide management of salts and nutrients from all sources in a manner that protects groundwater quality and beneficial uses. The salinity of the Colorado River is a critical factor in the development of Salt and Nutrient Management Plans for this region, given the large quantities of water that are diverted from the Colorado River to replenish the Coachella Valley municipal aquifer (over 3.2 million acre-feet to date), and to irrigate crops throughout the Imperial, Palo Verde, Bard and Coachella Valleys.

Controlling nonpoint source pollution generated from agricultural operations is also a top priority of the State and Regional Water Boards. Wastewater discharges from agricultural activities such as irrigation runoff, flows from tile drains and storm water runoff impact water quality by transporting pollutants - pesticides, sediment, nutrients, salts, pathogens, heavy metals and others - from cultivated fields into surface waters. To prevent agricultural discharges from impairing waters that receive these discharges, the State Water Board established the *Irrigated Lands Regulatory Program* in 2003. This program regulates discharges from irrigated agricultural lands by issuing waste discharge requirements (WDRs) or conditional waivers of WDRs (Orders) to growers. The Regional Water Board adopted Conditional Waivers of WDRs for Palo Verde Valley in 2012 and Bard Unit in 2013. Agricultural discharges in these areas are discharged to drains that are tributaries to the Colorado River. These Orders contain conditions requiring water quality monitoring of receiving waters and corrective actions when impairments are discovered.

COLORADO

Scope

Colorado's portion of the Colorado River Basin is comprised of six major drainages: 1) the main stem of the Colorado River from the continental divide to the Utah border, 2) the Roaring Fork River Basin, 3) the Yampa/White River Basin which flows to the Green River in Utah, 4) the Gunnison River Basin, 5) the Dolores River which flows to the main stem in Utah, and 6) the San Juan Basin which flows into New Mexico and then to the main stem in Utah.

NPDES Permitting

The Colorado Department of Public Health and Environment, Water Quality Control Division, administers the NPDES permitting program in the Colorado River Basin, with the exception that EPA issues permits for point source discharges on the Southern Ute and Ute Mountain Ute Reservations, as well as for federally owned lands such as National Parks. This would include permits for discharges to groundwater that would contribute salinity to the Colorado River system through a hydrologic connection to surface waters. Permits for industrial and municipal discharges are written in conformance with the associated Forum policies. Colorado continues to issue stormwater permits to construction of oil and gas development sites and related infrastructure (e.g. roads) of one or more acres of disturbance, even though the Energy Policy Act had exempted this activity from the requirement to obtain a permit at the federal level.

Currently there are more than 250 active discharge permits in the Colorado portion of the Colorado River Basin where the salinity requirements have been applied. A specific listing of the individual permits and compliance status is contained in Appendix C.

Water Quality Assessments and TMDLs

The waters in Colorado's portion of the Colorado River Basin, particularly at higher elevation, are generally of good quality. There are 279 water quality impaired stream segments, including provisional listings, in the Colorado River Basin in Colorado (Gunnison River Basin: 92 impaired segments; Upper and Lower Colorado River Basin: 152 impaired segments; San Juan River Basin: 35 impaired segments) which are included on the 2016 303d List of Impaired Waters. Of these, a significant majority in the lower ends of these basins are impaired for selenium. Water quality impairments in the mountainous portions of these basins are due to high concentrations of metals, primarily caused by the remnants of historic mining activities. No waters are currently listed for salinity related impacts.

The lower portions of each of these basins are underlain by bedrock deposits of the cretaceous period, most notably Mancos Shale and Dakota Sandstone. The Mancos Shale is a marine deposit and, as such, contains significant amounts of readily soluble constituent materials, including selenium. Groundwater which leaches to the relatively impermeable shale deposits tends to dissolve selenium and, as it flows atop the bedrock strata toward surface drainages, carries elevated levels of dissolved selenium with it. Various anthropogenic activities like sand and gravel extraction and agricultural and urban landscape irrigation accelerate the mobilization and transport of selenium from shale and shale-derived soil to surface water.

Watershed Planning - Colorado River Basin Selenium/Salinity Nonpoint Source Activities

Recent activities in the Basin range from watershed planning to Best Management Practices implementation for selenium and salinity reduction. The Middle Colorado Watershed Plan for the area from Glenwood Canyon to DeBeque Canyon has been completed and covers selenium impacted water bodies. The watershed stakeholders are now doing more detailed sampling and source characterization in a high priority sub-watershed. The Colorado Water Quality Control Division continues to monitor streams and lakes on or tributary to the main stem of the Colorado River and conduct outreach in preparation for developing TMDLs for impaired water bodies from DeBeque Canyon to the Utah state line.

Selenium reduction goals are highly dependent upon salinity control efforts occurring in the Basin where selenium is often found in conjunction with salinity. Numerous projects for selenium and salinity control are ongoing in the Basin. The Gunnison River Basin Selenium Management Program provides details of past, current and planned projects. Salinity reductions associated with this program are attributed to previous and on-going off-farm and on-farm salinity control efforts implemented through the Colorado River Basin Salinity Control Program, Environmental Quality Incentives Program, National Irrigation Water Quality Program, and Colorado Nonpoint Source Program. Of recent note is the marked increase in funding for the 2014 Lower Gunnison Project entitled, *Modernizing Agricultural Water Management in the Lower Gunnison River Basin: A Cooperative Approach to Increased Water Use Efficiency and Water Quality Improvement* through the U.S. Department of Agriculture, Natural Resources Conservation Service, Regional Conservation Partnership Program. This funding will significantly accelerate and expand control activities.

NEVADA

Scope

The Basin within Nevada consists of three major tributaries: 1) the Virgin River, 2) the Muddy River, and 3) the Las Vegas Wash. All of these tributaries flow into Lake Mead and provide nearly all of the inflow to the river from Nevada.

NPDES Permitting

The Nevada Division of Environmental Protection is the EPA delegated authority for the issuance of NPDES Permits. As of December 31, 2016, there were 94 active discharge permits in the Nevada portion of the Colorado River System. The largest dischargers, the City of Las Vegas, the Clark County Water Reclamation District, the City of Henderson, and the City of North Las Vegas are permitted to discharge a maximum flow up to 91 mgd, 150 mgd, 40 mgd, and 25 mgd respectively. The quality of the water affected by these permits is closely monitored and all necessary programs to protect water quality standards are being implemented. Nevada continues to apply the policies adopted by the Forum.

Water Quality Management Planning

Area-wide water quality management planning duties and powers have been vested to certain counties and entities. The Clark County Board of Commissioners was designated the Area-Wide Water Quality Management Planning organization within Clark County. The initial 208 Plan was adopted by the Clark County Board of Commissioners in 1978 and was approved by the EPA. Since that time, several 208 Plan revisions have been made as needed to address changing needs.

TMDLs

In 1987, the Nevada Division of Environmental Protection established total phosphorus and total ammonia Waste Load Allocations (WLAs) in the Las Vegas Wash at Northshore Road as needed to meet the Las Vegas Bay water quality standards. The WLAs set are applicable for only April through September and were based upon target concentrations (0.64 mg/L total phosphorus, 1.43 mg/L total ammonia) and average stream flows.

NEW MEXICO

Scope

New Mexico's portion of the Basin above Imperial Dam is comprised of two major drainages: 1) the Rio Puerco, which is a tributary of the Little Colorado River, and 2) the San Juan River, which is a major tributary of the Colorado River.

NPDES Permitting

In New Mexico, authority for issuing permits is administered by EPA Region 6, except for facilities located on the Navajo Indian Reservation, which are administered by Region 9. Permits for industrial and municipal discharges are written in conformance with the associated Forum policies. The State of New Mexico Water Quality Standards for Interstate and Intrastate

Surface Waters 20.6.4.54 adopt the standards of the Colorado River Basin Salinity Control Forum by reference. Currently, there are 34 discharge permits (active and inactive) in the New Mexico portion of the Basin, of which Region 6 administers 21 permits and Region 9 administers 13 Navajo Reservation permits. Of these, 18 permits (14 non-Indian, 4 Navajo) are for industrial discharges and 16 permits (6 non-Indian, 1 Jicarilla Apache, 9 Navajo) are associated with municipal wastewater discharges.

Water Quality Assessment and TMDLs

The New Mexico Water Quality Control Commission has adopted the framework for water quality in New Mexico, which includes the State of New Mexico Water Quality Management Plan and the New Mexico Nonpoint Source Management Plan. Both plans cover the entire state, except for that portion of the tribal and pueblo lands lying therein. Planning within the reservations is the sole responsibility of the Tribes and Pueblos. Much of the Basin in New Mexico falls within the boundaries of the Navajo Tribe's reservation.

The following TMDLs have been adopted by the New Mexico Water Quality Control Commission and approved by EPA within the New Mexico portion of the Basin at this time:

- Animas River: *E. coli*, nutrients
- Gallegos Canyon: selenium
- La Plata River: *E. coli*, siltation, dissolved oxygen
- San Juan River: *E. coli*, sedimentation/siltation

Sample collection for the most recent San Juan Basin Surface Water Quality Survey was completed in 2010 by the Surface Water Quality Bureau of the New Mexico Environment Department. A new survey for this basin begins March 2017 and will span 2 years for sampling throughout the basin. These surveys are normally scheduled throughout the various watersheds and basins in the state on a 7 to 8 year cycle.

Watershed Planning

Work plans are developed and grant funding secured under Clean Water Act Section 319(h) for watershed-associated development, riparian area restoration, certification of Section 404 permits, spill response and treatment of abandoned mines. The work plans identify and coordinate efforts by state, federal and local agencies, along with other groups and private citizens, to reduce or prevent non-point source pollution and implement Best Management Practices to reduce non-point source pollutants. The New Mexico Environment Department and the San Juan Watershed Group, an unincorporated citizen and interagency group funded by the Section 319(h) program, are working to improve water quality in the San Juan River by implementing Best Management Practices for non-point source contributors of nutrients and *E. coli*. State Revolving Loan Funds and other funds are authorized and available for use in funding salinity control projects. State actions in support of salinity control include: 1) inclusion of salinity control measures in the Section 208 plans, 2) dissemination of information on salinity sources and control, 3) consultation with industries on potential salinity reduction measures, 4) implementation of Forum policy through NPDES permits, and 5) maintaining a continuous water quality planning program whereby new or additional salinity control measures can be addressed.

UTAH

Scope

Utah's portion of the Colorado River Basin is comprised of ten major sections: 1) the main stem of the Colorado River from the Colorado border to the Arizona Border in Lake Powell, 2) the Green River Basin from the Wyoming state line in Flaming Gorge Reservoir to the confluence with the Colorado River, 3) the Duchesne River Basin, 4) the lower Yampa and White River Basins which flow to the Green River in Utah, 5) the Price and San Rafael River Basins, 6) the Dirty Devil and Escalante Rivers, 7) the lower portion of the San Juan River Basin which flows into the main stem of the Colorado River in Utah, 8) the Paria River, 9) the Kanab Creek Basin to the Arizona State Line, and 10) the Virgin River Basin to the Arizona state line.

NPDES Permitting

The Utah Division of Water Quality (DWQ) within the Utah Department of Environmental Quality administers the NPDES permitting program in Utah. Permits for industrial and municipal discharges within the Colorado River Basin are written in conformance with the associated Forum policies and are available for viewing on line at:
https://deq.utah.gov/Permits/water/updes/index.htm.

As of December 31, 2016, there are 74 discharge permits as issued by DWQ in the Utah portion of the Colorado River Basin. Of these, 32 are for municipal discharges and 42 are for industrial discharges, of which 6 industrial permits have been recently terminated. A specific listing of the individual permits and their compliance status is contained in Appendix C. Multiple discharge permits for coal mining operations in Utah were developed to offset salinity contributions from industrial sources in accordance with the Forum policy initially adopted as part of the 2002 Triennial Review. The salinity-offset project plans have been finalized previously, with projects implemented to offset salinity contributions in excess of the one ton per day requirement from those facilities.

Water Quality Assessments and TMDLs

The waters in Utah's portion of the Colorado River Basin are generally of good quality. There have been 30 stream segments listed for impacts from salinity/TDS/chlorides. These segments are generally in the lower reaches of the respective basins and are the result of a combination of natural salt loadings and agricultural drainage. TMDLs have been developed to address these salinity/TDS/chloride impairments. F or information about the completed studies and to view the current Utah 303(d) list of impaired water bodies, please visit:
https://deq.utah.gov/ProgramsServices/programs/water/watersheds/index.htm.

Watershed Planning

Utah's Watershed Protection program is focused on protecting and restoring the water quality of its streams, lakes and groundwater resources by employing the following key elements: Stewardship, Monitoring and Assessment, Coordination, Implementation of Best Management Practices and Watershed Planning. Although projects exist in other regions, currently the Upper Colorado Basin region in Utah has no w atershed planning projects in progress to specifically

address Total Dissolved Solids. The Basin Plans for the Utah State Water Plan include water quality as part of the process and these plans are updated periodically.

WYOMING

Scope

Wyoming's portion of the Basin is comprised of two major main stream drainages: 1) the Little Snake River, which is a tributary of the Yampa River in Colorado, and 2) the Green River, which empties into Flaming Gorge Reservoir on the Wyoming-Utah border.

NPDES Permits

Currently there are 32 active discharge permits in the Wyoming portion of the Colorado River system. All permits for industrial and municipal discharges are written in conformance with Forum policies. Of the 32 permits, 13 are for industrial discharges related to fish hatcheries, coal mines, power plants or oil and gas production facilities and 19 of the permits are associated with municipal wastewater discharges. These facilities serve a total population of approximately 50,000 people. A specific listing of the individual permits and compliance status is contained in Appendix C.

Water Quality Assessments and TMDLs

In general, water quality in the Upper Colorado River basin in Wyoming is good. There are currently only 11 streams and rivers identified as either impaired or threatened in the State's 2014 Section 303(d) List (12 pollutant/segment combinations on 7 streams/rivers in the Green River Basin and 7 pollutant/segment combinations on 4 streams in the Little Snake River Basin). Of these impaired waters, Bitter Creek in the Green River Basin and Muddy Creek in the Little Snake River Basin are listed for salinity related impacts (chloride). A TMDL for Bitter Creek was initiated in 2012. A TMDL for Muddy Creek is not scheduled for development at this time. Complete assessment information can be found at http://deq.wyoming.gov/wqd/watershed-protection/.

Watershed Planning

Local watershed groups have conducted watershed planning activities for several of the impaired waters within the Green River and Little Snake River Basins. These groups have worked to implement the watershed plans through Wyoming's Clean Water Act Section 319 Grant Program and other state and federal cost-share programs.

In 2010, the Wyoming Water Development Commission (WWDC) revised the river basin water plan for the Green River and Little Snake River drainages. This report updates information about the current uses and projected future uses of water in the basin and includes other useful information such as irrigated lands delineation, hydrologic modeling of major streams, estimated availability of surface and groundwater for future use, and recommendations and strategies for facing current and future water use challenges. Detailed information can be accessed at: http://waterplan.state.wy.us.

In 2012, the WWDC completed a study to identify a consistent viewpoint and accounting

process for environmental and recreational water demands and to help guide river basin planning efforts in moving forward. The study identified the need for available data sources to be defined and analyzed in a way that would assess their interactions with traditional water uses throughout the State of Wyoming. The methodologies developed in the 2012 study are currently being employed in the Green River Basin. This study is scheduled to be completed in the fall of 2017.

CONCLUSION AND ADOPTION OF THE STANDARDS

The Standards consist of two components, the numeric criteria and the Plan of Implementation. No change has been made in the numeric criteria since their adoption in 1975 by the Basin States and approval by EPA. After having conducted this Review, the Forum has again found the numeric criteria to be appropriate and recommends no changes in these criteria. The Forum also finds that the updated Plan of Implementation is adequate to keep the salinity concentration of the Colorado River below the numeric criteria through 2020, thus providing significant benefits to the Basin. The effect of the Plan of Implementation on the Standard is that the probability of exceeding the numeric criteria is extremely low, less than 5 percent in any given year, for the review period and provides a measurable improvement to the quality of the Colorado River.

The Forum and the Basin States remain committed to continued improvement of the water quality of the Colorado River.

The Program is truly unique and it cannot be successful without cooperation from a multitude of agencies and governments involved at the local, state and federal levels. First, the Program is reliant on the cooperation of land owners in implementing important and cost-effective salinity control measures. Second, the Program is dependent on a multitude of agreements among the Basin States which have always been accomplished by consensus. Last, the Program depends on the cooperation of a number of federal agencies for its success. In addition to the three federal implementing agencies, there are other federal agencies which are involved in the Program, and cooperation and coordination with these agencies is also essential. Three notable agencies are: United States Fish & Wildlife Service, United States Geological Survey and EPA. All the federal agencies are a critical part of the Program. It is expected that by their involvement in the preparation of this Review, those federal agencies will support the Plan of Implementation and its programs.

In June of 2017, the Forum adopted their proposed 2017 Review. During the summer of 2017 comments on the proposed 2017 Review were solicited. Each state sent out notice of the proposed 2017 Review and it was posted on the Forum's website. No comments were received requesting modification of the draft 2017 Review. At the Forum meeting held October 24, 2017, the Forum approved this 2017 Review.

With the approval of this Review by the Forum, each of the Basin States will include these standards as a part of its own water quality standards through its own procedures and obtain approval of its own water quality standards from EPA. Because the Basin contains portions of three EPA regions, the States of Utah, Colorado and Wyoming submit their triennial reviews to EPA Region 8 in Denver, Colorado; New Mexico to EPA Region 6 in Dallas, Texas; and Nevada, Arizona and California to EPA Region 9 in San Francisco, California. It is anticipated that EPA, by approval of the states' submittals, will fully support this salinity control effort.

FUTURE PROGRAM

As described in earlier sections of this report, the water quality standard for salinity in the Colorado River Basin is expected to be met during the review period (over the next three years, 2018-2020). Given average hydrology in the basin, the probability of exceeding the numeric criteria, while putting into practice the outlined Plan of Implementation, is well within the established water quality standard. Nonetheless, as water development continues to occur throughout the Basin, salinity concentrations and the associated economic damages are projected to increase. Therefore, this section will analyze the comparative changes in Colorado River salinity under different implementation scenarios from the present through 2035. The efforts of the Program are to minimize downstream economic damages while the Upper Basin States continue to develop their Compact-apportioned water supplies. This effort is increasingly challenging as economic damage levels and costs increase over time, thus placing greater burdens on Program implementation.

Reclamation used its Colorado River Simulation System (CRSS) model to project salinity levels for the period 2017 through 2035 with the varying levels of Program implementation. The CRSS model simulates 107 separate hydrologic traces for each year and then calculates the average annual salinity. A detailed description of the CRSS model and the model runs made for this Review are found in Appendix E.

The Forum requested that Reclamation analyze the effects on the salinity of the River for four levels of program implementation (tons of salt removed). The Forum chose the levels of implementation based on different assumptions regarding federal funding and state cost share and the tons of salt available for future control. Scenario 1 shows implementation ceasing new salinity control measures post 2017 without executing the Plan of Implementation described in the Review. Scenario 2 shows execution of the Plan of Implementation through 2020 and ceasing to implement new salinity control measures thereafter. Two additional scenarios evaluate the water quality improvement of the Colorado River with continued implementation of salinity control beyond 2020. These scenarios differ by levels of anticipated funding to support implementation. Scenario 3 assumes a consistent level of federal appropriation provided to the program as in recent years and implements measures to control an additional 270 Ktons by 2035. Scenario 4 targets longer term Forum goals to implement measures to control an additional 400 Ktons by 2035. These additional measures will require a 30% increase in Program funding above current levels (Scenario 3).

Table 4 shows the four scenarios modeled by Reclamation with the tons of annual salinity control in place by the year 2035.

Table 4
Plan of Implementation Levels Modeled by CRSS

Description	Total Control
Scenario 1 - No additional controls beyond 2017 (does not implement the Plan of Implementation identified herein)	1.33M tons
Scenario 2 - No additional controls after this review period (i.e. Program ceases after 2020)	1.39M tons
Scenario 3 - Controls associated with recent Program funding levels through 2035	1.66M tons
Scenario 4 - Controls associated with expanded Program funding levels through 2035	1.79M tons

Note: "No additional controls" contemplates some continuing O&M expenditures to maintain existing facilities.

The modeling shows that the difference between no additional salinity controls (Scenario 1) and an optimistic level of Program implementation of 1.79 million tons (Scenario 4) is approximately 30-40 mg/L by the year 2035. These values are summarized in Figures 7, 8 and 9 below for the three numeric criteria points.

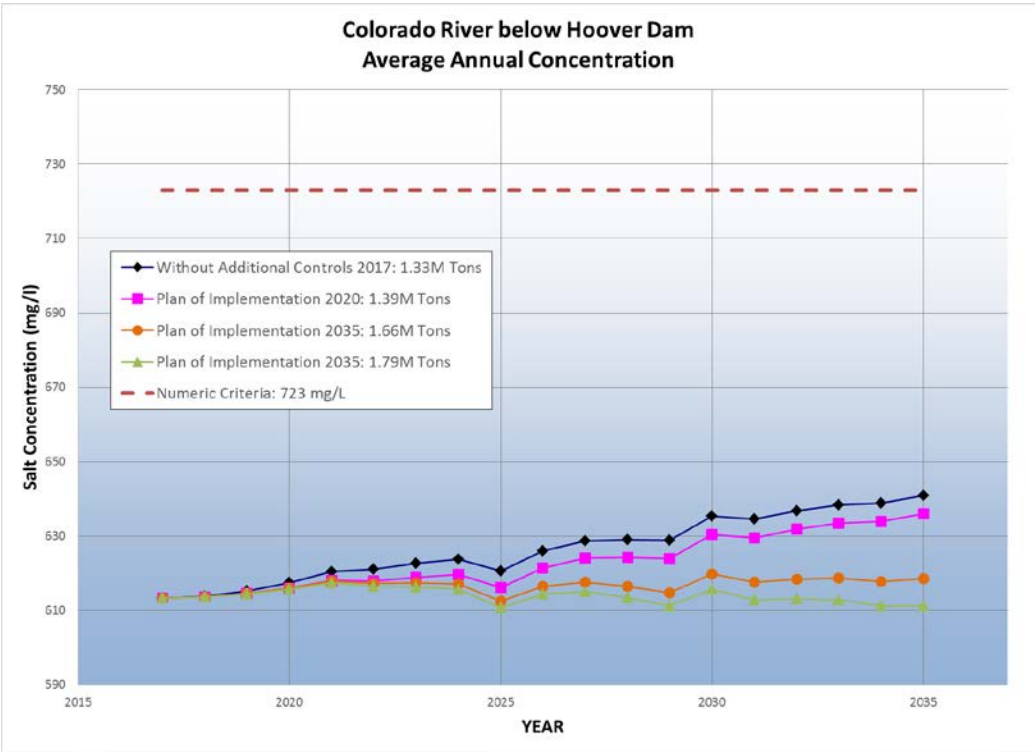

Figure 7 – Projected Average Annual Salinity Concentration below Hoover Dam

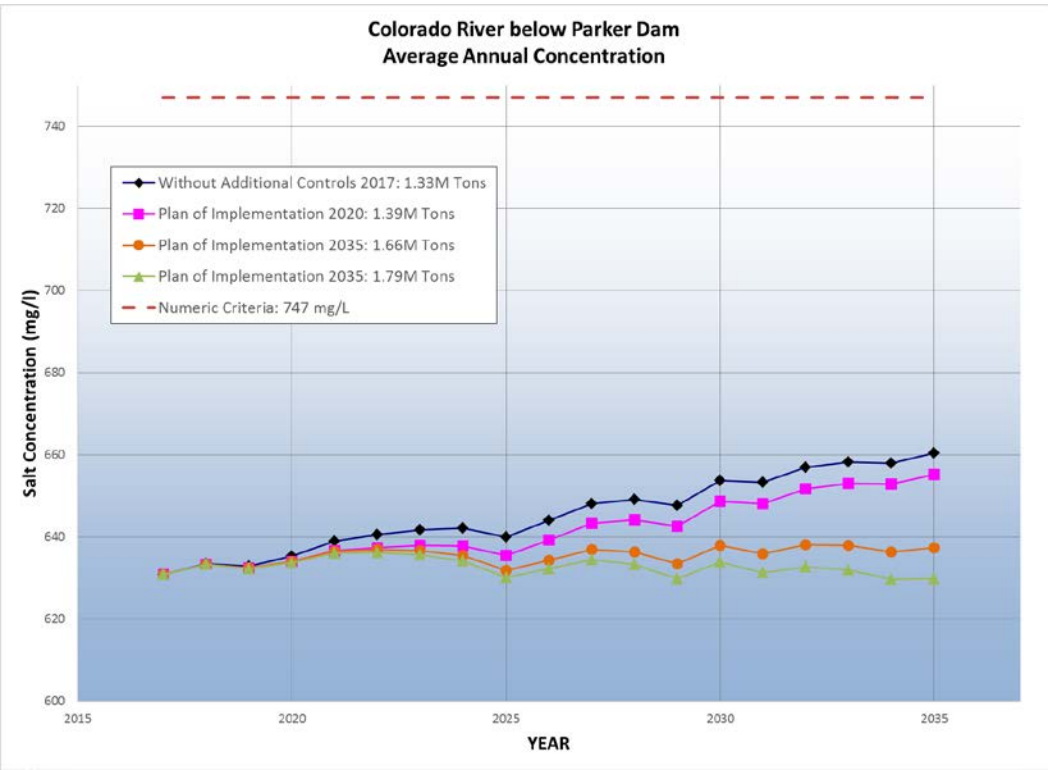

Figure 8 – Projected Average Annual Salinity Concentration below Parker Dam

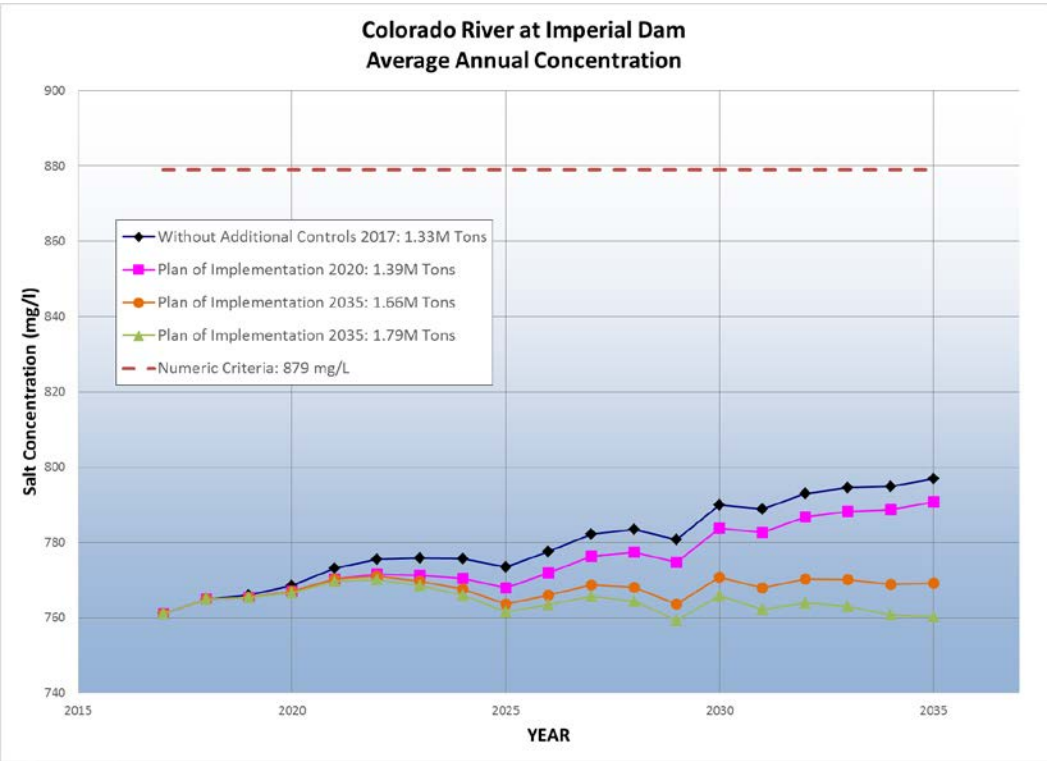

Figure 9 – Projected Average Annual Salinity Concentration at Imperial Dam

To further understand the impacts of reducing the salinity concentrations in the Lower Basin, the Forum used Reclamation's Salinity Economic Impact Model (SEIM), which is described in Appendix F, to estimate damages under the four Plan of Implementation alternatives. Damage estimates for each alternative are listed in Table 5 under the heading "Total Quantified Damages." Estimated damage reductions resulting from lower salinity concentrations projected under each alternative were derived by subtracting the "Total Quantified Damages" from the base case of 1.33 Mtons removed, or $574.2M. These estimates are listed in Table 5 as "Annual Damage Reductions." The SEIM model only estimates damages to the Lower Basin that can be reasonably *quantified* at the present time (see Appendix F). In addition to the currently *unquantified* damages in the Lower Basin, there are also benefits from the Program in the Upper Basin that have yet to be quantified.

Table 5
Annual Damages and Damage Reductions for Plan of Implementation Alternatives

Alternative	Salinity Reduction at Imperial Dam in 2035 (mg/L)	Total Quantified Damages (2014 Dollars)	Annual Damage Reductions as Compared to No Additional Future Controls Beyond 2017
1.33 Mtons removed	--	$574.2M	--
1.39 Mtons removed	6	$558.1M	$16.1M
1.66 Mtons removed	28	$500.4M	$73.8M
1.79 Mtons removed	37	$477.4M	$96.8M

All damage and reduced-damage estimates correspond to year 2035.

From these calculations, it can be seen that as more salinity control is implemented and the concentrations at the numeric criteria points are reduced, the *quantified* economic damages projected to be experienced annually by users in the Lower Basin are also reduced. For example, as indicated in Table 5, with the additional 63,500 tons of control (the difference between the 1.33 million ton and 1.39 million ton alternatives) annually, the *quantified* economic damages to agricultural and municipal and industrial water users are reduced by approximately $16.1 million annually.

While it is essential to continue to maintain salinity concentrations at or below the numeric criteria, the Forum will continue to focus on opportunities to further reduce future economic damages. The Forum believes a more robust salinity control program is needed to achieve the reductions indicated in Table 5. Two of the challenges facing the Forum in pursuing such a program are finding cost effective salinity control projects and acquiring the necessary funding to implement those projects. The Forum is committed to continue working with the federal

agencies to identify cost effective projects. The Forum is also committed to working with the federal agencies and Congress to seek additional appropriations and to generate the cost share revenues needed to support additional federal expenditures. The Forum determines that all of the alternatives evaluated above are economically justifiable. However, given the current financial constraints, the Forum, for this review period, will pursue a Program designed to remove at least 1.66 million tons annually by the year 2035. This may require legislation to alter the states' cost share or other actions to meet the identified Program levels.

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APPENDIX A

Flow Weighted Salinity Values at the Three Numeric Criteria Stations

Observed Flow-Weighted Average Salinity at the Numeric Criteria Stations (Total Dissolved Solids in mg/L)[1]

Calendar Year (Numeric Criteria)	Below Hoover Dam (723 mg/L)	Below Parker Dam (747 mg/L)	At Imperial Dam (879 mg/L)
1970	743	760	896
1971	748	758	892
1972	724	734	861
1973	675	709	843
1974	681	702	834
1975	680	702	829
1976	674	690	822
1977	665	687	819
1978	678	688	812
1979	688	701	802
1980	691	712	760
1981	681	716	821
1982	679	713	827
1983	659	678	727
1984	598	611	675
1985	556	561	615
1986	517	535	577
1987	519	538	612
1988	529	540	648
1989	564	559	683
1990	587	600	702
1991	629	624	749
1992	657	651	767
1993	665	631	785
1994	667	673	796
1995	654	671	803
1996	618	648	768
1997	585	612	710
1998	559	559	655
1999	549	550	670
2000	539	549	661
2001	550	549	680
2002	561	572	689
2003	584	592	695
2004	625	644	729
2005	643	668	710
2006	646	671	720
2007	632	657	715
2008	620	644	733
2009	604	624	717
2010	577	600	690
2011	568	591	681
2012	548	569	677
2013	551	567	677
2014	581	598	695
2015	615	635	725
2016 [2]	583	621	702

[1] Determined by the USGS from data collected by Reclamation and USGS
[2] 2016 values are provisional

Salinity concentrations are based on TDS as the sum of constituents whenever possible. The sum of constituents is defined to include calcium, magnesium, sodium, chloride, sulfate, a measure of the carbonate equivalent of alkalinity and, if measured, silica and potassium.

APPENDIX B

Forum Policies

POLICY FOR IMPLEMENTATION OF COLORADO RIVER SALINITY STANDARDS THROUGH THE NPDES PERMIT PROGRAM

Adopted by
The Colorado River Basin Salinity Control Forum

February 28, 1977
Revised October 30, 2002

In November 1976, the United States Environmental Protection Agency Regional Administrators notified each of the seven Colorado River Basin states of the approval of the water quality standards for salinity for the Colorado River System as contained in the document entitled "Proposed Water Quality Standards for Salinity Including Numeric Criteria and Plan of Implementation for Salinity Control, Colorado River System, June 1975, and the supplement dated August 25, 1975. The salinity standards including numeric criteria and a plan of implementation provide for a flow weighted average annual numeric criteria for three stations in the lower main stem of the Colorado River: below Hoover Dam, below Parker Dam, and at Imperial Dam.

In 1977, the states of the Colorado River Basin adopted the "Policy for Implementation of Colorado River Salinity Standards through the NPDES Permit Program." The plan of implementation is comprised of a number of federal and non-federal projects and measures to maintain the flow- weighted average annual salinity in the Lower Colorado River at or below numeric criteria at the three stations as the Upper and Lower Basin states continue to develop their compact-apportioned waters. One of the components of the Plan consists of the placing of effluent limitations, through the National Pollutant Discharge Elimination System (NPDES) permit program, on industrial and municipal discharges.

NPDES Policy for Municipal and Industrial Discharges of Salinity in the Colorado River

The purpose of this policy is to provide more detailed guidance in the application of salinity standards developed pursuant to Section 303 and through the NPDES permitting authority in the regulation of municipal and industrial sources. (See Section 402 of the Federal Water Pollution Control Act.) The objective of the policy, as provided in Sections I.A. and I.B., is to achieve "no salt return" whenever practicable for industrial discharges and an incremental increase in salinity over the supply water for municipal discharges. This policy is applicable to discharges that would have an impact, either direct or indirect on the lower main stem of the Colorado River System. The lower main stem is defined as that portion of the River from Hoover Dam to Imperial Dam.

In October, 2002, the Forum substantially amended the NPDES policies relating to industrial discharges but made no changes to the procedures for municipal discharges. In the printing of the 2002 Review, however, the section relating to municipal discharges and an additional appendix entitled “Guidance on New Construction Determination” were inadvertently omitted.

Both errors have been corrected in this printing and the Forum reaffirms the validity of all of the policies as they appear in this document.

NPDES Policies Separately Adopted by the Forum

The Forum developed a separate and specific policy for the use of brackish and/or saline waters for industrial purposes on September 11, 1980. The Forum addressed the issue of intercepted ground water and adopted a specific policy dealing with that type of discharge on October 20, 1982. On October 28, 1988, the Forum adopted a specific policy addressing the water use and discharge associated with fish hatcheries. Each of these separately adopted policies is attached hereto.

NPDES Policies for Specified Industrial Discharges – 2002 Amendments

On October 30, 2002, the Forum amended this policy for implementation of Colorado River salinity standards through the NPDES permit program in order to address the following three additional types of industrial discharges: (1) water that has been used for once-through noncontact cooling water purposes; (2) new industrial sources that have operations and associated discharges at multiple locations; and (3) "fresh water industrial discharges" where the discharged water does not cause or contribute to exceedances of the salinity standards for the Colorado River System. This policy was also amended to encourage new industrial sources to conduct or finance one or more salinity-offset projects in cases where the permittee has demonstrated that it is not practicable to prevent the discharge of all salt from proposed new construction.

Discharges Of Once-Through Noncontact Cooling Water

Section I.C. of this policy has been added to address discharges of water that has been used for once-through noncontact cooling water purposes. The policy for such discharges shall be to permit these uses based upon a finding that the returned water does not contribute to the loading or the concentration of salts in the waters of the receiving stream beyond a *de minimis* amount. A *de minimis* amount is considered, for purposes of this policy, as an average annual increase of not more than 25 milligrams per liter (mg/L) in total dissolved solids measured at the discharge point or outfall prior to any mixing with the receiving stream in comparison to the total dissolved solids concentration measured at the intake monitoring point of the cooling process or facility. This policy is not intended to supersede any other water quality standard that applies to the receiving stream, including but not limited to narrative standards promulgated to prohibit impairment of designated uses of the stream. It is the intent of the Forum to permit the return of once-through noncontact cooling water only to the same stream from which the water was diverted. Noncontact cooling water is distinguished from blowdown water, and this policy specifically excludes blowdown or any commingling of once-through noncontact cooling water with another waste stream prior to discharge to the receiving stream. Sections I.A. and I.B. of this policy govern discharges of blowdown or commingled water.

New Industrial Sources with Operations and Discharges at Multiple Locations under Common or Affiliated Ownership or Management

Recently there has been a proliferation of new industrial sources that have operations and associated discharges at multiple locations. An example is the recent growth in the development of energy fuel and mineral resources that has occurred in the Upper Colorado River Basin. This type of industrial development may involve the drilling of relatively closely spaced wells into one or more geological formations for the purpose of extracting oil, gas or minerals in solution. Large-scale ground water remediation efforts involving multiple pump and treat systems operating for longer than one year may share similar characteristics. With such energy and mineral development and ground water remediation efforts there is the possibility of a single major industrial operation being comprised of numerous individual point source discharges under common or affiliated ownership or management that produce significant quantities of water as a waste product or byproduct over a long period. Given the large areal scope of these types of major industrial sources and the often elevated concentrations of salinity in their produced water, the total amount of salt loading that they could generate may be very large in comparison to the Forum's past and present salt removal projects. Relatively small quantities of this produced water could generate one ton per day in discharges to surface waters. Since salinity is a conservative water quality constituent, such discharges of produced water, if uncontrolled, could have an adverse effect on achieving the adopted numeric salinity standards for the Colorado River System.

These kinds of major industrial sources strain the conventional interpretation of the industrial source waiver for new construction set forth in Section I.A.1.a. of this policy, which authorizes a discharge of salinity from a single point source of up to one ton per day in certain circumstances. The Forum adopted this provision in 1977, well before most of the new major industrial sources that have operations and discharges at multiple locations began to appear in the Colorado River Basin. A new category of industrial sources is, therefore, warranted. NPDES permit requirements for New Industrial Sources with Operations and Discharges at Multiple Locations under Common or Affiliated Ownership or Management are set forth in Section I.D. of this policy. These new requirements are intended to apply to new industrial sources with operations that commence discharging after October 30, 2002.

For purposes of interpreting this policy, "common or affiliated ownership or management" involves the authority to manage, direct, superintend, restrict, regulate, govern, administer, or oversee, or to otherwise exercise a restraining or directing influence over activities at one or more locations that result in a discharge of salinity into the Colorado River System. Common or affiliated ownership or management may be through the ownership of voting securities or may be indicated where individual sources are related through one or more joint ventures, contractual relationships, landlord/tenant or lessor/lessee arrangements. Other factors that indicate two or more discharging facilities are under common or affiliated ownership or management include: sharing corporate executive officers, pollution control equipment and responsibilities, common

workforces, administrative functions, and/or payroll activities among operational facilities at different locations.

Fresh Water Industrial Discharges

Sections I.A. and I.B. of this policy have been amended to allow the permitting authority to authorize "fresh water industrial discharges" where the discharged water does not cause or contribute to exceedances of the adopted numeric salinity standards for the Colorado River System. Different end-of-pipe concentrations of salinity as shown in Table 1 of the policy, are appropriate for discharges to tributaries depending upon their location within the Basin. The concept of "benchmark concentrations" has been developed in order to address this need for different end-of-pipe concentrations. These benchmark concentrations are not to be interpreted as water quality standards. Rather, they are intended to serve solely for the establishment of effluent limits for implementing the waiver for "fresh water discharges." The allowance for freshwater discharges is intended to preserve flows from discharges in the Basin, which do not cause significant degradation of existing ambient quality with respect to salinity. Operations or individual discharges that qualify for the freshwater waiver shall not be subject to any further limitation on salt loading under this policy.

Salinity-Offset Projects

This policy has been amended to allow the permitting authority to authorize industrial sources of salinity to conduct or finance one or more salinity-offset projects when the permittee has determined that it is not practicable: (i) to prevent the discharge of all salt from proposed new construction; (ii) to reduce the salt loading to the Colorado River to less than one ton per day or 366 tons per year; or (iii) the proposed discharge is of insufficient quality in terms of TDS concentrations that it could be considered "fresh water" as defined below. Presently, the permitting authority can consider the costs and availability of implementing off-site salinity control measures to mitigate the adverse impacts of the permitted salt load. It is not intended that the applicant be required to develop or design an off-site salinity control project or establish a salt bank, but rather to assess the costs of conducting or buying into such projects where they are available. In the future the Forum or another entity may create a trading/banking institution to facilitate the implementation of a salinity-offset program, basin-wide. This would allow industrial sources to conduct or finance the most cost effective project available at the time an offset project is needed regardless of the project's location in the Basin.

NPDES PERMIT PROGRAM POLICY FOR IMPLEMENTATION OF COLORADO RIVER SALINITY STANDARDS

I. Industrial Sources

The Salinity Standards state that "The objective for discharges shall be a no-salt return policy whenever practicable." This is the policy that shall be followed in issuing NPDES discharge permits for all new industrial sources, and upon the reissuance of permits for all existing industrial sources, except as provided herein. The following addresses those cases where "no discharge of salt" may be deemed not to be practicable.

A. New Construction

1. "New construction" is defined as any facility from which a discharge may occur, the construction of which is commenced after October 18, 1975. (Date of submittal of water quality standards as required by 40 CFR 120, December 11, 1974.) Attachment 1 provides guidance on new construction determination. "A new industrial source with operations and discharging facilities at multiple locations under common or affiliated ownership or management" shall be defined for purposes of NPDES permitting, as an industrial source that commenced construction on a pilot, development or production scale on or after October 30, 2002.

   a. The permitting authority may permit the discharge of salt upon a satisfactory demonstration by the permittee that:

      i. It is not practicable to prevent the discharge of all salt from the new construction or,

      ii. In cases where the salt loading to the Colorado River from the new construction is less than one ton per day or 366 tons per year, or

      iii. The proposed discharge from the new construction is of sufficient quality in terms of TDS concentrations that it can be considered "fresh water" that would have no adverse effect on achieving the adopted numeric standards for the Colorado River System. The permitting authority may consider a discharge to be fresh water if the maximum TDS concentration is: (i) 500 mg/L for discharges into the Colorado River and its tributaries upstream of Lees Ferry, Arizona; or, (ii) 90% of the applicable in-stream salinity standard at the appropriate benchmark monitoring station for discharges into the Colorado River downstream of Lees Ferry as shown in Table 1, below

Table 1

	Benchmark Monitoring Station	Applicable Criteria	Freshwater Discharge (mg/L)
1	Colorado River at Lees Ferry, Arizona	N/A	500
2	Colorado River below Hoover Dam	723	650
3	Colorado River below Parker Dam	747	675
4	Colorado River at Imperial Dam	879	790

b. Unless exempted under Sections I.A.1.a.ii. or iii., above, the demonstration by the applicant must include information on the following factors relating to the potential discharge:

i. Description of the proposed new construction.

ii. Description of the quantity and salinity of the water supply.

iii. Description of water rights, including diversions and consumptive use quantities.

iv. Alternative plans that could reduce or eliminate salt discharge. Alternative plans shall include:

(A) Description of alternative water supplies, including provisions for water reuse, if any;

(B) Description of quantity and quality of proposed discharge;

(C) Description of how salts removed from discharges shall be disposed of to prevent such salts from entering surface waters or groundwater aquifers;

(D) Costs of alternative plans in dollars per ton of salt removed; and

(E) Unless the permitting authority has previously determined through prior permitting or permit renewal actions that it is not practicable to prevent the discharge of all salt from the new construction in accordance with Section I.A.1.a.i., the applicant must include information on project options that would offset all or part of the salt loading to the Colorado River associated with the proposed discharge or that would contribute to state or interstate salinity control projects or salt banking programs.

v. A statement as to the one plan among the alternatives for reduction of salt discharge that is recommended by the applicant and also information as to which of the other evaluated alternatives are economically infeasible.

vi. Such other information pertinent to demonstration of non- practicability as the permitting authority may deem necessary.

c. In determining what permit conditions shall be required under I.A.1.a.i., above, the permit issuing authority shall consider, but not be limited to the following:

i. The practicability of achieving no-discharge of salt from the new construction.

ii. Where "no discharge" is determined not to be practicable:

(A) The impact of the total proposed salt discharge of each alternative on the lower main stem in terms of both tons per year and concentration.

(B) Costs per ton of salt removed from the discharge for each plan alternative.

(C) Capability of minimizing salinity discharge.

(D) If applicable under I.A.1.b.(iv)(E), costs and practicability of offsetting all or part of the salt load by the implementation of salt removal or salinity control projects elsewhere in the Colorado River Basin. The permittee shall evaluate the practicability of offsetting all or part of the salt load by comparing such factors as the cost per ton of salt removal for projects undertaken by the Colorado River Basin Salinity Control Forum and the costs in damages associated with increases in salinity concentration against the permittee's cost in conducting or buying into such projects where they are available.

iii. With regard to subparagraphs, (b) and (c) above, the permit issuing authority shall consider the compatibility of state water laws with either the complete elimination of a salt discharge or any plan for minimizing a salt discharge.

B. Existing Facilities or any discharging facility, the construction of which was commenced before October 18, 1975

1. The permitting authority may permit the discharge of salt upon a satisfactory demonstration by the permittee that it is not practicable to prevent the discharge of all salt from an existing facility.

2. The demonstration by the applicant must include, in addition to that required under Section I.A.1.b the following factors relating to the potential discharge:

a. Existing tonnage of salt discharged and volume of effluent.

b. Cost of modifying existing industrial plant to provide for no salt discharge.

c. Cost of salt minimization.

3. In determining what permit conditions shall be required, the permit issuing authority shall consider the items presented under I.A.1.c.(ii), and in addition; the annual costs of plant modification in terms of dollars per ton of salt removed for:

a. No salt return.

b. Minimizing salt return.

4. The no-salt discharge requirement may be waived in those cases where:

a. The discharge of salt is less than one ton per day or 366 tons per year; or

b. The permitting authority determines that a discharge qualifies for a "fresh water waiver" irrespective of the total daily or annual salt load. The maximum TDS concentration considered to be fresh water is 500 mg/L for discharges into the Colorado River and its tributaries upstream of Lees Ferry, Arizona. For discharges into the Colorado River downstream of Lees Ferry the maximum TDS concentration considered to be afresh water shall be 90% of the applicable in-stream standard at the appropriate benchmark monitoring station shown in Table 1, above.

C. Discharge of Once-Through Noncontact Cooling Water

1. Definitions:

a. The terms "noncontact cooling water" and "blowdown" are defined as per 40CFR 401.11 (m) and (n).

b. "Noncontact cooling water" means water used for cooling that does not come into direct contact with any raw material, intermediate product, waste product or finished product.

c. "Blowdown" means the minimum discharge of recirculating water for the purpose of discharging materials contained in the water, the further buildup of which would cause concentration in amounts exceeding limits established by best engineering practice.

d. "Salinity" shall mean total dissolved solids as the sum of constituents.

2. Permits shall be authorized for discharges of water that has been used for once-through noncontact cooling purposes based upon a finding that the returned water does not contribute to the loading of salts or the concentration of salts in the waters of the receiving stream in excess of a *de minimis* amount.

3. This policy shall not supplant nor supersede any other water quality standard of the receiving stream adopted pursuant to the Federal Clean Water Act, including but not limited to impairment of designated uses of the stream as established by the governing water quality authority having jurisdiction over the waters of the receiving stream.

4. Noncontact cooling water shall be distinguished from blowdown, and Section 1.C. of this policy specifically excludes blowdown or any commingling of once-through noncontact cooling water with another waste stream prior to discharge to the receiving stream. Sections I.A. and I.B of this policy shall in all cases govern discharge of blowdown or commingled water.

5. Once-through noncontact cooling water shall be permitted to return only to the same stream from which the water was diverted.

6. Because the increase in temperature of the cooling water will result in some evaporation, a *de minimis* increase in the concentration of dissolved salts in the receiving water may occur. An annual average increase in total dissolved solids of not more than 25 milligrams per liter (mg/L) measured at the intake monitoring point, as defined below, of the cooling process or facility, subtracted from the effluent total dissolved solids immediately upstream of the discharge point to the receiving stream, shall be considered *de minimis*.

7. At the time of NPDES discharge permit issuance or reissuance, the permitting authority may permit a discharge in excess of the 25 mg/L increase based upon a satisfactory demonstration by the permittee pursuant to Section 1.A.1.a.

8. Once-through demonstration data requirements:

   a. Description of the facility and the cooling process component of the facility.

   b. Description of the quantity, salinity concentration and salt load of intake water sources.

   c. Description of the discharge, covering location, receiving waters, quantity of salt load and salinity concentration of both the receiving waters and the discharge.

   d. Alternative plans for minimizing salt discharge from the facility which shall include:

      i. Description of alternative means to attain no discharge of salt.

      ii. Cost of alternative plans in dollars per ton of salt removed from discharge.

      iii. Such other information pertinent to demonstration of non- practicability as the permitting authority may deem necessary.

9. If, in the opinion of the permitting authority, the database for the salinity characteristics of the water source and the discharge is inadequate, the permit will require that the permittee monitor the water supply and the discharge for salinity. Such monitoring program shall be completed in two years and the permittee shall then present the once-through demonstration data as specified above.

10. All new and reissued NPDES permits for once-through noncontact cooling water discharges shall require at a minimum semiannual monitoring of the salinity of the intake water supply and the effluent, as provided below.

    a. The intake monitoring point shall be the point immediately before the point of use of the water.

    b. The effluent monitoring point shall be prior to the discharge point at the receiving stream or prior to commingling with another waste stream or discharge source.

    c. Discrete or composite samples may be required at the discretion of the permitting authority, depending on the relative uniformity of the salinity of the water supply.

d. Analysis for salinity may be either total dissolved solids or electrical conductivity where a satisfactory correlation with total dissolved solids has been established. The correlation shall be based on a minimum of five different samples.

D. Discharges of Salinity from a New Industrial Source with Operations and Discharging Facilities at Multiple Locations

1. The objective for discharges to surface waters from a new industrial source with operations and discharging facilities at multiple locations shall be to assure that such operations will have no adverse effect on achieving the adopted numeric salinity standards for the Colorado River System.

2. NPDES permit requirements for a new industrial source with operations and discharging facilities at multiple locations shall be defined, for purposes of establishing effluent limitations for salinity, as a single industrial source if these facilities meet the criteria:

a. The discharging facilities are interrelated or integrated in any way including being engaged in a primary activity or the production of a principle product; and

b. The discharging facilities are located on contiguous or adjacent properties or are within a single production area e.g. geologic basin, geohydrologic basin, coal or gas field or 8 digit hydrologic unit watershed area; and

c. The discharging facilities are owned or operated by the same person or by persons under common or affiliated ownership or management.

3. The permitting authority may permit the discharge of salt from a new industrial source with operations and discharging facilities at multiple locations if one or more of the following requirements are met:

a. The permittee has demonstrated that it is not practicable to prevent the discharge of all salt from the industrial source. This demonstration by the applicant must include detailed information on the factors set forth in Section I.A.1.b of the Policy for implementation of Colorado River Salinity Standards through the NPDES permit program; with particular emphasis on an assessment of salinity off-set options that would contribute to state or interstate salinity control projects or salt banking programs and offset all or part of the salt loading to the Colorado River associated with the proposed discharge.

b. In determining what permit conditions shall be required under I.A.1.a.i., above, the permit issuing authority shall consider the requirement for an offset project to be feasible if the cost per ton of salt removal in the offset

project options (i.e. the permittee's cost in conducting or buying into such projects where they are available) is less than or equal to the cost per ton of salt removal for projects undertaken by the Colorado River Basin Salinity Control Forum or less than the cost per ton in damages caused by salinity that would otherwise be cumulatively discharged from the outfalls at the various locations with operations controlled by the industrial source; or

c. The pemittee has demonstrated that one or more of the proposed discharges is of sufficient quality in terms of TDS concentrations to qualify for a "fresh water waiver" from the policy of "no salt return, whenever practical." An individual discharge that can qualify for a fresh water waiver shall be considered to have no adverse effect on achieving the adopted numeric salinity standards for the Colorado River System.

4. For the purpose of determining whether a freshwater waiver can be granted, the quality of water discharged from the new industrial source with operations and discharging facilities at multiple locations, determined as the flow weighted average of salinity measurements at all outfall points, must meet the applicable benchmark concentration in accordance with Section I.A.1.a.iii., as set forth above.

5. Very small-scale pilot activities, involving 5 or fewer outfalls, that are sited in areas not previously developed or placed into production by a new industrial source operations and discharges at multiple locations under common or affiliated ownership or management, may be permitted in cases where the discharge of salt from each outfall is less than one ton per day or 366 tons per year. However, no later than the date of the first permit renewal after the pilot activities have become part of a larger industrial development or production scale effort, all discharging facilities shall be addressed for permitting purposes as a single industrial source with operations and discharges at multiple locations under common or affiliated ownership or management.

6. The public notice for NPDES permits authorizing discharges from operations at multiple locations with associated outfalls shall be provided promptly and in the most efficient manner to all member states in the Colorado River Basin Salinity Control Forum in relation to this policy.

II. Municipal Discharges

The basic policy is that a reasonable increase in salinity shall be established for municipal discharges to any portion of the Colorado River stream system that has an impact on the lower main stem. The incremental increase in salinity shall be 400 mg/L or less, which is considered to be a r easonable incremental increase above the flow weighted average salinity of the intake water supply.

F. The permitting authority may permit a discharge in excess of the 400 mg/L incremental increase at the time of issuance or reissuance of a NPDES discharge permit, upon satisfactory demonstration by the permittee that it is not practicable to attain the 400 mg/L limit.

G. Demonstration by the applicant must include information on the following factors relating to the potential discharge:

1. Description of the municipal entity and facilities.

2. Description of the quantity and salinity of intake water sources.

3. Description of significant salt sources of the municipal wastewater collection system, and identification of entities responsible for each source, if available.

4. Description of water rights, including diversions and consumptive use quantities.

5. Description of the wastewater discharge, covering location, receiving waters, quantity, salt load, and salinity.

6. Alternative plans for minimizing salt contribution from the municipal discharge. Alternative plans should include:

   a. Description of system salt sources and alternative means of control.

   b. Cost of alternative plans in dollars per ton, of salt removed from discharge.

7. Such other information pertinent to demonstration of non-practicability as the permitting authority may deem necessary.

H. In determining what permit conditions shall be required, the permit issuing authority shall consider the following criteria including, but not limited to:

1. The practicability of achieving the 400 mg/L incremental increase.

2. Where the 400 mg/L incremental increase is not determined to be practicable:

   a. The impact of the proposed salt input of each alternative on the lower main stem in terms of tons per year and concentration.

b. Costs per ton of salt removed from discharge of each alternative plan.

c. Capability of minimizing the salt discharge.

D. If, in the opinion of the permitting authority, the data base for the municipal waste discharger is inadequate, the permit will contain the requirement that the municipal waste discharger monitor the water supply and the wastewater discharge for salinity. S uch monitoring program shall be completed within 2 years and the discharger shall then present the information as specified above.

E. Requirements for establishing incremental increases may be waived in those cases where the incremental salt load reaching the main stem of the Colorado River is less than one ton per day or 366 tons per year. Evaluation will be made on a case-by-case basis.

F. All new and reissued NPDES permits for all municipalities shall require monitoring of the salinity of the intake water supply and the wastewater treatment plant effluent in accordance with the following guidelines:

Treatment Plant Design Capacity	Monitoring Frequency	Type of Sample
<1.0 MGD*	Quarterly	Discrete
1.0 - 5.0 MGD	Monthly	Composite
>5.0 - 50.0 MGD	Weekly	Composite
50.0 MGD	Daily	Composite

1. Analysis for salinity may be either as total dissolved solids (TDS) or be electrical conductivity where a satisfactory correlation with TDS has been established. T he correlation should be based on a minimum of five different samples.

2. Monitoring of the intake water supply may be at a reduced frequency where the salinity of the water supply is relatively uniform.

Attachment 1

Guidance on New Construction Determination

For purposes of determining a new construction, a source should be considered new if by October 18, 1975, there has not been:

I. Significant site preparation work such as major clearing or excavation; and/or

II. Placement, assembly or installation of unique facilities or equipment at the premises where such facilities or equipment will be used; and/or

III. Any contractual obligation to purchase unique facilities or equipment. Facilities and equipment shall include only the major items listed below, provided that the value of such items represents a substantial commitment to construct the facility:

   A. structures; or
   B. structural materials; or
   C. machinery; or
   D. process equipment; or
   E. construction equipment.

IV. Contractual obligation with a firm to design, engineer, and erect a completed facility (i.e., a turnkey plant).

POLICY FOR USE OF
BRACKISH AND/OR SALINE WATERS
FOR INDUSTRIAL PURPOSES

Adopted by
The Colorado River Basin Salinity Control Forum

September 11, 1980

The states of the Colorado River Basin, the Federal Executive Department, and the Congress have all adopted as a policy that the salinity in the lower main stem of the Colorado River shall be maintained at or below the flow-weighted average values found during 1972, while the Basin states continue to develop their compact-apportioned waters. In order to achieve this policy, all steps which are practical and within the framework of the administration of states' water rights must be taken to reduce the salt load of the river. One such step was the adoption in 1975 by the Forum of a policy regarding effluent limitations for industrial discharges with the objective of "no-salt return" wherever practicable. Another step was the Forum's adoption in 1977 of the "Policy for Implementation of Colorado River Salinity Standards through the NPDES Permit Program." These policies are part of the basinwide plan of implementation for salinity control which has been adopted by the seven Basin states.

The Forum finds that the objective of maintaining 1972 salinity levels would be served by the exercise of all feasible measures including, wherever practicable, the use of brackish and/or saline waters for industrial purposes.

The summary and page 32 of the Forum's 1978 Revision of the Water Quality Standards for Salinity state: "The plan also contemplates the use of saline water for industrial purposes whenever practicable,..." In order to implement this concept and thereby further extend the Forum's basic salinity policies, the Colorado River Basin states support the Water and Power Resources Service (WPRS) appraisal study of saline water collection, pretreatment and potential industrial use.

The Colorado River Basin contains large energy resources which are in the early stages of development. The WPRS study should investigate the technical and financial feasibility of serving a significant portion of the water requirements of the energy industry and any other industries by the use of Basin brackish and/or saline waters. The Forum recommends that:

I. The Colorado River Basin states, working with federal agencies, identify, locate and quantify such brackish and/or saline water sources.

II. Information on the availability of these waters be made available to all potential users.

III. Each state encourage and promote the use of such brackish and/or saline waters, except where it would not be environmentally sound or economically feasible, or would significantly increase consumptive use of Colorado River System water in the state above that which would otherwise occur.

IV. The WPRS, with the assistance of the states, encourages and promotes the use of brackish return flows from federal irrigation projects in lieu of fresh water sources, except where it would not be environmentally sound or economically feasible, or would significantly increase consumptive use of Colorado River System water.

V. The WPRS considers a federal contribution to the costs of industrial use of brackish and/or saline water, where cost-effective, as a joint private-government salinity control measure. Such activities shall not delay the implementation of the salinity control projects identified in Title II of P.L. 93-320.

POLICY FOR IMPLEMENTATION OF COLORADO RIVER SALINITY STANDARDS THROUGH THE NPDES PERMIT PROGRAM FOR INTERCEPTED GROUND WATER

Adopted by
The Colorado River Basin Salinity Control Forum

October 20, 1982

The States of the Colorado River Basin in 1977 agreed to the "Policy for Implementation of Colorado River Salinity Standards through the NPDES Permit Program" with the objective for industrial discharge being "no-salt return" whenever practicable. That policy required the submittal of information by the applicant on alternatives, water rights, quantity, quality, and costs to eliminate or minimize the salt discharge. The information is for use by the NPDES permit-issuing agency in evaluating the practicability of achieving "no-salt" discharge.

There are mines and wells in the Basin which discharge intercepted ground waters. The factors involved in those situations differ somewhat from those encountered in other industrial discharges. Continued development will undoubtedly result in additional instances in which permit conditions must deal with intercepted ground water.

The discharge of [1]intercepted ground water needs to be evaluated in a manner consistent with the overall objective of "no-salt return" whenever practical. The following provides more detailed guidance for those situations where ground waters are intercepted with resultant changes in ground-water flow regime.

I. The "no-salt" discharge requirement may be waived at the option of the permitting authority in those cases where the discharged salt load reaching the main stem of the Colorado River is less than one ton per day or 366 tons per year. Evaluation will be made on a case-by-case basis.

II. Consideration should be given to the possibility that the ground water, if not intercepted, normally would reach the Colorado River System in a reasonable time frame. An industry desiring such consideration must provide detailed information including a description of the topography, geology, and hydrology. Such information must include direction and rate of ground-water flow; chemical quality and quantity of ground water; and the location, quality, and quantity of surface streams and springs that might be affected. If the information adequately demonstrates that the ground water to be intercepted normally would reach the river system in a reasonable time frame and would contain approximately the same or greater salt load than if intercepted, and if no significant

[1]The term "intercepted ground water" means all ground water encountered during mining or other industrial operations.

localized problems would be created, then the permitting agency may waive the "no-salt" discharge requirement.

III. In those situations where the discharge does not meet the criteria in I or II above, the applicant will be required to submit the following information for consideration:

A. Description of the topography, geology, and hydrology. Such information must include the location of the development, direction and rate of ground-water flow, chemical quality and quantity of ground water, and relevant data on surface streams and springs that are or might be affected. This information should be provided for the conditions with and without the project.

B. Alternative plans that could substantially reduce or eliminate salt discharge. Alternative plans must include:

1. Description of water rights, including beneficial uses, diversions, and consumptive use quantities.

2. Description of alternative water supplies, including provisions for water reuse, if any.

3. Description of quantity and quality of proposed discharge.

4. Description of how salts removed from discharges shall be disposed of to prevent their entering surface waters or ground-water aquifers.

5. Technical feasibility of the alternatives.

6. Total construction, operation, and maintenance costs; and costs in dollars per ton of salt removed from the discharge.

7. Closure plans to ensure termination of any proposed discharge at the end of the economic life of the project.

8. A statement as to the one alternative plan for reduction of salt discharge that the applicant recommends be adopted, including an evaluation of the technical, economic, and legal Practicability of achieving no discharge of salt.

9. Such information as the permitting authority may deem necessary.

IV. In determining whether a "no-salt" discharge is Practicable, the Permit-issuing authority shall consider, but not be limited to, the water rights and the technical, economic, and legal practicability of achieving no discharge of salt.

V. Where "no-salt" discharge is determined not to be Practicable the permitting authority shall, in determining permit conditions, consider:

A. The impact of the total proposed salt discharge of each alternative on the lower main stem in terms of both tons per year and concentration.

B. Costs per ton of salt removed from the discharge for each plan alternative.

C. The compatibility of state water laws with each alternative.

D. Capability of minimizing salinity discharge.

E. The localized impact of the discharge.

F. Minimization of salt discharges and the preservation of fresh water by using intercepted ground water for industrial processes, dust control, etc. whenever it is economically feasible and environmentally sound.

POLICY FOR IMPLEMENTATION OF COLORADO RIVER SALINITY STANDARDS THROUGH THE NPDES PERMIT PROGRAM FOR FISH HATCHERIES

Adopted by
The Colorado River Basin Salinity Control Forum

October 28, 1988

The states of the Colorado River Basin in 1977 adopted the "Policy for Implementation of Colorado River Salinity Standards through the NPDES Permit Program." The objective was for "no-salt return" whenever practicable for industrial discharges and an incremental increase in salinity over the supply water for municipal discharges. The Forum addressed the issue of intercepted ground water under the 1977 policy, and adopted a specific policy dealing with that type of discharge.

A specific water use and associated discharge which has not been here-to-fore considered is discharges from fish hatcheries. This policy is limited exclusively to discharges from fish hatcheries within the Colorado River Basin. The discharges from fish hatcheries need to be addressed in a manner consistent with the 1977 and 1980 Forum policies.

The basic policy for discharges from fish hatcheries shall permit an incremental increase in salinity of 100 mg/L or less above the flow weighted average salinity of the intake supply water. The 100 mg/L incremental increase may be waived if the discharged salt load reaching the Colorado River system is less than one ton per day, or 366 tons per year. Evaluation is to be made on a case-by-case basis.

I. The permitting authority may permit a discharge in excess of the 100 mg/L incremental increase at the time of issuance or reissuance of a NPDES discharge permit. Upon satisfactory demonstration by the permittee that it is not practicable to attain the 100 mg/L limit.

II. Demonstration by the applicant must include information on the following factors relating to the potential discharge:

   A. Description of the fish hatchery and facilities.

   B. Description of the quantity and salinity of intake water sources.

   C. Description of salt sources in the hatchery.

   D. Description of water rights, including diversions and consumptive use quantities.

   E. Description of the discharge, covering location, receiving waters, quantity salt load, and salinity.

F. Alternative plans for minimizing salt discharge from the hatchery. Alternative plans should include:

1. Description of alternative means of salt control.

2. Cost of alternative plans in dollars per ton, of salt removed from discharge.

G. Such other information pertinent to demonstration of non-practicability as the permitting authority may deem necessary.

III. In determining what permit conditions shall be required, the permit-issuing authority shall consider the following criteria including, but not limited to:

A. The practicability of achieving the 100 mg/L incremental increase.

B. Where the 100 mg/L incremental increase is not determined to be practicable:

1. The impact of the proposed salt input of each alternative on the lower main stem in terms of tons per year and concentration.

2. Costs per ton of salt removed from discharge of each alternative plan.

3. Capability of minimizing the salt discharge.

IV. If, in the opinion of the permitting authority, the database for the hatchery is inadequate, the permit will contain the requirement that the discharger monitor the water supply and the discharge for salinity. Such monitoring program shall be completed within two years and the discharger shall then present the information as specified above.

V. All new and reissued NPDES permits for all hatcheries shall require monitoring of the salinity of the intake water supply and the effluent at the time of peak fish population.

A. Analysis for salinity may be either as total dissolved solids (TDS) or be electrical conductivity where a satisfactory correlation with TDS has been established. The correlation should be based on a minimum of five different samples.

APPENDIX C

States NPDES Permits List

LEGEND

NPDES PERMITS
EXPLANATION CODES

COLORADO RIVER BASIN SALINITY CONTROL FORUM
January 1, 2014 through December 31, 2016

NPDES permits are reviewed under two different criteria under Forum policy; these being municipal and industrial. In order for a permittee to be in compliance under the municipal criteria, the increase in concentration between inflow and outflow cannot be greater than 400 mg/L. Forum industrial criteria requires that no industrial user discharges more than 1.00 ton/day. Under Forum policy there can be granted exceptions to these limitations by the states. The following gives an explanation of the current status of the NPDES permits. Because at any given time many of the permits identified in this list are being reviewed, reissued, and/or terminated, and new discharge permits are being filed, this list must be considered as being subject to frequent change.

MUNICIPAL

(M) Municipal user in compliance with Forum policy.

(M-A) Municipal user in compliance with the 400 mg/L incremental increase provision.

(M-B) Municipal user in compliance with the 1 ton per day or 366 tons per year provision for intermittent discharges.

(M-1)* Permit has expired or been revoked. No discharge.

(M-2) Permittee did not discharge during the reporting period.

(M-3) Measurement of TDS is not currently required, but the state and/or EPA plans to require measurements of both inflow and outflow when the permit is reissued.

Measurements of inflow are not consistent with Forum policy;

(M-4A) Therefore, it is not known whether or not this municipal user is in compliance.

(M-4B) However, since outflow concentration is less than 500 mg/L it is presumed that this permit is not in violation of the ≤400 mg/L increase.

(M-5) Permittee is in violation of Forum policy in that there is an increase in concentration of >400 mg/L over the source waters. No provision has been made allowing this violation of Forum policy.

(M-5A) The state and/or EPA is currently working to bring permittee into compliance.

(M-5B) Though discharge is >400 mg/L over source waters, in keeping with Forum policy the permittee has demonstrated the salt reduction is not practicable and the requirement has been waived.

(M-6) This permit requires no discharge or discharge only under rare and extreme hydrologic conditions. Thus, flow and concentration measurements are not required.

(M-7) Insufficient data to know the current status of this permit.

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* Permits that have been expired or revoked and listed with the M-1 and I-1 explanation codes shall be removed from the NPDES list during the subsequent triennial review.

INDUSTRIAL

(I) Industrial user in compliance with Forum policy.

(I-A) Industrial user in compliance with the Forum's salinity offset policy.

(I-B) Industrial user in compliance with the 1 ton per day or 366 tons per year provision for intermittent discharges.

(I-1)* Permit has expired or been revoked. No discharge.

(I-2) Permittee did not discharge during the reporting period.

(I-3) Measurement of TDS is not currently required, but the state and/or EPA plans to require measurements of both volume and concentration of outflow when the permit is reissued.

(I-4) Either concentration or volume of outflow are not currently being reported, thus the permittee is in violation of Forum policy. It is not known if the discharge is in excess of the <1.00 ton/day requirement.

(I-5) Permittee is in violation of Forum policy in that discharge of salts is >1.00 ton/day. No provision has been made allowing this violation of Forum policy.

(I-5A) The state and/or EPA is currently working to bring permittee into compliance.

(I-5B) Though discharge is >1.00 ton/day, in keeping with Forum policy the permittee has demonstrated the salt reduction is not practicable and the requirement has been waived.

(I-5C) The use of ground water under this permit is for geothermal energy and only heat is extracted. The intercepted salt and water are naturally tributary to the Colorado River System and hence, this discharge does not increase salt in the river. The permit is covered by the Forum's policy on intercepted ground waters.

(I-5D) This permit is in compliance with the Forum's policy for fish hatcheries. The use of the water is a one-time pass through, and the incremental increase in salinity is ≤ 100 mg/l.

(I-5E) This permit is for the interception and passage of ground waters and thus is excepted under the Forum's policy on intercepted ground waters.

(I-6) This permit requires no discharge or discharge only under rare and extreme hydrologic conditions. Thus, flow and concentration measurements are not required.

(I-7) Insufficient data to know the current status of this permit.

LEGEND (continued)
NPDES PERMITS
REACH DEMARCATIONS

COLORADO RIVER BASIN SALINITY CONTROL FORUM

In order to provide a better understanding of the location of the various NPDES permits and the geographical sequence in the Colorado River System, each of the following NPDES permits is identified with a Colorado River reach number. The reach numbers have their origin in the old CRSS river model. Though this model is no longer used, the reach numbers assist in understanding the general location of the permits. The reaches are defined as:

100	Upper Main Stem	from headwaters of Colorado River to Colorado River near Cameo
190	Taylor Park	from headwaters of Gunnison River to above Blue Mesa Reservoir
200	Blue Mesa	from above Blue Mesa Reservoir to below Blue Mesa Dam
210	Morrow Point	from below Blue Mesa Dam to Crystal Reservoir
220	Lower Gunnison	from Crystal Reservoir to confluence with Colorado River
300	Grand Valley	from Colorado River near Cameo to confluence with Green River
310	Dolores River	from headwaters of Dolores River to confluence with Colorado River
401	Fontenelle	from headwaters of Green River to Green River near Green River, WY
411	Flaming Gorge	from Green River near Green River, WY to confluence with White and Duchesne Rivers
500	Yampa River	from headwaters of Yampa River to confluence with Green River
510	White River	from headwaters of White River to confluence with Green River
600	Green River	Green River from confluence with White and Duchesne Rivers to confluence with Colorado River
610	Duchesne River	from headwaters of Duchesne River to confluence with Green River
700	Lake Powell	Colorado River from confluence of with Green River to Lees Ferry
710	San Rafael River	from headwaters of San Rafael River to confluence with Green River
801	Upper San Juan River	from headwaters of San Juan River to San Juan near Bluff
802	Lower San Juan River	from San Juan near Bluff to confluence with Lake Powell
900	Glen Canyon to Lake Mead	Colorado River from Lees Ferry to backwaters of Lake Mead
905	Virgin River	from headwaters of Virgin River to backwaters of Lake Mead
910	Lake Mead	from backwaters of Lake Mead to Colorado River below Hoover Dam
920	Lake Mohave	Colorado River from below Hoover Dam down to I-40 bridge
930	Lake Havasu	Colorado River from I-40 bridge to below Parker Dam
940	Parker Dam to Imperial Dam	Colorado River from below Parker Dam to above Imperial Dam
945	Imperial Dam	Colorado River from above Imperial Dam to Gila and Yuma users

NPDES PERMITS

Colorado River Basin Salinity Control Forum

January 1, 2014 through December 31, 2016

NPDES PERMIT#	REACH	NAME of Discharging Facility	TDS Conc. AVG.(Mg/L)	Flow Rate AVG.(MGD)	Salt Load Tons/Day	Explanantion Code
Arizona						
AZ0025224	900	APACHE-SITGREAVES NATIONAL FOREST BLACK MESA	375	0.0025	0.0039	M
AZ0025399	900	BISON RANCH			0.0000	M-1
AZ0024015	900	CANYON-VALLE AIRPORT WWTP			0.0000	M-2
AZ0025755	900	CITY OF WILLIAMS - WASTEWATER TREATMENT PLANT	278	0.16	0.1855	M
AZ0023639	900	FLAGSTAFF, CITY OF RIO DE FLAG POTW	210	1.25	1.0946	M-4B
AZ0020427	900	FLAGSTAFF, CITY OF WILDCAT HILL POTW	550	1.15	2.6375	M-A
AZ0024279	900	HIGH COUNTRY PINES			0.0000	M-1
AZ0025542	900	HOLBROOK, CITY OF PAINTED MESA POTW			0.0000	M-2
AZ0025437	900	PINETOP LAKESIDE SANITARY DISTRICT WWTP			0.0000	M-2
AZ0024422	900	SANDERS SCHOOL DISTRICT NO. 6 WWTP			0.0000	M-1
AZ0023841	900	SHOW LOW, CITY OF POTW	555	0.99	2.2912	M-A
AZ0026034	900	SNOWFLAKE, CITY OF POTW	413	0.26	0.4478	M-2
AZ0023477	900	SOUTH GRAND CANYON SANITARY DISTRICT WWTP	687	0.09	0.2578	M
AZ0026069	900	USBR/GLEN CANYON WWTP	1048	0.015	0.0656	M
AZ0025666	900	USBR/GLEN CANYON PPDS	566	0.85	2.0062	I
AZ0023612	900	USNPS/GRAND CANYON/ DESERT VIEW	1090	0.009	0.0409	M
AZ0023621	900	USNPS/GRAND CANYON/INDIAN GARDENS	166	1.25	0.8653	I
AZ0110426	900	USNPS/GRAND CANYON/NORTH RIM	599	0.15	0.3747	M
AZ0022152	900	USNPS/GRAND CANYON/SOUTH RIM WWTP	688	0.26	0.7459	M
AZ0023833	900	WINSLOW, CITY OF POTW	1003	0.2	0.8365	M-B
AZ0023655	905	VIRGIN RIVER DOMESTIC WASTEWATER IMP DISTRICT	840	0.015	0.0525	M
AZ0025160	910	USBR/HOOVER DAM	876	0.03	0.1096	M
AZ0000132	910	USFWS/WILLOW BEACH NATIONAL FISH HATCHERY	748	7.63	23.7992	I-5D
AZ0110248	920	USBR/DAVIS DAM			0.0000	I-2
AZ0023523	920	USNPS/KATHERINE'S LANDING WTP			0.0000	M-1
AZ0023990	930	CAWCD-HAVASU PUMPING PLANT	584	0.017	0.0414	I-B
AZ0026018	930	KINGMAN, CITY OF DOWNTOWN POTW	716	0.238	0.7106	M
AZ0022756	930	PETRO STOP CENTER/KINGMAN	720	0.0300	0.0901	M
AZ0022268	930	FREEPORT-McMoRan BAGDAD Inc.			0.0000	I-3
AZ0023752	940	QUARTZSITE, CITY OF POTW	1234	0.2	1.0292	M-A
Colorado						
CO0000051	100	Iles Dome Unit Production	1743.333	0.728	5.292	I-5
CO0000230	100	Henderson Mill				I-2
CO0000248	100	Climax Mine	1258.167	24.857	130.412	I-5B
CO0020451	100	Frisco Sanitation District WWTF	438.200	0.624	1.141	M-A
CO0020699	100	Granby Sanitation District		0.317		M-7
CO0020826	100	Blue River WWTF	398.618	1.228	2.042	M-A
CO0021369	100	Vail WWTF	388.455	1.369	2.218	M-A
CO0021385	100	Red Cliff WWTF	202.000	0.039	0.032	M-A
CO0021539	100	Farmers Korner WWTF	353.313	1.193	1.757	M-A
CO0021598	100	Copper Mtn Cons Metro District WWTF	342.333	0.284	0.405	M-A
CO0023086	100	Snowmass Water Sanitation Dist WWTF	264.515	0.738	0.814	M-A
CO0023876	100	Arapahoe Basin Ski Area	736.333	0.009	0.026	M-5/M-B
CO0024431	100	Avon WWTF				M-2
CO0026051	100	Winter Park Water and Sanitation District WWTF		0.160		M-7
CO0026069	100	Eisenhower Tunnel		0.363		I-4
CO0026387	100	Aspen Consolidated San Distrct WWTF	580.774	1.261	3.054	M-A
CO0029955	100	Summit County Snake River WWTF	328.152	0.595	0.815	M-A
CO0037311	100	Edwards WWTF	365.538	0.967	1.475	M-5

NPDES PERMITS

Colorado River Basin Salinity Control Forum

January 1, 2014 through December 31, 2016

NPDES PERMIT#	REACH	NAME of Discharging Facility	TDS Conc. AVG.(Mg/L)	Flow Rate AVG.(MGD)	Salt Load Tons/Day	Explanantion Code
CO0037681	100	Willow Creek Lagoons	315.833	0.451	0.595	M-A
CO0038342	100	Mcclane Canyon Mine	868.000	0.076	0.274	I-B
CO0038598	100	Sunlight WWTF	380.875	0.005	0.007	I-B
CO0040142	100	Upper Fraser Valley Treatment Plant		0.762		M-7
CO0040487	100	Valleywide Sewerage System	823.000	0.076	0.260	M-5/M-B
CO0042447	100	Rifle Station	1893.667	0.027	0.215	I-B
CO0042480	100	Eagle Mine Remediation WWTF	3112.000	0.308	3.993	I-5B
CO0044750	100	Roaring Fork Water and San District WWTF	839.917	0.066	0.232	M-A
CO0045411	100	Crooked Creek Ranch	956.667	0.009	0.037	M-5/M-B
CO0045420	100	Iowa Hill Water Reclamation	396.771	0.397	0.657	M-A
CO0045501	100	Tabernash Meadows WSD WWTF		0.044		M-7
CO0045802	100	Oak Meadows WWTF	700.167	0.016	0.046	M-A
CO0046124	100	Spring Valley Sanitation Dist WWTF	829.750	0.031	0.107	M-A
CO0046175	100	Gilsonite Refinery Sand And Gravel Facility				I-2
CO0046370	100	Redstone Water Sanitation Dist WWTF	535.000	0.025	0.056	M-B
CO0046566	100	Devil's Thumb Ranch	456.400	0.013	0.024	M-A
CO0048119	100	Golden Wonder Mine	4014.750	0.000	0.004	I-B
CO0048135	100	Debeque WWTF	917.833	0.044	0.169	M-B
CO0048151	100	Rifle Regional WW Reclamation Facility	1171.619	0.790	3.859	M-4A
CO0048233	100	North Thompson Creek Mines				I-2
CO0048241	100	Eagle WWTF	624.800	0.512	1.335	M-A
CO0048437	100	Kremmling Sanitation District WWTF	238.518	0.119	0.119	M-A
CO0048577	100	Redstone Well 21-9 Geothermal Project	21200.000	0.489	43.219	I-5B
CO0048815	100	South Canyon Landfill				I-2
CO0048823	100	Avalanche Ranch	1354.068	0.122	0.691	I-B
CO0048830	100	Gypsum WWTF	331.417	0.420	0.580	M-A
CO0048847	100	Cameo Eagle Travel Center	438.182	0.004	0.007	I-B
CO0048852	100	Glenwood Springs Regional WWTF	727.500	0.915	2.777	M-5B
CO0048901	100	Eagle Valley Clean Energy LLC	12.300	0.115	0.006	M-A
CO0048952	100	Lib 4	241.875	0.174	0.175	I-B
CO0048958	100	Glenwood Hot Spgs Lodge and Pool	16300.000	3.057	207.793	I-5B
CO0048999	100	Steamboat Springs Health and Recreation Association	888.000	0.250	0.926	M-B
COG130001	100	Crystal River Fish Hatchery		5.831		I-5D
COG130007	100	Finger Rock Rearing Unit		2.565		I-5D
COG130011	100	Rifle Falls Fish Hatchery		5.485		I-5D
COG315285	100	NGL Release Bargath Parachute Facility	1245.000	0.004	0.023	I-B
COG500003	100	Latham-Burkett Pit				I-2
COG500062	100	Williams Fork Pit				I-2
COG500088	100	Eagle West Pit	1226.333	0.603	3.081	I-5
COG500119	100	Rifle Pit (Chambus Pit)	1339.250	6.527	36.453	I-5
COG500216	100	River Road Pit	3737.500	0.275	4.292	I-5
COG500299	100	Railhead Gravel Pit	7153.333	0.102	3.034	I-5
COG500342	100	Gypsum Ranch Pit				I-2
COG500356	100	Yule Marble Quarry				I-2
COG500380	100	Monument View Gravel Pit	5177.333	0.650	14.033	I-5
COG500433	100	Maryland Creek Ranch Pit	143.600	7.649	4.580	I-5
COG500437	100	15 Road Pit	2812.857	0.168	1.970	I-5
COG500467	100	Glens Pit	1240.333	0.235	1.218	I-5
COG500482	100	North Bank Pit	796.071	1.688	5.605	I-5
COG500497	100	15.5 Road Pit	560.000	4.650	10.859	I-5
COG501534	100	Steamboat Sand and Gravel Fisker Trail		1.613		I-4
COG501590	100	Hayden Pit		0.054		I-4
COG588006	100	Riverbend Subdivision	1588.727	0.007	0.048	M-B
COG588008	100	West Glenwood Springs Sanitation Dist WWTF	318.597	0.274	0.364	M-A

NPDES PERMITS

Colorado River Basin Salinity Control Forum

January 1, 2014 through December 31, 2016

NPDES PERMIT#	REACH	NAME of Discharging Facility	TDS Conc. AVG.(Mg/L)	Flow Rate AVG.(MGD)	Salt Load Tons/Day	Explanantion Code
COG588029	100	El Rocko Mhp	461.792	0.004	0.007	M-A
COG588035	100	H Lazy F Mhp WWTF	816.583	0.021	0.070	M-A
COG588041	100	Ouray Ranch Homeowners Assn WWTF	216.167	0.008	0.007	M-A
COG588046	100	Silt WWTF	738.417	0.147	0.452	M-A
COG588049	100	Lazy Glen HOA WWTF	407.364	0.030	0.052	M-A
COG588050	100	Carbondale WWTF	322.833	0.520	0.700	M-A
COG588051	100	Ranch At Roaring Fork HOA WWTF	413.818	0.048	0.083	M-A
COG588061	100	Talbott Enterprises WWTF	1248.000	0.066	0.342	M-5/M-B
COG588062	100	New Castle WWTF	790.083	0.241	0.793	M-5/M-B
COG588063	100	Basalt Sanitation District WWTF	402.364	0.455	0.763	M-A
COG588067	100	Grizzly Creek Rest Area WWTF	763.775	0.002	0.005	M-A
COG588070	100	Two Rivers Village Metro Dist WWTF	416.909	0.022	0.039	M-A
COG588072	100	C Lazy U Ranch	325.917	0.008	0.010	M-A
COG588074	100	Blue Creek Ranch	786.727	0.011	0.038	M-5/M-B
COG588075	100	Bair Ranch Rest Area	1184.808	0.001	0.006	M-5/M-B
COG588076	100	Hanging Lake Rest Area WWTF	754.000	0.002	0.005	M-A
COG588079	100	East River Regional Sanitation Dist WWTF	281.042	0.050	0.058	M-A
COG588083	100	Rock Gardens MHP & Campground	362.917	0.004	0.006	M-A
COG588084	100	Hot Sulphur Springs WWTF	374.509	0.076	0.119	M-A
COG588085	100	Aspen Village	422.909	0.034	0.059	M-A
COG588103	100	Woody Creek Mobile Home Park	394.000	0.017	0.027	M-5/M-B
COG588105	100	Mid Valley Metro Dist WWTF	414.364	0.395	0.683	M-A
COG588116	100	Roundup River Ranch WWTF	1203.417	0.006	0.032	M-A
COG589067	100	Nucla WWTF	960.400	0.080	0.320	M-5/M-B
COG589086	100	Battlement Mesa Metro Dist WWTF	619.417	0.405	1.045	M-A
COG589094	100	Fruita WWTF				M-2
COG589110	100	Cottonwood Springs Mhp WWTF	811.636	0.035	0.118	M-A
COG603008	100	Founders Garage Eagle	525.818			I-4
COG603012	100	Ski and Bike Kare Project	334.000			I-4
COG603013	100	Winter Park Base Area	91.250			I-4
COG603031	100	Parking Garage Pitkin Co	505.556			I-4
COG603050	100	Little Nell Well City Well 4	158.686			I-4
COG603076	100	Mountain Plaza Parking Garage (Formerly Vail's Front Door)	280.000			I-4
COG603117	100	Frisco Sanitation District WWTP	214.250			I-4
COG603127	100	Ritz-Carlton Residences And Club At Vail	1.169			I-4
COG603151	100	Arrabelle Hotel	599.208			I-4
COG603155	100	Solaris	892.625			I-4
COG603170	100	Fraser Crossing Founders Pointe	91.250			I-4
COG603205	100	Passport Parking Garage	637.091			I-4
COG603217	100	Snowmass Base Village	384.929			I-4
COG603219	100	Springs Lodge	194.167			I-4
COG603220	100	Keystone Lodge And Argentine Condos	150.955			I-4
COG603222	100	Manor Vail Lodge	786.909			I-4
COG603223	100	Red Hawk Lodge	123.727			I-4
COG603295	100	Strata Vail Residences	982.200			I-4
COG603318	100	Copper Mountain Alluvial Well No 4	226.000			I-4
COG605009	100	Covered Bridge Building	270.500	0.036	0.041	I-B
COG605015	100	Main St Station Breckenridge		0.113		I-7
COG641006	100	Dillon Straight Creek WTP	132.000	0.421	0.232	I-B
COG641019	100	Hot Sulphur Springs WTP	146.158	0.005	0.003	I-B
COG641052	100	Red Mountain WTP				I-2
COG641066	100	Castle Creek WTP	266.138	0.045	0.050	I-B
COG641067	100	Wayne Bristol WTP	90.055	0.040	0.015	I-B
COG641072	100	Gateway Metro WTP	820.182	0.003	0.011	I-B

NPDES PERMITS

Colorado River Basin Salinity Control Forum

January 1, 2014 through December 31, 2016

NPDES PERMIT#	REACH	NAME of Discharging Facility	TDS Conc. AVG.(Mg/L)	Flow Rate AVG.(MGD)	Salt Load Tons/Day	Explanantion Code
COG641092	100	New Castle WTP	708.500	0.003	0.007	I-B
COG641095	100	Basalt Springs WTP	96.091	0.003	0.001	I-B
COG641105	100	Edwards WTP				I-2
COG641108	100	Beaver Creek WTP	187.817	0.148	0.116	I-B
COG641112	100	Silt WTP	540.909	0.002	0.003	I-B
COG641135	100	Red Sky Ranch WTP	515.667	0.012	0.025	I-B
COG641154	100	Hamilton Creek Metropolitan District		0.014		I-4
COG641181	100	Peak 9 Water Plant	57.000	0.058	0.014	I-B
COG840002	100	Greenback Schaeffer Ranch				I-2
CO0020443	190	Crested Butte WWTF		0.195		M-7
CO0022756	190	Pitch Reclamation Project	791.500	0.543	1.791	I-5B
CO0027171	190	Mt Crested Butte WSD WWTF	262.161	0.324	0.354	M-A
CO0035394	190	Mt Emmons Project	797.083	0.550	1.827	I-5
CO0045217	190	Irwin Mountain Lodge				M-2
CO0048900	190	Bear Ranch	403.556	0.001	0.001	M-B
COG130004	190	Pitkin State Fish Hatchery		4.405		I-5D
COG130006	190	Roaring Judy Fish Hatchery		5.099		I-5D
COG500010	190	Gunnison Pit	605.200	0.452	1.142	I-5
COG500420	190	Sea Horse No 2 Pit	224.286	1.329	1.243	I-5
COG500464	190	Anderson Pit	1405.000	1.702	9.972	I-5
COG500498	190	Tri County Pit	2191.000	0.830	7.583	I-5
COG501510	190	Scott Pit	990.667	1.393	5.756	I-5
COG588012	190	Almont WWTF	411.088	0.013	0.022	M-A
COG588045	190	Crested Butte South Metro Dist WWTF	316.004	0.072	0.095	M-A
COG588109	190	Ute Trail Ranch	489.425	0.002	0.005	M-A
COG588123	190	Camp Red Cloud	514.450	0.000	0.000	M-B
COG588132	190	Vickers Horse River Ranch	427.977	0.007	0.013	M-5/M-B
COG588138	190	Taylor River Canyon LLC	302.500	0.005	0.006	M-A
CO0040673	200	Lake City WWTF	321.181	0.068	0.091	M-A
CO0043133	200	Blue Mesa Recreation Ranch				I-2
COG588052	200	L and N Inc	710.600	0.003	0.009	M-A
COG589091	200	Elk Meadows	500.583	0.004	0.009	M-A
COG603287	200	Montrose Community Recreation Center and Park	2656.167			I-4
COG603285	210	Town of Hotchkiss Drain Seep Line	1679.500			I-4
CO0000132	220	Sanborn Crk & Elk Crk Mines				I-2
CO0020907	220	Olathe WWTF	1888.833	0.249	1.960	M-5B
CO0022969	220	Morrison Creek Metro WSD WWTF	432.575	0.065	0.118	M-A
CO0030449	220	West Montrose Sanitation Dist WWTF	575.583	0.288	0.691	M-A
CO0031984	220	Cedaredge WWTF	330.875	0.144	0.198	M-A
CO0037206	220	Ruby Trust Mine	191.900	0.021	0.017	I-B
CO0037729	220	Crawford WWTF	288.727	0.024	0.029	M-A
CO0038776	220	West Elk Mine		0.010		I-4
CO0039624	220	Montrose WWTF	967.735	2.231	9.003	M-5/M-B
CO0039641	220	Delta WWTF	1321.088	0.957	5.274	M-5
CO0041530	220	Gunnison WWTF	411.040	1.085	1.859	M-A
CO0042617	220	Horizon Health Care & Retirement Community	373.000	0.009	0.014	M-A
CO0043397	220	Ouray WWTF	710.900	0.248	0.735	M-5/M-B
CO0044776	220	Bowie No. 2 Mine	668.565	0.011	0.032	I-B
CO0044903	220	Hotchkiss WWTF	1005.411	0.142	0.594	M-5/M-B
CO0047431	220	Paonia WWTF	808.167	0.163	0.548	M-5/M-B
COG500127	220	No 500 Pit	1471.556	0.040	0.245	I-B
COG500210	220	Mule Farm Gravel Pit	840.000			I-4
COG500444	220	Delta Paving Pit				I-2
COG500458	220	Janet Pit	1176.000	1.640	8.042	I-5

NPDES PERMITS						
Colorado River Basin Salinity Control Forum						
January 1, 2014 through December 31, 2016						
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COG501532	220	Gunnison River Gravel Pit 5		0.290		I-4
COG501615	220	Western Gravel Inc				I-2
COG588032	220	Delta Correctional Center	480.727	0.031	0.063	M-A
COG588066	220	Riversbend Apartments	787.583	0.001	0.003	M-A
COG588112	220	Camp Gunnison Church Camp	312.673	0.003	0.004	M-A
COG600544	220	Ouray Hot Springs Pool	1644.385	0.328	2.246	I-5
COG641015	220	Cedaredge WTP	73.677	0.009	0.003	I-B
COG641081	220	Orchard City WTP	47.691	0.027	0.005	I-B
COG641104	220	Spaulding Peak Treatment Plant	104.600	0.052	0.023	I-B
COG641134	220	Paonia WTP aka Lower Plant		0.021		I-4
COG641170	220	Dos Rios WTF		0.003		I-4
CO0000012	300	Palisade WWTF	317.000	0.215	0.284	M-B
CO0023485	300	Grande Mesa Metro Dist 2 WWTF	320.000	0.017	0.022	M-A
CO0027146	300	Roadside North & South Mines	1245.000	0.396	2.056	I-5B
CO0033791	300	Clifton Sanitation District WWTF	602.222	1.105	2.775	M-A
CO0040053	300	Persigo WWTF	836.576	8.584	29.946	M-5
CO0047562	300	Whirlwind Project				I-2
CO0048143	300	Mesa Water And San Dist WWTF	795.000	0.008	0.027	M-B
CO0048854	300	Fruita Wastewater Reclamation Facility	519.194	0.873	1.890	M-A
COG500001	300	Bunn Ranch Pit	668.000	0.144	0.401	I-B
COG500114	300	Silt Pit				I-2
COG500161	300	South Fruita Pit Arcuby Pit	3351.667	0.753	10.524	I-5
COG500229	300	West Rifle Pit				I-2
COG500252	300	Loesch Pit				I-2
COG500308	300	Feuerborn Gravel Pit				I-2
COG500364	300	Soaring Eagle Gravel Pit	1932.727	0.293	2.363	I-5
COG500408	300	Mamm Creek Gravel Pit				I-2
COG500435	300	D Road Gravel Pit				I-2
COG501505	300	Una Pit	765.636	0.890	2.842	I-5
COG501525	300	Gehrman Pit	312.000	0.911	1.185	I-5
COG501542	300	Debeque Pit No 2	2930.000	0.755	9.219	I-5
COG501567	300	Otter Creek Pit	5547.273	0.492	11.381	I-5
COG501614	300	Breeze Basin Sand and Gravel Pit		0.864		I-4
COG501617	300	5 Mile Pit				I-2
COG588086	300	SW Mesa County Rural Public Improvement District WWTF	1142.000	0.022	0.107	M-A
COG589139	300	Canyon Creek Estates	829.333	0.010	0.035	M-B
COG603260	300	Bank of the West GJ	5761.444			I-4
COG603314	300	Xcel Energy Mesa Service Center Groundwater Management System	4300.000			I-4
COG641068	300	Battlement Mesa Metro Dist WTP				I-7
COG840020	300	Elk Springs 3 Water Disposal	4780.000	14.355	286.132	I-5
CO0000003	310	Revenue Mine	223.600	0.668	0.623	I-B
CO0000213	310	New Horizon Mine	2420.667	0.472	4.760	I-5B
CO0000540	310	Nucla Station	1658.917	0.163	1.126	I-5B
CO0024007	310	Naturita WWTF	608.666	0.027	0.069	M-A
CO0036251	310	Jd-7 And Jd-9 Mines				I-2
COG588047	310	Ridgway WWTF	466.182	0.085	0.165	M-A
CO0000221	500	Seneca Mine Complex	2279.655	0.166	1.582	I-5B
CO0020834	500	Steamboat Springs WWTF	345.966	2.482	3.581	M-A
CO0027154	500	Mines 1&2 And Eckman Park Mine	2830.345	0.167	1.970	I-5B
CO0030635	500	Yampa WWTF	438.258	0.032	0.059	M-A
CO0031062	500	Whiteman School	297.167	0.002	0.003	M-A
CO0032115	500	Trapper Mine		0.172		I-4
CO0034142	500	Williams Fork Mine	1604.167	0.008	0.052	I-B

NPDES PERMITS

Colorado River Basin Salinity Control Forum

January 1, 2014 through December 31, 2016

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CO0035556	500	Steamboat Lake Water & Sanitation Dist WWTF	474.000	0.051	0.100	M-A
CO0036684	500	Fish Creek Tipple	3818.000	0.020	0.315	I-B
CO0040037	500	Craig WWTF	618.667	0.842	2.171	M-4B
CO0040959	500	Hayden WWTF	453.450	0.195	0.370	M-5/M-B
CO0041106	500	Oak Creek WWTF	501.636	0.194	0.405	M-5/M-B
CO0042161	500	Foidel Creek Mine	3132.333	0.048	0.626	I-B
CO0045161	500	Colowyo Mine	2090.308	0.049	0.423	I-B
CO0047449	500	Milner Community WWTF	661.636	0.015	0.041	M-A
CO0048275	500	Sage Creek Mine Complex	3821.885	0.201	3.205	I-5B
CO0048623	500	Barn Spring WTP	2040.000	0.018	0.149	I-B
COG500243	500	Hogue River Pit	371.000	0.595	0.921	I-B
COG500267	500	Sievers Ranch Pit	295.625	0.039	0.048	I-B
COG500312	500	Mesa Gravel Pit				I-2
COG500350	500	Tellier Pit	342.286	0.546	0.779	I-B
COG500396	500	Camilletti Milner Pit No2	291.400	1.145	1.391	I-5
COG500419	500	Deakins Pit	2011.800	1.000	8.389	I-5
COG501522	500	Lyster Pit	1146.889	0.093	0.447	I-B
COG501524	500	Wand Pit	687.000	1.000	2.865	I-5
COG589026	500	Routt County for Phippsburg Community WWTF	623.455	0.019	0.050	M-A
COG589040	500	Maybell WWTF	385.333	0.002	0.003	M-A
COG603045	500	Lake Catamount WWTF	245.333			I-4
COG850054	500	Foidel Creek Mine	908.000	0.003	0.012	I-B
CO0000010	510	Rangely WWTF	679.100	0.205	0.581	M-A
CO0038024	510	Deserado Mine	5439.111	0.119	2.710	I-5
CO0047139	510	Meeker Sanitation District WWTF	609.292	0.121	0.307	M-A
CO0048739	510	Bopco Lp Yellow Creek Water Management Facility				I-2
CO0048859	510	Corral Gulch WWTF				I-2
COG500484	510	White River City Pit	839.909	0.091	0.319	I-B
Nevada						
NV0000060	910	Titanium Metals Corporation	780.0	0.150	0.488	I
NV0020192	910	NDOW - Lake Mead Fish Hatchery			0.000	I - 5D
NV0021750	910	Las Vegas Hilton Hotel and Casino Parking Garage		0.003		I-7
NV0022195	910	Valley Hospital Medical Center	130.77	0.006	0.004	I-5E
NV0022691	910	Lake Las Vegas Resort (Dam)	0.0	0.000	0.000	I-1
NV0022772	910	Sterling/Squire/Crescendo HOA (formerly Saxton)	4704	0.621	12.190	I-5E
NV0022781	910	Shanghai Partners - Tomiyasu Residence	2400.0	0.010	0.100	I-5E
NV0022837	910	Conoco Phillips Company - Circle K Store No. 0695	2950.0	0.000	0.001	I-5E
NV0022870	910	7-Eleven Store # 19653	0.0	0.000	0.000	I-1
NV0022888	910	Las Vegas Sands-Venetian Casino Resort	1462.0	0.094	0.573	I-5E
NV0022942	910	Lloyd D. George Federal Courthouse	2240.0	0.025	0.234	I-5E
NV0022985	910	Planet Hollywood Resort Casino (formerly Aladdin Resort)	91.0	0.000	0.000	I-5E
NV0023035	910	Neonopolis Project	1130.0	0.013	0.061	I
NV0023043	910	Maryland Villas Apartment Complex	1598.0	0.056	0.373	I
NV0023060	910	Tronox LLC	3900.0	1.350	21.970	I
NV0023159	910	Clark County Regional Justice Center	1391.0	0.008	0.046	M
NV0023191	910	Caesar's Palace Hotel and Casino	2166.0	0.070	0.633	I
NV0023221	910	7-Eleven Store # 27607	0.0	0.000	0.000	I-1
NV0023256	910	The Stirling Club	2500.0	0.046	0.480	I
NV0023477	910	Sky Las Vegas Master Association	671.0	0.052	0.146	I
NV0023485	910	Las Vegas Academy	2600.0	0.002	0.026	M
NV0023507	910	NNSA/NSO North Las Vegas Facility	1460.0	0.003	0.017	M
NV0023515	910	The Cosmopolitan Resort & Casino	1800.0	0.049	0.368	I

NPDES PERMITS

Colorado River Basin Salinity Control Forum

January 1, 2014 through December 31, 2016

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NV0023523	910	Terrible's Hotel and Casino	2500.0	0.000	0.002	I
NV0023558	910	Panorama Towers	2160.0	0.003	0.027	I
NV0023566	910	Fountainbleau Casino and Resort	2565.0	0.169	1.809	I-5E
NV0023604	910	Howard Hughes Office Complex	2370.0	0.011	0.109	I
NV0023621	910	Echelon Resort	2100.0	0.269	2.357	I-5E
NV0023647	910	City of North Las Vegas Water Reclamation Facility	1040.0	17.100	74.159	M-4A
NV0023663	910	Former Conoco Station No. 28003	1600.0	0.001	0.007	I
NV0023701	910	City Center Land	2600.0	0.052	0.564	I
NV0023744	910	Baymont Inn and Suites (formerly Holiday Inn Hotel)	254.03	0.0134	0.014	I-5A
NV0023761	910	McCarran International Airport	1254.0	0.0310	0.162	I
NV0023809	910	Terrible Herbst #225	1000.0	0.0073	0.030	I
NV0023841	910	Hudson Cleaners	2400.0	0.0325	0.325	I-5E
NV0023931	910	Mendenhall Center - UNLV	3022.0	0.0044	0.055	I-7
NV0024112	910	American Pacific Corp AGTS	2700.0	1.0700	12.050	I-7
NV0024202	910	Sunset Regional Park Splash Pad	588	0.0900	0.221	I-7
NV0024206	910	The Waterhole	5187.0	0.0130	0.340	I-7
NV0024210	910	Las Vegas Wash Channel Improvement Project	6120.0	0.0050	0.128	I-2
NV0022845	910	Harrah's Las Vegas Hotel & Casino	0.0	0.000	0.000	I-1
NV0023094	910	Former Union 76 Station No. 4616				I-1
NV0023183	910	City Center Place				M-1
NV0023230	910	Kinder Morgan Las Vegas Terminal				I-1
NV0023248	910	Riviera Hotel and Casino				I-1
NV0023396	910	7-Eleven Store # 20826				I-1
NV0023787	910	Tesoro Refining & Marketing Co LLC #05326				I-1
NV0023833	910	Southern Nevada Water Authority - 5 Upper Wash Weirs				I-1
NV0023876	910	SNWA - Three Kids (Demonstration Replacement) Weir	0.0	0.0000	0.000	I-1
NV0023914	910	SNWA - Historic Lateral Weir Expansion	3523.6	0.4689	6.890	I-1
NV0023949	910	Former Texaco Service Station	655.3	0.0012	0.003	I-1
NV0024082	910	Whitney Mesa Trails & Trailhead	0.0	0.0000	0.000	I-1
NV0024155	910	Pecos Express Sinclair				I-1
NV0024180	910	Maryland Parkway Lift Station Decommissioning				I-1
NV0024198	910	Tropicana East Shopping Center				I-1
NV0024200	910	Central Plant Membranes Phase 2				I-1
NV0024209	910	Section Seven Community Association				I-1
NV0024211	910	Cooper Street Bridge Improvements		0.0000		I-1
NV0020133	910	City of Las Vegas	1080.0	43.400	195.570	M-A
NV0021261	910	Clark County Water Reclamation District - AWT Plant	1070.0	87.350		M-A
NV0021563	920	Clark County Water Reclamation District - Laughlin Plant	1150.0	1.650	7.917	M-A
NV0022098	910	Kurt Segler Water Reclamation Facility - City of Henderson	1139.5	17.310	63.631	M-A
NV0022993	910	Golden Nugget Hotel and Casino	1130.0	0.000	0.000	I-1
NV0023311	910	7-Eleven Store # 25586	0.0	0.014	0.000	I-2
NV0023671	910	Former Cappy's Cleaners	5700.0	0.144	3.425	I
NV0023736	910	Bowman Reservoir & Muddy River Outfalls				M-1
NV0023817	910	Alfred Merritt Smith WTF	665.0	.15-2	5.546	M-A
NV0024074	910	7-Eleven Store # 29643		0.0157		I-1
NV0024121	910	City of North Las Vegas Utilities Water System O&M		0.0050	-	I-7
NV0024139	910	City of Henderson Water Systems and Facilities	335	0.1130	-	M-B
NV0021911	910	Las Vegas Valley MS4			0.00	I-7
NV0024214	910	Las Vegas Wash & Flamingo Wash	2000	1.4000	11.68	I-5A
NV0024222	910	Low Lake Level Pumping Station	665		0.00	M-B
NV0024104	910	LVVWD/SNWA Operations and Maintenance	665		0.00	M-A
NV0024201	910	STATEWIDE VAULT MAINTENANCE DEWATERING		0.00015		I-7
NV0024220	910	VILLAGE SHOP #4/SINCLAIR STATION	1016	0.0288	0.12	I-7

NPDES PERMITS

Colorado River Basin Salinity Control Forum

January 1, 2014 through December 31, 2016

NPDES PERMIT#	REACH	NAME of Discharging Facility	TDS Conc. AVG.(Mg/L)	Flow Rate AVG.(MGD)	Salt Load Tons/Day	Explanantion Code
New Mexico*						
NM0028762	801	Aztec, City of / WTP	407.5	0.1625	0.1614	I
NM0020168	801	Aztec, City of / WWTP	253	0.584	0.61	M
NM0029319	801	Central Consolidated School District	0	0	0	I-1
NM0020770	801	Bloomfield, City of / WWTP	315	0.85	1.11	M
NM0000043	801	Farmington, City of / Animas Steam Plant	0	0	0	I-1
NM0031135	801	Farmington Electric Utiltiy System (FEUS)	NA	NA	2000	I
NM0028258	801	Farmington Sand & Gravel Co.	0	0	0	I-1
NM0020583	801	Farmington WWTP	420.54	5.15	9.03	M-5A
NM0029025	801	Harper Valley Subd.	372.4	0.4	0.05	M-5A
NM0030953	801	Navajo Dam DWC & NSW, Inc	0	0	0	I-2
NM0027995	801	Oldcastle SW Group, Inc.	0	0	0	I-1
NM0028606	801	Public Service Co of NM - San Juan	0	0	0	I-1
NM0029505	801	San Juan Coal Company - La Plata	0	0	0	I-3
NM0028746	801	San Juan Coal Company - San Juan	0	0	4000	I
NM0029432	801	Yampa Mining Co. (De-na-zin Mine)	0	0	0	I-1
NM0029475	801	Yampa Mining Co. (Gatew.)	0	0	0	I-1
NM0031160	801	Bloomfield, City of- Primary Raw Water Source	0	0	0	I-2
NM0020672	900	Gallup WWTP	NA	2.25	9.97	M-4A
NM0020524	900	Quivira Mining Company - Church Rock	0	0	0	I-1
NM0023396	900	Ramah Water & Sanitation Dist.	580	0.03	0.045	M-5
***Permits in New Mexico are issued by the U.S. EPA and certified by the State of New Mexico Environmental Department.**						
Utah						
UT0025828	300	Capitol Wash Water	788.4	0.019	0.062	I-B
UT0025712	300	Energy Queen Mine	-	0	0	I-2
UT0025917	300	Harley Dome	207.5	0.19	0.16	I
UT0020419	300	Moab, City of	364	0.987	1.49	M
UT0023922	300	Rim Mine	-	0	0	I-2
UT0025810	300	Velvet Mine	-	0	0	I-2
UTG640027	411	Ashely Valley WTP	-	-	-	M-6
UTG640003	411	Ashley Springs WTP	-	-	-	M-6
UT0025348	411	Ashley Valley Water & Sewer, Mechanical	494.4	2.8	5.77	M-5B
UTG640014	411	Dutch John WTP	-	-	-	M-6
UT0000035	411	Golden State Operating	1235	1.09	5.61	I-5B
UT0024015	411	Intermountain Concrete	257.9	0.018	0.019	I-B
UTG640023	411	Manilla WTP	-	-	-	M-6
UT0020338	411	USBOR-Flaming Gorge Dam	856	0.0012	0.004	M
UTG130001	411	USFWS-Jones Hole Fish Hatchery	188	6.38	5.001	I-5D
UT0000124	411	Western Energy Operating-Pan American Lease	-	0	0	I-1
UTG040007	600	Andalex Wildcat Loadout	-	0	0	I-2
UTG790028	600	Bill Barrett Corp-Nine Mile Compressor Station	458.7	0.034	0.065	I
UTG040011	600	Canyon Fuel Co.- Banning Loadout	-	0	0	I-2
UT0025593	600	Canyon Fuel Co.- Dugout Mine	1091.7	0.64	2.91	I-A
UT0023540	600	Canyon Fuel Co.- Skyline Mine	553.9	3.56	8.22	I-A
UT0023680	600	Canyon Fuel Co.-Soldier Creek Coal	-	0	0	I-2
UTG040028	600	Carbon Resources-Kinney No. 2 Mine	-	0	0	I-2
UTG640012	600	E. Carbon City-Sunnyside CWTP	-	-	-	M-6
UTG640017	600	Green River WTP	-	-	-	M-6
UT0025771	600	Green River, City of	4841.3	0.95	19.17	M-B
UT0023094	600	Hiawatha Coal Co.	583.5	0.192	0.467	I-B
UTG040019	600	Horizon Coal	-	0	0	I-2
UTG040024	600	Lila Canyon Mine	3662	0.106	1.62	I-A
UTG040010	600	NEICO	-	0	0	I-1
UTG790014	600	Olsen-Durrant (Former Bulk Fuel Facility)	-	0	0	I-1
UT0000094	600	PacifiCorp-Carbon Plant	1980.8	1.87	15.44	I-5B
UTG640035	600	Price City WTP	-	-	-	M-6
UT0021814	600	Price River Water Imp. Dist.	1085	1.52	6.87	M-A
UTG640034	600	Price River WID	-	-	-	M-6

NPDES PERMITS

Colorado River Basin Salinity Control Forum

January 1, 2014 through December 31, 2016

NPDES PERMIT#	REACH	NAME of Discharging Facility	TDS Conc. AVG.(Mg/L)	Flow Rate AVG.(MGD)	Salt Load Tons/Day	Explanantion Code
UTG040005	600	Savage Industries Coal Terminal (CV-Spur)	-	0	0	I-2
UTG040025	600	Star Point Refuse Pile(Sunnyside Cogen)	-	0	0	I-1
UT0024759	600	Sunnyside Cogen.	-	0	0	I-2
UT0025640	600	West Ridge Resources Mine	1030.1	2.32	9.96	I-A
UT0020095	610	Duchesne City Corp.	-	0	0	M-2
UT0025801	610	Duchesne Valley WTP	352.8	0.147	0.216	M-B
UTG640008	610	Myton Community Water System	-	-	-	M-6
UT0023001	610	Neola Town Water & Sewer Assoc.	-	0	0	M-2
UTG640002	610	Tridell-Lapoint Water WTP	-	-	-	M-6
UTG130012	610	UDWR-Whiterocks Fish Hatchery	246.1	4.89	5.02	I-5D
UT0022918	700	Canyon Fuel Co.- SUFCo Mine	971.6	3.44	13.93	I-A
UT0025798	700	Capital Reef National Park	-	-	-	I-2
UTG040026	700	Consolodated Coal Co.-Hidden Valley Mine Site	-	0	0	I-1
UT0022616	700	Consolodated Coal Co.-Underground	2659.3	0.164	1.82	I-5B
UTG040006	700	Hiawatha Coal Co.-Bear Canyon Mine	1033.6	0.0576	0.248	I
UTG130003	700	UDWR-Egan/Bicknell Fish Hatchery	131.2	9.43	5.16	I-5D
UTG130007	700	UDWR-Loa Fish Hatchery	158.6	8.18	5.41	I-5D
UTG640004	700	USNPS-Glen Canyon Hite WTP	-	-	-	M-6
UT0023663	710	Castle Valley SSD-Castle Dale	591.3	0.25	0.616	M-B
UT0020052	710	Castle Valley SSD-Ferron	-	0	0	M-2
UT0021296	710	Castle Valley SSD-Huntington	3905	0.216	3.52	M-B
UTG640030	710	Emery WTP	-	-	-	M-6
UTG640039	710	Ferron WTP	-	-	-	M-6
UT0024368	710	Genwal Resources, Inc.-Crandall Canyon Mine	550.2	0.437	1.002	I-A
UTG640040	710	Huntington WTP	-	-	-	M-6
UT0025534	710	James Canyon Well System	-	0	0	I-2
UTG640031	710	Orangeville WTP	-	-	-	M-6
UT0023604	710	PacifiCorp-Deer Creek Mine	546.1	1.55	3.53	I-5B
UTG040009	710	PacifiCorp-Hunter Plant Coal Prep & Blend Facility	-	0	0	I-1
UT0025607	710	PacifiCorp-Huntington Plant	-	0	0	I-1
UT0023728	710	PacifiCorp-Trail Mountain Mine	-	0	0	I-2
UT0022896	710	PacifiCorp-Wilberg Mine	682.8	0.028	0.079	I
UTG640019	802	Blanding Culinary Water Treatment	-	-	-	M-6
UT0024503	802	Monticello	-	0	0	M-2
UTG640015	802	Monticello City (Culinary WTP)	-	-	-	M-6
UT0025992	900	Alton Coal Development	537	0.011	0.024	I
UT0025224	905	Springdale	958.8	0.419	1.67	M-A
UTG640021	905	St. George WTP	-	-	-	M-6
UT0024686	905	St. George, City of	1218.6	9.31	47.31	M-5B
Wyoming						
WY0000027	401	Green River-Rock Springs JPB Water Plant			0	M-2
WY0000086	401	Daniel Fish Hatchery	11		0	I-1
WY0000094	401	Boulder Rearing Station	0		0	I-5D
WY0020133	401	Big Piney Wastewater Lagoon	93.3	0.07	0.03	M-A
WY0020656	401	Pinedale Wastewater Lagoons	166	0.73	0.51	M-4B
WY0021806	401	Superior Waste Water Lagoon	225		0	M-B
WY0021997	401	Marbleton Wastewater Lagoon	231	0.3	0.3	M-A
WY0022080	401	LaBarge Wastewater Lagoon	578	0.024	0.06	M-B
WY0022128	401	B & R Mobile Home Village	400	0.05	0.08	M-B
WY0022357	401	Rock Springs WWTP	812	2.41	8.16	M-5B
WY0023124	401	Daniels Mobile Home Park			0	M-2
WY0023825	401	Stansbury Mine			0	I-2
WY0028886	401	Leucite Hills Mine			0	I-2
WY0030261	401	Black Butte Mine		0	0	I-2
WY0030350	401	Jim Bridger Mine	1558		1	I-B
WY0054224	401	Jensen Disposal Facility - New Fork Discharge	128	0.17	0.09	I
WY0054232	401	Jensen Disposal Facility - Sand Draw Discharge			0	I-2
WY0020443	411	Green River Wastewater Lagoon	355	1.05	1.61	M-A
WY0056499	411	Pioneer Cryogenic Gas Plant	2000	0.025	0.22	I
WY0022896	411	Mountain View Wastewater Lagoon	393	0.2	0.33	M-B
WY0000051	411	Kemmerer Mine			0.26	I-B

NPDES PERMITS

Colorado River Basin Salinity Control Forum

January 1, 2014 through December 31, 2016

NPDES PERMIT#	REACH	NAME of Discharging Facility	TDS Conc. AVG.(Mg/L)	Flow Rate AVG.(MGD)	Salt Load Tons/Day	Explanantion Code
WY0000116	411	Kemmerer Water Treatment Plant	500	0.31	0.98	M-4B
WY0020117	411	Lyman Wastewater Lagoon	508	0.3	0.66	M-B
WY0020311	411	Naughton Plant	1300	2.32	19	I-5B
WY0020320	411	Kemmerer Wastewater Treatment	735	0.31	0.95	M-5B
WY0022071	411	Fort Bridger Sewer District	562	0.2	0.47	M-B
WY0022373	411	Granger Wastewater Lagoon			0	M-2
WY0032697	411	Carter Creek Gas Plant			0	I-2
WY0036153	411	Ft. Bridger Travel Stop		0	0	M-2
WY0094811	411	Haystack Coal				I-2
WY0021938	500	Dixon Wastewater Lagoon	269	0.05	0.04	M-A
WY0022888	500	Baggs Wastewater Lagoons	733	0.06	0.19	M-B
WY0042145	500	Cow Creek Unit	2130	0.05	0.44	I
WY0054038	500	Cow Creek CBNG Project			0	I-2
WY0056847	500	Morgan Run Unit II			0	I-2

APPENDIX D

EPA NPDES Permits List

LEGEND

NPDES PERMITS
EXPLANATION CODES

COLORADO RIVER BASIN SALINITY CONTROL FORUM
January 1, 2014 through December 31, 2016

NPDES permits are reviewed under two different criteria under Forum policy; these being municipal and industrial. In order for a permittee to be in compliance under the municipal criteria, the increase in concentration between inflow and outflow cannot be greater than 400 mg/L. Forum industrial criteria requires that no industrial user discharges more than 1.00 ton/day. Under Forum policy there can be granted exceptions to these limitations by the states. The following gives an explanation of the current status of the NPDES permits. Because at any given time many of the permits identified in this list are being reviewed, reissued, and/or terminated, and new discharge permits are being filed, this list must be considered as being subject to frequent change.

MUNICIPAL

(M) Municipal user in compliance with Forum policy.

(M-A) Municipal user in compliance with the 400 mg/L incremental increase provision.

(M-B) Municipal user in compliance with the 1 ton per day or 366 tons per year provision for intermittent discharges.

(M-1)* Permit has expired or been revoked. No discharge.

(M-2) Permittee did not discharge during the reporting period.

(M-3) Measurement of TDS is not currently required, but the state and/or EPA plans to require measurements of both inflow and outflow when the permit is reissued.

Measurements of inflow are not consistent with Forum policy;

(M-4A) Therefore, it is not known whether or not this municipal user is in compliance.

(M-4B) However, since outflow concentration is less than 500 mg/L it is presumed that this permit is not in violation of the ≤400 mg/L increase.

(M-5) Permittee is in violation of Forum policy in that there is an increase in concentration of >400 mg/L over the source waters. No provision has been made allowing this violation of Forum policy.

(M-5A) The state and/or EPA is currently working to bring permittee into compliance.

(M-5B) Though discharge is >400 mg/L over source waters, in keeping with Forum policy the permittee has demonstrated the salt reduction is not practicable and the requirement has been waived.

(M-6) This permit requires no discharge or discharge only under rare and extreme hydrologic conditions. Thus, flow and concentration measurements are not required.

(M-7) Insufficient data to know the current status of this permit.

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* Permits that have been expired or revoked and listed with the M-1 and I-1 explanation codes shall be removed from the NPDES list during the subsequent triennial review.

INDUSTRIAL

(I) Industrial user in compliance with Forum policy.

(I-A) Industrial user in compliance with the Forum's salinity offset policy.

(I-B) Industrial user in compliance with the 1 ton per day or 366 tons per year provision for intermittent discharges.

(I-1)* Permit has expired or been revoked. No discharge.

(I-2) Permittee did not discharge during the reporting period.

(I-3) Measurement of TDS is not currently required, but the state and/or EPA plans to require measurements of both volume and concentration of outflow when the permit is reissued.

(I-4) Either concentration or volume of outflow are not currently being reported, thus the permittee is in violation of Forum policy. It is not known if the discharge is in excess of the <1.00 ton/day requirement.

(I-5) Permittee is in violation of Forum policy in that discharge of salts is >1.00 ton/day. No provision has been made allowing this violation of Forum policy.

(I-5A) The state and/or EPA is currently working to bring permittee into compliance.

(I-5B) Though discharge is >1.00 ton/day, in keeping with Forum policy the permittee has demonstrated the salt reduction is not practicable and the requirement has been waived.

(I-5C) The use of ground water under this permit is for geothermal energy and only heat is extracted. The intercepted salt and water are naturally tributary to the Colorado River System and hence, this discharge does not increase salt in the river. The permit is covered by the Forum's policy on intercepted ground waters.

(I-5D) This permit is in compliance with the Forum's policy for fish hatcheries. The use of the water is a one-time pass through, and the incremental increase in salinity is ≤ 100 mg/l.

(I-5E) This permit is for the interception and passage of ground waters and thus is excepted under the Forum's policy on intercepted ground waters.

(I-6) This permit requires no discharge or discharge only under rare and extreme hydrologic conditions. Thus, flow and concentration measurements are not required.

(I-7) Insufficient data to know the current status of this permit.

LEGEND (continued)
NPDES PERMITS
REACH DEMARCATIONS

COLORADO RIVER BASIN SALINITY CONTROL FORUM

In order to provide a better understanding of the location of the various NPDES permits and the geographical sequence in the Colorado River System, each of the following NPDES permits is identified with a Colorado River reach number. The reach numbers have their origin in the old CRSS river model. Though this model is no longer used, the reach numbers assist in understanding the general location of the permits. The reaches are defined as:

100	Upper Main Stem	from headwaters of Colorado River to Colorado River near Cameo
190	Taylor Park	from headwaters of Gunnison River to above Blue Mesa Reservoir
200	Blue Mesa	from above Blue Mesa Reservoir to below Blue Mesa Dam
210	Morrow Point	from below Blue Mesa Dam to Crystal Reservoir
220	Lower Gunnison	from Crystal Reservoir to confluence with Colorado River
300	Grand Valley	from Colorado River near Cameo to confluence with Green River
310	Dolores River	from headwaters of Dolores River to confluence with Colorado River
401	Fontenelle	from headwaters of Green River to Green River near Green River, WY
411	Flaming Gorge	from Green River near Green River, WY to confluence with White and Duchesne Rivers
500	Yampa River	from headwaters of Yampa River to confluence with Green River
510	White River	from headwaters of White River to confluence with Green River
600	Green River	Green River from confluence with White and Duchesne Rivers to confluence with Colorado River
610	Duchesne River	from headwaters of Duchesne River to confluence with Green River
700	Lake Powell	Colorado River from confluence of with Green River to Lees Ferry
710	San Rafael River	from headwaters of San Rafael River to confluence with Green River
801	Upper San Juan River	from headwaters of San Juan River to San Juan near Bluff
802	Lower San Juan River	from San Juan near Bluff to confluence with Lake Powell
900	Glen Canyon to Lake Mead	Colorado River from Lees Ferry to backwaters of Lake Mead
905	Virgin River	from headwaters of Virgin River to backwaters of Lake Mead
910	Lake Mead	from backwaters of Lake Mead to Colorado River below Hoover Dam
920	Lake Mohave	Colorado River from below Hoover Dam down to I-40 bridge
930	Lake Havasu	Colorado River from I-40 bridge to below Parker Dam
940	Parker Dam to Imperial Dam	Colorado River from below Parker Dam to above Imperial Dam
945	Imperial Dam	Colorado River from above Imperial Dam to Gila and Yuma users

EPA ADMINISTERED NPDES PERMITS
Colorado River Basin Salinity Control Forum
January 1, 2014 through December 31, 2016

NPDES PERMIT#	REACH	NAME of Discharging Facility	TDS Conc. AVG.(Mg/L)	Flow Rate AVG.(MGD)	Salt Load Tons/Day	Explanantion Code

* Permit issued to a federal agency or an Indian tribe and the responsibility of EPA
** Issued by a tribal entity with delegation of the NPDES program

Region 6 Permits
Permits in New Mexico are issued by the U.S. EPA and certified by the
State of New Mexico Environment Department as reported in Appendix B.

Region 8 Permits

CO0034975*	190	USNPS - Colorado National Monument				M-6
CO0000086*	220	HOTCHKISS NTL. FISH HATCHERY	19	4.31	0.341	I-5D
CO0022853*	801	SOUTHERN UTE INDIAN TRIBE(E)	323	0.321	0.432	M
CO0034398*	801	USDINPS-MESA VERDE NAT PARK (E)	326	0.034	0.046	M
CO0034622*	801	USDINPS-MESA VERDE NAT PARK (E)		0.044		M-3
CO0034665*	801	FOUR CORNER MATERIALS	154	1.251	0.803	I
CO0034959*	801	IGNACIO PEAK WASTEWATER LAGOON				M-6
CO0034967*	801	SOUTHERN UTE WATER TRTMNT PLNT				M-2
COG589201*	801	TOWAOC WASTEWATER LAGOON				M-6
COG589202*	801	WHITE MESA WASTEWATER LAGOONS				M-6
COG589203*	801	TOWAOC WASTEWATER LAGOON 2				M-6
UT0000167*	510	American Gilsonite Co.	2,714	0.385	4.357	I-7
UT0025259*	510	American Gilsonite Co.			19.080	I-2

Region 9 Permits

AZ0022560*	900	BIA/KEAMS CANYON		0.03		M-1
AZ0024619*	900	HOPI INDIAN NATION/ UPPER VILLAGE OF MOENKOPI WWTP				M
AZ0021415*	940	COLORADO RIVER JOINT VENTURE	<400	1.2		M
NN0110094**	801	BIA/TEEC NOS POS TI'IS NAS BAZ SCHOOL	<400	0.08		M-1
NN0000019	801	APS Four Corners Power Plant		4.2		I-7
NN0028193	801	NTEC Navajo Mine				I-7
NN0020869	801	BIA Crystal Boarding School		0.015		M-6
NN0021016	801	BIA Lake Valley Boarding School		0.012		M-6
NN0020800	801	BIA Nenahnezad Community School		0.024		M-6
NN0020991	801	BIA Pueblo Pintado		0.016		M-6
NN0028584	801	Consolidation Coal Co Burnham Mine				I-7
NN0020621	801	NTUA Shiprock		1		M-6
NN0020265**	802	NTUA/CHINLE	<400	0.783		M
NN0020281**	802	NTUA/KAYENTA	<400	0.9		M
NN0110043**	802	BIA/NAZLINI BOARDING SCHOOL	<400	0.013		M
NN0020133	803	NACOGDOCHES OIL & GAS	<400	0.01		I-1
NN0020290**	900	NTUA/TUBA CITY	<400	1.1		M-6
NN0021555**	900	NTUA/WINDOW ROCK-FT.DEFIANCE	<400	1.32		M-6
NN0021610**	900	CAMERON TRADING POST		0.054		M-6
NN0022179**	900	PEABODY WESTERN COAL COMPANY/BLACK MESA COMPLEX				I
NN0022195**	900	NTUA/GANADO	<400	0.4		M
NN0024228**	900	NTUA/PINON WWTP				M
NN0030337**	900	BIA/LOW MOUNTAIN BOARDING SCHOOL	<400	0.014		M
NN0110167**	900	BIA/HUNTERS POINT SCHOOL	<400	0.014		M
NN0110183**	900	BIA/SEBA DALKAI BOARDING SCHOOL	<400	0.01		M
NN0020958	900	BIA Wingate School		0.1		M-6
NN0029386	900	Chevron Mining, Inc. / McKinley Mine				I-7
NN0030335	900	NTUA Navajo Townsite		0.32		M-6
NN0030325	900	Ramah Navajo School Board - Pine Hill		0.035		M-6
NN0025178	900	RJG Inc. - Gouldings Lodge		0.072		M-6
NN0030342	900	NTUA Cane Valley		0.001		M-1
NN0030339**		BIA/LUKACHUKAI COMMUNITY SCHOOL				M-6
NN0030341**		BIA/TORREON DAY SCHOOL				M-6
NN0030343		NTUA Northern Edge Casino		0.03		M
NN0030344		NTUA Twin Arrows Casino		0.13		M
NN0030345		Navajo Engineering & Construction Authority (NECA)				M
NN0030346		Mariano Lake Waterline Project				M

APPENDIX E

Colorado River Simulation System Model Description

COLORADO RIVER SIMULATION SYSTEM MODEL DESCRIPTION

The Colorado River Simulation System (CRSS) is the official long-term basin-wide planning model used by Reclamation's Upper Colorado and Lower Colorado Regions to simulate future Colorado River system conditions. The model framework used for this process is commercial software called RiverWare™, a generalized river basin modeling software package developed by the University of Colorado through a cooperative arrangement with Reclamation, the Tennessee Valley Authority and the U.S. Army Corps of Engineers.

CRSS was originally developed by Reclamation in the early 1970s and was implemented in RiverWare™ in 1996. The model projects future river and reservoir conditions on a monthly timestep over a period of decades into the future. CRSS has been used for most major modeling studies on the Colorado River, including several National Environmental Policy Act Environmental Impact Statements (EIS), the Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations for Lake Powell and Lake Mead EIS. CRSS was also the primary modeling tool for system projections in Reclamation's Colorado River Basin Water Supply and Demand Study under WaterSMART.

There are numerous inputs to, and assumptions made by, CRSS with respect to future conditions on the Colorado River. The input data for CRSS includes hydrologic inflows, various physical process parameters such as the evaporation rates for each reservoir, initial reservoir conditions, and the future diversion and depletion schedules for entities in the Basin States and for Mexico. These future schedules are based on demand and depletion projections prepared and submitted by the Basin States. The rules of operation of the Colorado River mainstream reservoirs, including Lakes Powell and Mead, are also provided as input to the model. These sets of operating rules describe how water is released and delivered under various hydrologic and system conditions.

As the period of analysis increases, the uncertainty in these inputs and assumptions also increases. Therefore, a large amount of uncertainty in the corresponding outputs is expected. Consequently, CRSS is not used to predict future conditions, but rather to simulate what might occur. CRSS is especially useful in making a relative comparison between hydrologic and salinity concentration impacts from different alternatives by holding constant most inputs, as well as other key modeling assumptions, so as to isolate the differences due to each alternative. Additionally, sensitivity analyses that answer the question, "What is the sensitivity of the output to a particular set of inputs or assumptions?" are commonly performed.

Future conditions of the Colorado River system are most sensitive to assumptions with respect to future inflows. Because it is impossible to predict the actual future inflows into the system, a range of possible future inflows are analyzed and used to quantify the probability of occurrences of particular events (e.g., higher or lower lake elevations). This technique involves running multiple hydrologic sequences for each scenario or operational alternative. These sequences can be derived from a number of techniques. Reclamation has used techniques based on (1) the historical observed natural flow record (1906-2012), (2) the paleo record derived from tree-rings

(762-2005), and (3) 112 downscaled Global Climate Model (GCM) projections based on 16 unique GCMs.

The CRSS RiverWare™ model includes a salinity module to analyze salinity concentrations throughout the Colorado River Basin. The salinity model simulates the effects of water development projects and the salinity control program (SCP) on future salinity concentration levels in the Colorado River. The salinity control criteria are purposely designed to be long-term and non-degradational goals, rather than exceedance standards such as those used for industry or drinking water. Efforts of the SCP are designed to meet the criteria by implementing, as needed, the most cost effective salinity control projects. This ensures that the salinity control numeric criteria will continue to be met in the future, even with the salinity impacts produced by increasing Upper Basin depletions.

Salinity module inputs include salinity accompanying hydrologic inflows, initial reservoir salinity concentrations, estimates of salt loading due to agricultural return flows and salt removed by salinity control projects. Model results simulate annual average salinity concentrations at the numeric criteria stations downstream of Hoover Dam and Parker Dam and at Imperial Dam and can be used to analyze the probability of exceeding the numeric criteria in future years.

The salinity module within CRSS is intended for long-term (15 to 20 years) simulation and it is highly sensitive to initial conditions during the first 10 to 12 years. The model assumes salinity is a conservative water quality parameter, and reservoirs are modeled as fully mixed systems.

Modeling Assumptions for the 2017 Triennial Review

The following lists major modeling assumptions in a bulleted format for the 2017 Triennial Review. These assumptions reflect the January 2017 Configuration of CRSS. Documents referenced in these assumptions include the Final Environmental Impact Statement (Final EIS), Record of Decision (ROD) for Colorado River Interim Guidelines for Lower Basin Shortages and the Coordinated Operations for Lake Powell and Lake Mead and the Prairie and Rajagopalan (2007) article entitled "A basin wide stochastic salinity model." Refer to these documents for additional detail regarding specific assumptions. All runs were performed using the CRSS long-term planning model.

Key Assumptions Common to All Scenarios Updated Since the 2014 Triennial Review

- Simulations performed from January 2017 through December 2035 at a monthly time step
- Initial conditions for all reservoirs are 2016 end-of-calendar year (EOCY) actual values
    - Includes pool elevation and reservoir salt concentration
- For modeling purposes, certain provisions (i.e., Shortage, Surplus, and Coordinated Operations) of the Interim Guidelines as adopted in the ROD (Section XI.G.) were extended from 2026 through 2035.
- Future water demands for Upper Division water users are based on depletion projections prepared by the Upper Division states in coordination with the Upper Colorado River Commission (UCRC) dated December 2007.

- Future water demands for the Lower Division States (during Normal Conditions) are according to the schedules provided for the 2007 FEIS for the Colorado River Interim Guidelines modeling with updates to Nevada's demands in December 2016.
- Intentionally Created Surplus (ICS)
    - ICS creation and delivery schedules were updated in 2009, 2012, and 2016 by the Lower Division states. Initial ICS balances were updated January 2017
    - Rules for ICS activity remain unchanged from the ROD
- Water Quality Improvement Projects (WQIP) have been updated to reflect historical and projected control levels.

Description of Four 2017 Triennial Review Scenarios

1.	**Without Additional Controls 2017: 1.33M Tons** • No additional future control beyond 2017 • 1,330,000 tons of control in 2035
2.	**Plan of Implementation 2020: 1.39M Tons** • No additional controls after this review period beyond 2020 • 1,394,000 tons of control in 2035
3.	**Plan of Implementation 2035: 1.66M Tons** • Controls associated with recent Program funding levels • 1,662,000 tons of control in 2035
4.	**Plan of Implementation 2035: 1.79M Tons** • Controls associated with preferred Program control levels • 1,786,000 tons of control in 2035

Other Assumptions Common to All Scenarios

1. Future hydrologic inflows are generated at 29 separate inflow points or nodes in the Colorado River watershed using the Indexed Sequential Method (Final Interim Guidelines EIS, Chapter 4.2.5). This technique is applied to the 107-year (1906 through 2012) historical record of calculated natural flows to produce 107 hydrologic inflow sequences or traces for each scenario.

2. Future salinity concentrations are generated at 20 nodes in the Colorado River watershed using Reclamation's nonparametric natural salt model. The natural salt model includes annual (Upper Basin) and monthly (Lower Basin) regressions built with 1971-2012 natural flow and salt mass data. The natural salt model provides salt mass based on flows. Salt concentrations are computed from flow and salt mass. Prairie and Rajagopalan (2007) describes the methods used in the basin-wide salinity modeling framework.

3. Annual salt loading values from agriculture are assumed constant throughout the simulation horizon. Variations in salt mass resulting from variation in flow conditions (high and low) are not considered; therefore, when computing natural salt we expect negative natural salt values.

4. Reservoirs upstream of Lake Powell are generally operated to meet monthly storage targets or downstream demands (Final EIS, Appendix A).

5. Lake Mead flood control procedures are always in effect.

6. Except during flood control conditions, Lake Mead is operated to meet downstream demands under the applicable water supply condition (Normal, Surplus, or Shortage).

7. If Lake Mead elevation falls below 1,000 feet, delivery to the Southern Nevada Water Authority (SNWA) is reduced to zero for that month.

8. Lake Mohave and Lake Havasu are operated in accordance with their existing rule curves.

9. Future water demands for Lower Division water users are based on depletion schedules prepared by the Lower Division states for the Final EIS (Final EIS, Appendix D).

10. Future water deliveries to Mexico are made as follows:
    a. CRSS accounts for the entire delivery to Mexico at the Northerly International Boundary (NIB).
    b. Mexico's annual delivery schedule is set to 1,500 kaf.
    c. An additional 70 kaf is delivered at the NIB for a total annual delivery to Mexico of 1,570 kaf.
    d. Mexico's annual delivery schedule is set to 1,700 kaf during Flood Control.

11. Non-storable flows arriving at NIB are assumed to be 70 kaf (1964 through 2015 average excluding flood years) for all years except the first year of the model simulation. In the first model year, the non-storable flows arriving at NIB are assumed to be 30 kaf. Bypass of return flows from the Wellton-Mohawk Irrigation and Drainage District to the Cienega de Santa Clara in Mexico is assumed to be 113 kaf annually (historical average from 1990 through 2016) and is not counted as part of the 1944 Treaty delivery to Mexico.

12. Yuma Desalting Plant is assumed to not operate.

APPENDIX F

Salinity Economic Impact Model Executive Summary

SALINITY ECONOMIC IMPACT MODEL
EXECUTIVE SUMMARY

The Salinity Economic Impact Model (SEIM) estimates the annual quantified damages (economic impacts) incurred in metropolitan and agricultural areas in the Lower Colorado River Basin (LCRB) that depend, either wholly or in part, on Colorado River water.

The SEIM is the current version of a salinity model that was originally developed in the late 1980s by the Milliken Chapman Research Group, Inc. (Lohman, 1988) to quantify the economic impacts of salinity from projects improving water efficiency in the Lower Colorado River Basin. Strategies to improve agricultural water efficiency included concrete-lining canals and retrofitting flood irrigation systems with drip or sprinkler irrigation systems. Prior to the use of salinity models such as the SEIM, the impacts of the salinity reduction on the economies of Lower Colorado River water users were unknown.

The model development in the 1980s was funded by the Bureau of Reclamation to quantify the efforts of the Colorado River Basin Salinity Control Advisory Council (Advisory Council). The Advisory Council's function is to:

> *"…advise the Secretaries of the Departments of the Interior and Agriculture…on all matters relating to efficient and timely planning and execution of salinity control measures…specified in the Colorado River Basin Salinity Control Act."*

The original salinity model estimated the economic impact due to salinity by considering five economic sectors that may be impacted by high-salinity Colorado River water. Over time, the original salinity model was updated and modified as new data became available. Brummer and Yahnke (1999) provided improved agricultural economic impact procedures for all areas except the Metropolitan Water District (MWD) service area. The MWD service area improvements are documented in MWD and Bureau of Reclamation (1999) and included updated procedures and data across all economic sectors.

A second salinity model was developed in the early 2000s based on this revised salinity model to improve the representation of the Central Arizona portion of the original model and support salinity economic impact analysis for the Central Arizona Salinity Study (Bureau of Reclamation, 2003). From 2003 until 2016, these two salinity models were run in tandem whenever an economic impact analysis was needed. In 2016, these two models were combined into a single Excel workbook model or the SEIM.

The SEIM was reviewed by representatives from Arizona, California and Nevada to provide recommendations on redefining model regions and updating data for use in the 2017 triennial review. Another objective of the SEIM review was to improve usability, efficiency and transparency of the SEIM.

Where possible, published data has been used in the SEIM. In some cases, current published data are not available, so historical data has been indexed to 2014 dollars using either the *Consumer Price Index* (Bureau of Labor Statistics, 2017) or the *Producer Price Index* (Bureau of Labor Statistics, 2017).

The SEIM estimates economic impact attributed to salinity levels greater than a baseline value of 500 mg/L[1] total dissolved solids (TDS) on household water-using appliances, the treatment and infrastructure replacement costs in the commercial, industrial and water utilities sectors, and income losses to agriculture. It also estimates the additional costs related to meeting California water quality standards for groundwater and recycled and publicly-owned treatment work (POTW) water use in the MWD service area. The model does not calculate an absolute value of the economic impacts due to salinity. The model estimates salinity impacts from the baseline condition and then calculates the change in economic impacts when salinity rises or declines in the Colorado River water used in the LCRB.

The SEIM accepts salinity concentrations, either measured from actual sampling or projected from the Colorado River Simulation System (CRSS), from three diversion points along the mainstem Lower Colorado River. Quantified damages due to salinity concentration are estimated for seven economic sectors across five regions. T able 1 summarizes the diversion points, economic sectors and regions that are included in SEIM.

Table 1
Names of Locations, Damage Sectors, and Regions Included in SEIM

Diversion Points	Economic Sectors	Regions
Hoover Dam	Agriculture	Central Arizona
Parker Dam	Residential	Mainstem Arizona
Imperial Dam	Commercial	Mainstem Nevada
	Utility	Mainstem California, Non-MWD
	Industrial	MWD Service Area
	Groundwater[2]	
	Recycling & POTW[2]	

Table 2 lists the subdivision of the regions as subareas. It should be noted that some subarea names are county names and the subarea may not include the entire county, only the portion that received Lower Colorado River mainstem waters.

Table 2
Subareas within Each Region in SEIM

Region	Subarea
Central Arizona	Phoenix AMA[3], Pinal AMA, Tucson AMA
Mainstem Arizona	Mohave County, La Paz County, Yuma County
Mainstem Nevada	Clark County
Mainstem California Non-MWD	Imperial County, San Bernardino County, Riverside County
MWD	Northwest, Los Angeles, West Basin, Central Basin, San Gabriel, Chino Basin, Orange County, Western Riverside, San Diego, Eastern Riverside

[1] U.S. EPA's secondary drinking water quality standard
[2] Only applies to MWD Service Area
[3] These are active management areas (AMA) in Central Arizona in which groundwater use is strictly regulated by the Arizona Department of Water Resources. Nearly 80% of Arizona's population resides in these 3 AMAs.

The SEIM estimates the annual quantitative damages by diversion point, economic sector for each region and subarea listed above. Table 3 presents the impacted items that are included in each economic sector's categories.

Table 3
Economic Sector Impact Category Items Included in the SEIM

Economic Sector	Impact Category Items
Residential	Water Pipes, Water Heater, Faucet, Garbage Disposal, Clothes Washer, Dishwasher, Water Softener, Detergent
Commercial	Sanitary, Cooling, Irrigation, Kitchen, Laundry, Misc.
Industrial	Process Water, Cooling Tower, Boiler, Sanitation, Irrigation
Water Utilities	Treatment Plant, Distribution System
Groundwater	Direct Recharge, Indirect Recharge, Incidental Recharge
Recycled Water & POTW	Irrigation, Direct Groundwater Recharge, Indirect Groundwater Recharge
Agriculture	**MWD Subareas Crops:** Strawberry, Nursery, Cut Flowers, Misc. Vegetable, Citrus, Avocado, Vineyard, Pasture/grain, Deciduous, Field Crops **All Other Subareas Crops:** Head Lettuce, Leaf Lettuce, Romaine Lettuce, Broccoli, Cauliflower, Alfalfa Hay, Onions, Avocados, Cantaloupe, Carrots, Oranges, Tangerines, Lemon/Limes, Grapefruit, Table Grapes, Potatoes, Corn, Wheat, Cotton, Barley, Olives, Honeydews, Tomatoes, Leaching Management Costs

The SEIM estimates damages (economic impact) on household, industrial, commercial, water utilities, agriculture sectors, groundwater, recycled and POTW. A general description of how each sector is calculated in the SEIM model is provided below.

Household Damage Calculation

The SEIM model estimates damages for 10 household items that have reduced useful life due to salinity. Each area in the model was updated with the best available data for the number of units per household and average cost per unit. Useful life functions based on given salinity values were developed from previous salinity research and can be found in the Milliken-Chapman study (1988). The SEIM model estimates the annual cost per household for each area based on the reduced useful life from increased salinity during the year of interest.

Commercial Damage Calculation

Commercial damages are calculated using one of two methods, which is determined by the data available for commercial water users. Method 1: Areas where commercial water use data resolution aligned with the five SEIM commercial categories are calculated as the product of the annual water use and the salinity cost function for each commercial category. The salinity cost functions were developed by MWD specifically for the SEIM. Method 2: Areas without the commercial water use data resolution required to use the salinity cost functions use an alternative approach based on the relationship between commercial and household water use. The relationship is the average ratio of annual commercial water use to annual residential water use. The commercial costs for these areas are calculated as the product of the commercial water use ratio and the cost of residential damages.

Industrial Damage Calculation

Salinity damages are estimated in the SEIM for five major types of industrial water use. Damage functions developed for these categories are applied to the amount of industrial water use by

category for each area in the model. Industries with processes requiring better quality water have larger costs associated with increasing salinity.

Water Utilities Damage Calculation

The SEIM estimates the damages to water utilities using two methods, depending on if per capita or total capital investment replacement costs are available. Method 1: In subareas with per capita costs of capital improvement replacement of water production and distribution facilities due to salinity, the damages are estimated using useful life functions of water production and distribution facilities that were developed by MWD. The per capita costs for water production and distribution costs are divided by the average life of the facilities based on the given salinity level and then multiplied by the metropolitan population for the year of interest. Method 2: In subareas with total capital improvement costs, the damages are estimated using only the useful life functions of distribution facilities that were developed by MWD. The total distribution costs are divided by the average life of the facilities based on the given salinity level. Under method two, water utility distribution replacement costs are not available.

Agriculture Damage Calculation

Agriculture damages are estimated in the SEIM through changes in gross revenue due to reduced crop yields of salt sensitive crops. Crop yield functions for the most common types of agriculture were developed or used from available research. The number of acres and current crop price per acre were updated with best available data in the current SEIM model. The gross crop revenue is estimated based on the crop yield per acre at a given salinity level and the price per acre for that crop. The revenue of the projected salinity is compared to the baseline TDS based revenue to determine the reduced revenue from increases in salinity for each area in the model. Areas that have more acres of crops sensitive to salinity changes have the largest amount of damages from reduced crop yields.

Groundwater, Recycling and Public-Owned Treatment Works

In the MWD service area, the SEIM calculates the costs of removing salts to maintain water quality requirements for groundwater and recycled water that are used extensively in the service area. MWD estimates the amount of water that drains into the groundwater system and the amount that is used for recycled water purposes. Salinity cost functions (costs to desalt these sources of water) estimate the costs at given salinity levels.

Figure 1 presents a map of the regions included in the SEIM with shading indicating the portion of each subarea that receives Colorado River mainstem waters, along with the economic sectors impacted within each respective subarea. The commercial and utilities economic sectors have two methods available to calculate economic impact. The map indicates whether method 1 or method 2 was used within each subarea.

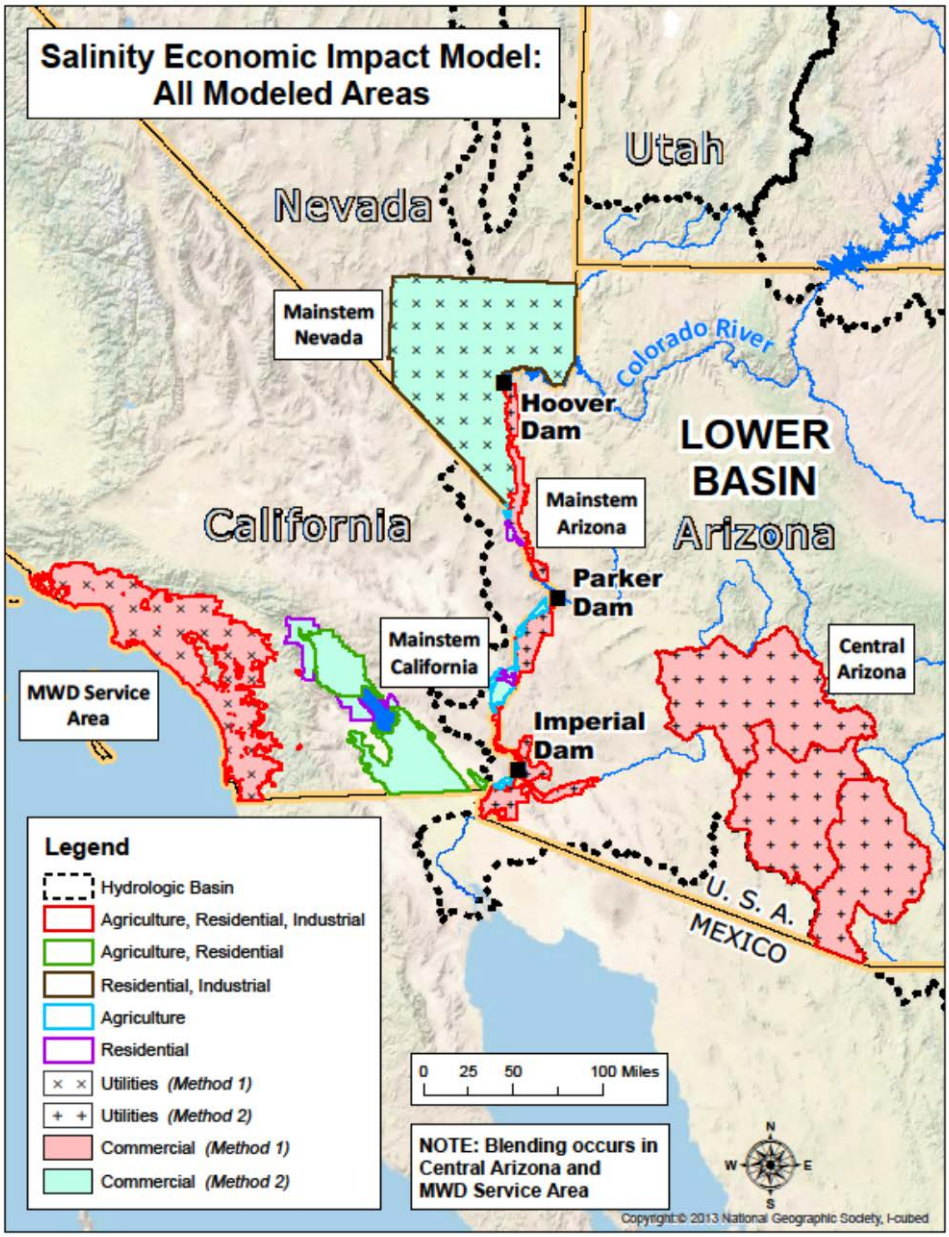

Figure 1 – Economic Sectors for the Regions Included in the SEIM

The impacts or damages estimated by the SEIM are based on the change in impacts from the 500 mg/L baseline with the projected increase in salinity from another modeling effort conducted by Reclamation, which includes incorporation of current and future salinity control projects mainly in the Upper Colorado River Basin. The model applies projected diversion point salinity to projected demographics and future water supply portfolios for each subarea. Reclamation collects projected demographics and water supply portfolios from Forum members. Collected data include projected population, housing and employment, along with projected residential, commercial and industrial water demands by subarea. The model currently projects annual damages for any year between 2015 and 2040.

The latest SEIM dated 06/29/17 was used during the 2017 Triennial Review to estimate quantified damages in the Lower Colorado River Basin. Table 4 presents the diversion point projected salinity concentrations from CRSS and the SEIM average annual quantified damages for the years 2017 and 2035.

Table 4
CRSS Projected Average Annual Concentration and the SEIM Economic Impact

2017							
	Average Annual Concentration (mg/L)			Average Annual Quantified Damages ($ millions)			
Alternative	Hoover	Parker	Imperial	Hoover	Parker	Imperial	Total
1.33M tons removed	613	631	761	$48.524	$169.327	$236.262	$454.113
1.39M tons removed	613	631	761	$48.524	$169.327	$236.262	$454.113
1.66M tons removed	613	631	761	$48.524	$169.327	$236.262	$454.113
1.79M tons removed	613	631	761	$48.524	$169.327	$236.262	$454.113

2035							
	Average Annual Concentration (mg/L)			Average Annual Quantified Damages ($ millions)			
Alternative	Hoover	Parker	Imperial	Hoover	Parker	Imperial	Total
1.33M tons removed	641	660	797	$78.361	$222.814	$273.013	$574.188
1.39M tons removed	636	655	791	$75.583	$215.347	$267.124	$558.054
1.66M tons removed	619	637	769	$66.120	$188.775	$245.541	$500.436
1.79M tons removed	611	630	760	$61.665	$179.040	$236.710	$477.415

Table 5 p resents the annual reduction in salinity concentration and quantified damages as compared to the No Additional Future Controls Beyond 2017 (1.33M tons removed) alternative at each diversion point and as a LCRB total.

Table 5
Annual Reduction in Salinity Concentration and Quantified Damages as Compared to the No Additional Future Controls Beyond 2017 (1.33M tons removed)

2017							
	Annual Concentration Reduction (mg/L)			Annual Quantified Damage Reduction ($ millions)			
Alternative	Hoover	Parker	Imperial	Hoover	Parker	Imperial	Total
1.33M tons removed	0	0	0	$0.000	$0.000	$0.000	$0.000
1.39M tons removed	0	0	0	$29.837	$0.000	$0.000	$29.837
1.66M tons removed	0	0	0	$29.837	$0.000	$0.000	$29.837
1.79M tons removed	0	0	0	$29.837	$0.000	$0.000	$29.837

2035							
	Annual Concentration Reduction (mg/L)			Annual Quantified Damage Reduction ($ millions)			
Alternative	Hoover	Parker	Imperial	Hoover	Parker	Imperial	Total
1.33M tons removed	0	0	0	$0.000	$0.000	$0.000	$0.000
1.39M tons removed	5	5	6	$2.778	$7.467	$5.889	$16.134
1.66M tons removed	22	23	28	$12.241	$34.039	$27.472	$73.752
1.79M tons removed	30	30	37	$16.696	$43.774	$36.303	$96.773

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Herndon, Rudy. Oct. 31, 2013. “State turns attention to selenium levels in river.” Times Independent.

print

State turns attention to selenium levels in river

by Rudy Herndon
Staff Writer
10.31.13 - 10:35 am

Like other trace minerals, selenium is essential to human health: It repairs DNA, it boosts immune systems and some researchers believe that it might even halt cancer in its tracks.

But in high doses and some chemical forms, it can be toxic to people, fish and migratory birds.

Some once-common native fish species are especially sensitive to long-term selenium exposure, which can damage their reproductive systems, cause deformities or kill them outright.

At least eight of those species happen to live in the Colorado River between the Utah-Colorado state line and the Green River confluence. Yet that same stretch of river occasionally contains elevated levels of selenium, and researchers believe those conditions may be one of many factors that led to the species’ overall decline.

Living Rivers Conservation Director John Weisheit worries that the situation could hamper efforts to restore populations of endangered or at-risk species, including the humpback chub, bonytail, Colorado pikeminnow and razorback sucker. It also points to a much broader ecological problem, he said.

“One could say, ‘to hell with these silly fish,’ but 35 million people also drink this water and 5 million acres are irrigated with this water, as well,” Weisheit said in an email to *The Times-Independent*. “It’s just another canary in the coal mine for a river system that is crashing on more than one level.”

There are some encouraging trends to report, though, according to the Utah Division of Water Quality.

Years of research show that selenium levels in the Colorado River are down significantly from where they were at the turn of the century.

According to the U.S. Geological Survey, levels at the state line have dropped by about 40 percent since the mid-1980s.

The problem that remains appears to be seasonal in nature.

Data from four Utah Department of Environmental Quality monitoring sites along the river show that August is the only time of year that selenium loads actually exceed state standards.

Herndon, Rudy. Oct. 31, 2013. “State turns attention to selenium levels in river.” Times Independent.

“When the Colorado River is really low, that’s when you see these conditions,” Utah Division of Water Quality Project Manager Mike Allred said earlier this month.

To gain a better understanding of the issue, Division of Water Quality researchers collected just under 150 samples from the river between 2000 and 2010.

They found that 40 of those samples exceeded the state’s standards. But they also noticed a couple of trends: Selenium concentrations at each site appear to be falling over time, and they’re also going down from one monitoring site to the next.

“It actually gets better at each monitoring site further downstream,” Allred said.

That’s not to say that things are back to normal yet.

In 2006, the Utah stretch of the river between the state line and the Green River confluence appeared on the state’s list of impaired waters under the Clean Water Act, and it will remain there until federal regulators say otherwise.

The state Division of Water Quality responded by drafting new limits on the highest amounts of selenium that can enter the river each day, short of violating federal water quality standards. (The proposed limits are called Total Maximum Daily Loads, or TMDLs.) The state released the selenium study in late September and the public comment period closed Oct. 30.

Aside from that work, however, Allred said there isn’t much that people on this side of the state line can do to address the problem.

Agricultural operations cover less than 3 percent of the total Upper Colorado River watershed in Utah, and urban impacts to the area are even smaller, at about one-third of 1 percent.

“It really means that it’s going to be hard for us to do anything on the Utah side because of the small amount of agriculture,” he said.

But there is more that can be done on the Colorado side of the border, where the problem originates, according to Allred.

“I hate to point a finger upstream, but the data really does that,” Allred said.

Selenium from the Grand Valley and the Lower Gunnison River Basin has been trickling into the Colorado River since an ancient seabed dried up, creating a geological formation known as the Mancos Shale.

While the shale contains high levels of selenium, the area’s dry climate served as

Herndon, Rudy. Oct. 31, 2013. “State turns attention to selenium levels in river.” Times Independent.

a natural check on loads into the river.

However, the mineral dissolves easily when it’s exposed to water, and more than a century of agricultural development in and around Grand Junction created a pathway that increased those loads.

According to estimates from the Gunnison Basin/ Grand Valley Selenium Task Forces, up to 75 percent of the selenium loading near the state line comes from the Grand Valley and the Uncompahgre irrigation project. The Gunnison River alone accounts for more than half of all selenium loading into the Colorado.

The good news, from Allred’s perspective, is that upstream users are aware of the problem, and they’re collaborating on projects to address it.

“They’re actually working quite hard to reduce the selenium there,” he said.

By some estimates, the various stakeholders in the area have spent $250 million on related improvements.

Task force coordinator Sonja Chavez de Baca said that work includes upgrades to more efficient irrigation techniques, including center pivot sprinklers, micro-spray and drip irrigation systems. Other projects have focused on improvements to unlined canals and lateral ditches that previously seeped water into selenium-rich soils.

“I think we’re starting to see things happen, which is good,” she said Oct. 22. “Hopefully, we can continue this downward trend.”

Moving forward, Chavez de Baca would like to see more farmers embrace practices that build healthier soils and use water more wisely.

In doing so, they can also develop healthier crops and increase their production, she said.

However, she believes that some stakeholders are counting a bit too much on agricultural improvement projects to solve the overall problem.

As communities from Grand Junction to Delta and Montrose continue to grow, selenium is reaching the river system through a new pathway: Suburban sprawl.

Montrose County’s population alone grew by nearly 25 percent between 2000 and 2010, and much of that growth occurred in previously undeveloped rural areas.

In recent years, new homes have been built on adobe soils, where selenium concentrations are up to 34 times higher than normal levels, according to Chavez de Baca.

Herndon, Rudy. Oct. 31, 2013. “State turns attention to selenium levels in river.” Times Independent.

Homeowners in those areas are often hooked up to individual septic systems, and many of them have installed water-loving lawns that ultimately leach selenium back into the river and its tributaries.

The 2008 recession put a dent in that growth, and Chavez de Baca sees a new window of opportunity for community leaders to adopt water conservation measures.

“I think that in the future, it would be great to see county officials buy in [to that idea],” she said.

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PUBLIC LAW 93-320–JUNE 24, 1974

88 STAT.

Public Law 93-320

AN ACT

Juen 24, 1974
[sic]
{H.R.12165}

To authorize the construction, operation, and maintenance of certain works in the Colorado River Basin to control the salinity of water delivered to users in the United States and Mexico.

Colorado River Basin Salinity Control Act.
43 USC 1571 note.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That this Act may be cited as the "Colorado River Basin Salinity Control Act".

TITLE I—PROGRAMS DOWNSTREAM FROM IMPERIAL DAM

U.S. and Mexico, water quality improvement.
43 USC 1571.

SEC. 101. (a) The Secretary of the Interior, hereinafter referred to as the "Secretary", is authorized and directed to proceed with a program of works of improvement for the enhancement and protection of the quality of water available in the Colorado River for use in the United Sates and the Republic of Mexico, and to enable the United States to comply with its obligations under the agreement with Mexico of August 30, 1973 (Minute No. 242 of the International Boundary and Water Commission, United States and Mexico), concluded pursuant to the Treaty of February 3, 1944 (TS 994), in accordance with the provisions of this Act.

24 UST 1968.

59 Stat. 1219.

Desalting complexes, construction and maintenance.

(b)(1) The Secretary is authorized to construct, operate, and maintain a desalting complex, including (1) a desalting plant to reduce the salinity of drain water from the Wellton-Mohawk division of the Gila project, Arizona (hereinafter referred to as the division), including a pretreatment plant for settling, softening, and filtration of the drain water to be desalted; (2) the necessary appurtenant works including the intake pumping plant system, product waterline, power transmission facilities, and permanent operating facilities; (3) the necessary extension in the United States and Mexico of the existing bypass drain to carry the reject stream from the desalting plant and other drainage waters to the Santa Clara Slough in Mexico, with the part in Mexico, subject to arrangements made pursuant to section 101(d); (4) replacement of the metal flume in the existing main outlet drain extension with a concrete siphon; (5) reduction of the quantity of irrigation return flows through acquisition of lands to reduce the size of the division, and irrigation efficiency improvements to minimize return flows; (6) acquire on behalf of the United States such lands or interest in lands in the Painted Rock Reservoir as may be necessary to operate the project in accordance with the obligations of Minute No. 242, and (7) all associated facilities including roads, railroad spur, and transmission lines.

Desalting plants, treatment capacity.

(2) The desalting plant shall be designed to treat approximately one hundred and twenty-nine million gallons a day of drain water using advanced

technology commercially available. The plant shall effect recovery initially of not less than 70 per centum of the drain water as product water, and shall effect reduction of not less than 90 per centum of the dissolved solids in the feed water. The Secretary shall use sources of electric power supply for the desalting complex that will not diminish the supply of power to preference customers from Federal power systems operated by the Secretary. All costs associated with the desalting plant shall be nonreimbursable.

Nonreimbursable costs

(c) Replacement of the reject stream from the desalting plant and of any Wellton-Mohawk drainage water bypassed to the Santa Clara Slough to accomplish essential operation except at such times when there exists surplus water of the Colorado River under the terms of the Mexican Water Treaty of 1944, is recognized as a national obligation as provided in section 202 of the Colorado River Basin Project Act (82 Stat. 895). Studies to identify feasible measures to provide adequate replacement water shall be completed not later than June 30, 1980. Said studies shall be limited to potential sources within the States of Arizona, California, Colorado, New Mexico, and those portions of Nevada, Utah, and Wyoming which are within the natural drainage basin of the Colorado River. Measures found necessary to replace the reject stream from the desalting plant and any Wellton-Mohawk drainage bypassed to the Santa Clara Slough to accomplish essential operations may be undertaken independently of the national obligation set forth in section 202 of the Colorado River Basin Project Act.

Replacement water, studies.

59 Stat. 1219.

43 USC 1512.

(d) The Secretary is hereby authorized to advance funds to the United States section, International Boundary and Water Commission (IBWC), for construction, operation, and maintenance by Mexico pursuant to Minute No. 242 of that portion of the bypass drain within Mexico. Such funds shall be transferred to an appropriate Mexican agency, under arrangements to be concluded by the IBWC providing for the construction, operation, and maintenance of such facility by Mexico.

U.S. section, IBWC, advance funds.

24 UST 1968.

(e) Any desalted water not needed for the purpose of this title may be exchanged at prices and under terms and conditions satisfactory to the Secretary and the proceeds therefrom shall be deposited in the General Fund of the Treasury. The city of Yuma, Arizona, shall have first right of refusal to any such water.

Desalted water exchange.

(f) For the purpose of reducing the return flows from the diversion to one hundred and seventy-five thousand acre-feet or less, annually, the Secretary is authorized to:

Return flow reduction.

(1) Accelerate the cooperative program of Irrigation Management Services with the Wellton-Mohawk Irrigation and Drainage District, hereinafter referred to as the district, for the purpose of improving irrigation efficiency. The district shall bear its share of the cost of such program as determined by the Secretary.

(2) Acquire, by purchase or through eminent domain or exchange, or the extent determined by him to be appropriate, lands or interests in lands to reduce the existing seventy-five thousand developed and undeveloped irrigable acres authorized by the Act of July 30, 1947 (61 Stat. 628), known as the Gila Reauthorization Act. The initial reduction in irrigable acreage shall be limited to approximately ten thousand acres. If the Secretary determines that the irrigable acreage of the division must be reduced below sixty-five thousand acres of irrigable lands to carry out the

Irrigable acreage reduction.

43 USC 613.

Limitation.

purpose of this section, the Secretary is authorized, with the consent of the district, to acquire additional lands, as may be deemed by him to be appropriate.

Acquired lands, disposal.

(g) The Secretary is authorized to dispose of the acquired lands and interests therein on terms and conditions satisfactory to him and meeting the objective of this Act.

System improvements, installation assistance.

(h) The Secretary is authorized, either in conjunction with or in lieu of land acquisition, to assist water users in the division in installing system improvements, such as ditch lining, change of field layouts, automatic equipment, sprinkler systems and bubbler systems, as a means of increasing irrigation efficiencies: *Provided, however,* That all costs associated with the improvements authorized herein and allocated to the water users on the basis of benefits received, as determined by the Secretary, shall be reimbursed to the United States in amounts and on terms and conditions satisfactory to the Secretary.

Costs, reimbursement to U.S.

Contract amendment.

(i) The Secretary is authorized to amend the contract between the United States and the district dated March 4, 1952, as amended, to provide that—

(1) the portion of the existing repayment obligation owing to the United States allocable to irrigable acreage eliminated from the division for the purposes of this title, as determined by the Secretary, shall be nonreimbursable; and

(2) if deemed appropriate by the Secretary, the district shall be given credit against its outstanding repayment obligation to offset any increase in operation and maintenance assessments per acre which may result from the district's decreased operation and maintenance base, all as determined by the Secretary.

Land acquisition for storage

(j) The Secretary is authorized to acquire through the Corps of Engineers fee title to, or other necessary interests in, additional lands above the Painted Rock Dam in Arizona that are required for the temporary storage capacity needed to permit operation of the dam and reservoir in times of serious flooding in accordance with the obligations of the United States under Minute No. 242. No funds shall be expended for acquisition of land or interests therein until it is finally determined by a Federal court of competent jurisdiction that the Corps of Engineers presently lacks legal authority to use said lands for this purpose. Nothing contained in this title nor any action taken pursuant to it shall be deemed to be a recognition or admission of any obligation to the owners of such land on the part of the United States or a limitation or deficiency in the rights or powers of the United States with respect to such lands or the operation of the reservoir.

24 UST 1968.

Transfer of funds

(k) To the extent desirable to carry out sections 101(f)(1) and 101(h), the Secretary may transfer funds to the Secretary of Agriculture as may be required for technical assistance to farmers, conduct of research and demonstrations, and such related investigations as are required to achieve higher on-farm irrigation efficiencies.

Nonreimbursable costs.

(l) All cost associated with the desalting complex shall be nonreimbursable except as provided in sections 101(f)(1) and 101(h).

Canal or canal lining, construction
43 USC 1572

SEC. 102. (a) To assist in meeting salinity control objectives of Minute No. 242 during an interim period, the Secretary is authorized to construct a new concrete-lined canal or, to line the presently unlined portion of the Coachella Canal of the Boulder Canyon project, California, from station 2 plus 26 to the beginning of siphon numbered 7, a length of approximately forty-nine miles. The United States shall be entitled to temporary use of a quantity of water, for

the purpose of meeting the salinity control objectives of Minute No. 242, during an interim period, equal to the quantity of water conserved by constructing or lining the said canal. The interimperiod shall commence on completion of construction or lining said canal and shall end the first year that the Secretary delivers main stream Colorado River water to California in an amount less than the sum of the quantities requested by (1) the California agencies under contracts made pursuant to section 5 of the Boulder Canyon Project Act (45 Stat. 1057), and (2) Federal establishments to meet their water rights acquired in California in accordance with the Supreme Court decree in Arizona against California (376 U.S. 340).

43 USC 617d.

(b) The charges for total construction shall be repayable without interest in equal annual installments over a period of forty years beginning In the year following completion of construction: *Provided*, That, repayment shall be prorated between the United States and the Coachella Valley County Water District, and the Secretary is authorized to enter into a repayment contract with Coachella Valley County Water District for that purpose. Such contract shall provide that annual repayment installments shall be nonreimbursable during the interim period, defined in section 102(a) of this title and shall provide that after the interim period, said annual repayment installments or portions thereof, shall be paid by Coachella Valley County Water District.

Repayment.

Repayment contract.

(c) The Secretary is authorized to acquire by purchase, eminent domain, or exchange private lands or interests therein, as may be determined by him to be appropriate, within the Imperial Irrigation District on the Imperial East Mesa which receive, or which have been granted rights to receive, water from Imperial Irrigation District's capacity in the Coachella Canal. Costs of such acquisitions shall be nonreimbursable and the Secretary shall return such lands to the public domain. The United States shall not acquire any water rights by reason of this land acquisition.

Private lands, acquisition.

(d) The Secretary is authorized to credit Imperial Irrigation District against its final payments for certain outstanding construction charges payable to the United States on account of capacity to be relinquished in the Coachella Canal as a result of the canal lining program, all as determined by the Secretary: *Provided*, That, relinquishment of capacity shall not affect the established basis for allocating operation and maintenance costs of the main All-American Canal to existing contractors.

Imperial Irrigation District, construction charges, credit.

(e) The Secretary is authorized and directed to cede the following land to the Cocopah Tribe of Indians, subject to rights-of-way for existing levees, to be held in trust by the United States for the Cocopah Tribe of Indians:

Cocopah Tribe of Indians, lands In trust.

Township 9 south, range 25 west of the Gila and Salt River meridian, Arizona;

Section 25: Lots 18, 19, 20, 21, 22, and 23;

Section 26: Lots 1, 12, 13, 14, and 15;

Section 27: Lot 3; and all accretion to the above described lands.

The Secretary is authorized and directed to construct three bridges, one of which shall be capable of accommodating heavy vehicular traffic, over the portion of the bypass drain which crosses the reservation of the Cocopah Tribe of Indians. The transfer of lands to the Cocopah Indian Reservation and the construction of bridges across the bypass drain shall constitute full and complete payment to said tribe for the rights-of-way required for construction of the bypass drain and electrical transmission lines for works authorized by this title.

Bridges construction.

43 USC 1573.
Well kids, construction and maintenance.
24 UST 1968.
59 Stat. 1219.
Land acquisition.

SEC. 103. (a) The Secretary is authorized to:

(1) Construct, operate, and maintain, consistent with Minute No. 242, well fields capable of furnishing approximately one hundred and sixty thousand acre-feet of water per year for use in the United States and for delivery to Mexico in satisfaction of the 1944 Mexican Water Treaty.

(2) Acquire by purchase, eminent domain, or exchange, to the extent determined by him to be appropriate, approximately twenty-three thousand five hundred acres of lands or interests therein within approximately five miles of the Mexican border on the Yuma Mesa: *Provided, however*, That any such lands which are presently owned by the State of Arizona may be acquired or exchanged for Federal lands.

Land replacement.
43 USC 613.

(3) Any lands removed from the jurisdiction of the Yuma Mesa Irrigation and Drainage District pursuant to clause (2) of this subsection which were available for use under the Gila Reauthorization Act (61 Stat. 628) shall be replaced with like lands within or adjacent to the Yuma Mesa division of the project. In the development of these substituted lands or any other lands within the Gila project, the Secretary may provide for full utilization of the Gila Gravity Main Canal in addition to contracted capacities.

Nonreimbursable costs.

(b) The cost of work provided for in this section, including delivery of water to Mexico, shall be nonreimbursable; except to the extent that the waters furnished are used in the United States.

Project modification.
43 USC 1574.

SEC. 104. The Secretary is authorized to provide for modifications of the projects authorized by this title to the extent he determines appropriate for purposes of meeting the international settlement objective of this title at the lowest overall cost to the United States. No funds for any such modification shall be expended until the expiration of sixty days after the proposed modification has been submitted to the appropriate committees of the Congress, unless the Congress approves an earlier date by concurrent resolution. The Secretary shall notify the Governors of the Colorado River Basin States of such modifications.

Contract authority.
43 USC 1575.

SEC. 105. The Secretary is hereby authorized to enter into contracts that he deems necessary to carry out the provisions of this title in advance of the appropriation of funds therefor.

Interagency cooperation.
43 USC 1576.

SEC. 106. In carrying out the provisions of this title, the Secretary shall consult and cooperate with the Secretary of State, the Administrator of the Environmental Protection Agency, the Secretary of Agriculture, and other affected Federal, State, and local agencies.

43 USC 1577.
42 USC 4321 note.
33 USC 1251 note.

SEC. 107. Nothing in this Act shall be deemed to modify the national Environmental Policy Act of 1969, the Federal Water Pollution Control Act, as amended, or, except as expressly stated herein, the provisions of any other Federal law.

Appropriation.
43 USC 1578.

SEC. 108. There is hereby authorized to be appropriated the sum of $121,500,000 for the construction of the works and accomplishment of the purposes authorized in sections 101 and 102, and $34,000,000 to accomplish the purposes of section 103, based on April 1973 prices, plus or minus such amounts as may be justified by reason of ordinary fluctuations in construction costs involved therein, and such sums as may be required to operate and maintain such works and to provide for such modifications as may be made pursuant to section 104. There is further authorized to be appropriated such sums as may be necessary to pay condemnation awards in

excess of appraised values and to cover costs required in connection with the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (Public Law 90-646).

42 USC 4601 note.

TITLE 11-MEASURES UPSTREAM FROM IMPERIAL DAM

43 USC 1591.

SEC. 201. (a) The Secretary of the Interior shall implement the salinity control policy adopted for the Colorado River in the "Conclusions and Recommendations" published in the Proceedings of the Reconvened Seventh Session of the Conference in the Matter of Pollution of the Interstate Waters of the Colorado River and Its Tributaries in the States of California, Colorado, Utah, Arizona, Nevada, New Mexico, and Wyoming, held in Denver, Colorado, on April 26-27, 1972, under the authority of section 10 of the Federal Water Pollution Control Act (33 U.S.C. 1160), and approved by the Administrator of the Environmental Protection Agency on June 9, 1972.

(b) The Secretary is hereby directed to expedite the investigation, planning, and implementation of the salinity control program generally as described in chapter VI of the Secretary's report entitled "Colorado River Water Quality Improvement Program, February 1972".

Interagency cooperation.

(c) In conformity with section 201 (a) of this title and the authority of the Environmental Protection Agency under Federal laws, the Secretary, the Administrator of the Environmental Protection Agency, and the Secretary of Agriculture are directed to cooperate and coordinate their activities effectively to carry out the objective of this title.

Salinity control units, construction and maintenance.
43 USC 1592.

SEC. 202. The Secretary is authorized to construct, operate, and maintain the following salinity control units as the initial stage of the Colorado River Basin salinity control program.

(1) The Paradox Valley unit, Montrose County, Colorado, consisting of facilities for collection and disposition of saline ground water of Paradox Valley, including wells, pumps, pipelines, solar evaporation ponds, and all necessary appurtenant and associated works such as roads, fences, dikes, power transmission facilities, and permanent operating facilities.

(2) The Grand Valley unit, Colorado, consisting of measures and all necessary appurtenant and associated works to reduce the seepage of irrigation water from the irrigated lands of Grand Valley into the ground water and thence into the Colorado River. Measures shall include lining of canals and laterals, and the combining of existing canals and laterals into fewer and more efficient facilities. Prior to initiation of construction of the Grand Valley unit the Secretary shall enter into contracts through which the agencies owning, operating, and maintaining the water distribution systems in Grand Valley, singly or in concert, will assume all obligations relating to the continued operation and maintenance of the unit's facilities to the end that the maximum reduction of salinity inflow to the Colorado River will be achieved. The Secretary is also authorized to provide, as an element of the Grand Valley unit, for a technical staff to provide information and assistance to water users on means and measures for limiting excess water applications to irrigated lands: *Provided*, That such assistance shall not exceed a period of five years after funds first become available under this title. The Secretary will enter into agreements with the Secretary of Agriculture to develop a unified control plan for the Grand Valley unit. The Secretary of agriculture is directed to cooperate in the planning and construction of on-farm system measures under programs available to that Department.

(3) The Crystal Geyser unit, Utah, consisting of facilities for collection and disposition of saline geyser discharges; including dikes, pipelines, solar evaporation ponds, and all necessary appurtenant works including operating facilities.

(4) The Las Vegas Wash unit, Nevada, consisting of facilities for collection and disposition of saline ground water of Las Vegas Wash, including infiltration galleries, pumps, desalter, pipelines, solar evaporation facilities, and all appurtenant works including but not limited to roads, fences, power transmission facilities, and operating facilities.

3 USC 1593.
Planning reports.

SEC. 203. (a) The Secretary is authorized and directed to—

(1) Expedite completion of the planning reports on the following units, described in the Secretary's report, "Colorado River Water Quality Improvement Program, February 1972":

(i) Irrigation source control:
Lower Gunnison
Uintah Basin
Colorado River Indian Reservation
Palo Verde Irrigation District

(ii) Point source control:
LaVerkin Springs
Littlefield Springs
Glenwood -Dotsero Springs

(iii) Diffuse source control:
Price River
San Rafael River
Dirty Devil River
McElmo Creek
Big Sandy River

Reports.

(2) Submit each planning report on the units named in section 203(a) (1) of this title promptly to the Colorado River Basin States and to such other parties as the Secretary deems appropriate for their review and comments.

Submittal to President and Congress.

After receipt of comments on a unit and careful consideration thereof, the Secretary shall submit each final report with his recommendations, simultaneously, to the President, other concerned Federal departments and agencies, the Congress, and the Colorado River Basin States.

(b) The Secretary is directed—

Research and demonstration projects.

(1) in the investigation, planning, construction, and implementation of any salinity control unit involving control of salinity from irrigation sources, to cooperate with the Secretary of Agriculture in carrying out research and demonstration projects and in implementing on-the-farm improvements and farm management practices and programs which will further the objective of this title;

(2) to undertake research on additional methods for accomplishing the objective of this title, utilizing to the fullest extent practicable the capabilities and resources of other Federal departments and agencies, interstate institutions, States, and private organizations.

Colorado River Basin Salinity Control Advisory Council.

Establishment; membership.

43 USC 1594.

Duties.

SEC. 204. (a) There is hereby created the Colorado River Basin Salinity Control Advisory Council composed of no more than three members from each State appointed by the Governor of each of the Colorado River Basin States.

(b) The 'Council shall be advisory only and shall—

(1) act as liaison between both the Secretaries of Interior and Agriculture and the Administrator of the Environmental Protection Agency and the States in accomplishing the purposes of this title;

(2) receive reports from the Secretary on the progress of the salinity control program and review and comment on said reports; and

(3) recommend to both the Secretary and the Administrator of the Environmental Protection Agency appropriate studies of further projects, techniques, or methods for accomplishing the purposes of this title.

Costs, allocation.
43 USC 1595.

SEC. 205. (a) The Secretary shall allocate the total costs of each unit or separable feature thereof authorized by section 202 of this title, as follows:

(1) In recognition of Federal responsibility for the Colorado River as an interstate stream and for international comity with Mexico, Federal ownership of the lands of the Colorado River Basin from which most of the dissolved salts originate, and the policy embodied in the Federal Water Pollution Control Act Amendments of 1972 (86 Stat. 816), 75 per centum of the total costs of construction, operation, maintenance, and replacement of each unit or separable feature thereof shall be nonreimbursable.

33 USC 1251 note.

(2) Twenty-five per centum of the total costs shall be allocated between the Upper Colorado River Basin Fund established by section 5 (a) of the Colorado River Storage Project Act (70 Stat. 107) and the Lower Colorado River Basin Development Fund established by section 403(a) of the Colorado River Basin Project Act (82 Stat. 895), after consultation with, the Advisory Council created in section 204(a) of this title and consideration of the following items:

43 USC 620d.

43 USC 1543.

(i) benefits to be derived in each basin from the use of water of improved quality and the use of works for improved water management;

(ii) causes of salinity; and

(iii) availability of revenues in the Lower Colorado River Basin Development Fund and increased revenues to the Upper Colorado River Basin Fund made available under section 205(d) of this title: *Provided,* That costs allocated to the Upper Colorado River Basin Fund under section 205 (a) (2) of this title shall not exceed 15 per centum of the costs allocated to the Upper Colorado River Basin Fund and the Lower Colorado River Basin Development Fund.

Costs, limitation.

Construction costs, repayment.

(3) Costs of construction of each unit or separable feature thereof allocated to the upper basin and to the lower basin under section 205 (a) (2) of this title shall be repaid within a fifty-year period without interest from the date such unit or separable feature thereof is determined by the Secretary to be in operation.

(b)(1) Costs of construction, operation, maintenance, and replacement of each unit or separable feature thereof allocated for repayment by the lower basin under section 205(a)(2) of this title shall be paid in accordance with subsection 205(b) (2) of this title, from the Lower Colorado River Basin Development Fund.

43 USC 1543.

(2) Section 403(g) of the Colorado River Basin Project Act (82 Stat. 896) is hereby amended as follows: strike the word "and" after the word "Act" in line 8; insert after the word "Act," the following "(2) for repayment to the general fund of the Treasury the costs of each salinity control unit or separable feature thereof payable from the Lower Colorado River Basin Development Fund in accordance with sections 205(a)(2), 205(a)(3), and 205(b)(1) of the Colorado River Salinity Control Act and"; change paragraph (2) to paragraph (3).

(c) Costs of construction, operation, maintenance, and replacement of each unit or separable feature thereof allocated for repayment by the upper

basin under section 205(a) (2) of this title shall be paid in accordance with section 205(d) of this title from the Upper Colorado River Basin Fund within the limit of the funds made available under section 205(e) of this title.

43 USC 620d.

(d) Section 5(d) of the Colorado River Storage Project Act (70 Stat. 108) is hereby amended as follows: strike the word "and" at the end of paragraph (3); strike the period after the word "years" at the end of paragraph (4) and insert a semicolon in lieu thereof followed by the word "and"; add a new paragraph (5) reading:

"(5) the costs of each salinity control unit or separable feature thereof payable from the Upper Colorado River Basin Fund in accordance with sections 205(a) (2), 205(a) (3), and 205(c) of the Colorado River Salinity Control Act."

Electrical energy rates, adjustments.

(e) The Secretary is authorized to make upward adjustments in rates charged for electrical energy under all contracts administered by the Secretary under the Colorado River Storage Project Act (70 Stat. 105, 43 U.S.C. 620) as soon as practicable and to the extent necessary to cover the costs of construction, operation, maintenance, and replacement of units allocated under section 205(a)(2) and in conformity with section 205(a)(3) of this title: *Provided*, That revenues derived from said rate adjustments shall be available solely for the construction, operation, maintenance, and replacement of salinity control units in the Colorado River Basin herein authorized.

Report to President, Congress and Advisory Council.
43 USC 1596.

SEC. 206. Commencing on January 1, 1975, and every two years thereafter, the Secretary shall submit, simultaneously, to the President, the Congress, and the Advisory Council created in section 204(a) of this title, a report on the Colorado River salinity control program authorized by this title covering the progress of investigations, planning, and construction of salinity control units for the previous fiscal year, the effectiveness of such units, anticipated work needed to be accomplished in the future to meet the objectives of this title, with emphasis on the needs during the five years immediately following the date of each report, and any special problems that may be impeding progress in attaining an effective salinity control program. Said report may be included in the biennial report on the quality of water of the Colorado River Basin prepared by the Secretary pursuant to section 15 of the Colorado River Storage Project Act (70 Stat. 111; 43 U.S. C. 602n), section 15 of the Navajo Indian irrigation project, and the initial stage of the San Juan Chama Project Act (76 Stat. 102), and section 6 of the Fryingpan-Arkansas Project Act (76 Stat. 393).

43 USC 615ww

43 USC 616c.

43 USC 1597

SEC. 207. Except as provided in section 205(b) and 205(d) of this title, with respect to the Colorado River Basin Project Act and the Colorado River Storage Project Act, respectively, nothing in this title shall be construed to alter, amend, repeal, modify, interpret, or be in conflict with the provisions of the Colorado River Compact (45 Stat. 1057), the Upper Colorado River Basin Compact (63 Stat. 31), the Water Treaty of 1944 with the United Mexican States (Treaty Series 994; 59 Stat. 1219), the decree entered by the Supreme Court of the United States in Arizona against California and others (376 U.S. 340), the Boulder Canyon Project Act (45 Stat. 1057), Boulder Canyon Project Adjustment Act (54 Stat. 774; 43 U.S.C. 618a), section 15 of the Colorado River Storage Project Act (70 Stat. 111; 43 U.S.C. 620n), the Colorado River Basin Project Act (82 Stat. 885), section 6 of the Fryingpan-Arkansas Project Act (76 Stat. 393), section 15 of the Navajo Indian irrigation project and initial stage of the San Juan-Chama Project Act (76 Stat. 102), the National Environmental Policy Act of 1969, and the Federal Water Pollution Control Act, as amended.

43 USC 1501 note.

42 USC 4321 note.

33 USC 1251 note.

SEC. 208. (a) The Secretary is authorized to provide for modifications of the projects authorized by this title as determined to be appropriate for purposes of meeting the objective of this title. No funds for any such modification shall be expended until the expiration of sixty days after the proposed modification has been submitted to appropriate committees of the Congress, and not then if disapproved by said committees, except that funds may be expended prior to the expiration of such sixty days in any case in which the Congress approves an earlier date by concurrent resolution. The Governors of the Colorado River Basin States shall be notified of these changes.

Project modifications.

Funds, expenditure.

43 USC 1598.

(b) The Secretary is hereby authorized to enter into contracts that he deems necessary to carry out the provisions of this title, in advance of the appropriation of funds therefor. There is hereby authorized to be appropriated the sum of $125,100,000 for the construction of the works and for other purposes authorized in section 202 of this title, based on April 1973 prices, plus or minus such amounts as may be justified by reason of ordinary fluctuations in costs involved therein, and such sums as may be required to operate and maintain such works. There is further authorized to be appropriated such sums as may be necessary to pay condemnation awards in excess of appraised values and to cover costs required in connection with the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (Public Law 90-646).

Contract authority.

Appropriation

42 USC 4601 note.

SEC. 209. As used in this title—

43 USC 1599.

(a) all terms that are defined in the Colorado River Compact shall have the meanings therein defined;

(b) "Colorado River Basin States" means the States of Arizona, California, Colorado, Nevada, New Mexico, Utah, and Wyoming.

"Colorado River Basin States."

Approved June 24, 1974.

Public Law 93-321

Bureau of Reclamation. 2017. Quality of Water Colorado River Basin Progress Report No. 25.

RECLAMATION
Managing Water in the West

QUALITY OF WATER
COLORADO RIVER BASIN
Progress Report No. 25

U.S. Department of the Interior
Bureau of Reclamation
Upper Colorado Region

2017

Mission Statements

The U.S. Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

Acronyms and Abbreviations

Af	acre feet
ACEC	Area of critical environmental concern
AMD	acid mine drainage
ARC	Application Review Committee
BLM	Bureau of Land Management
BSP	Basin State Program
CFS	Cubic feet per second
CRB	Colorado River Basin
CWP	Colorado Parks and Wildlife
EPA	Environmental Protection Agency
EQIP	Environmental Quality Incentives Program
FLPMA	Federal Land Management Policy Act of 1976
FOA	Funding Opportunity Announcement
Forum	Colorado River Basin Salinity Control Forum
FWS	Fish and Wildlife Service
GLCA	Glen Canyon Recreation Area
GKM	Gold King Mine
Maf	million acre feet
MWD	Metropolitan Water District
NEPA	National Environmental Policy Act
NPS	National Park Service
NRCS	Natural Resources Conservation Service
PCR	Polymerase Chain Reaction
PPM	Parts per Million
Reclamation	Bureau of Reclamation
Review	2014 Review, Water Quality Standards for Salinity, Colorado River System
RFP	Request for Proposal
SCP	Colorado River Basin Salinity Control Program
Secretary	Secretary of Interior
TDS	Total Dissolved Solids (salinity)
TMDL	Total Maximum Daily Load
UCRB	Upper Colorado River Basin
UDAF	Utah Department of Agriculture and Food
USBR	United States Bureau of Reclamation
USDA	United States Department of Agriculture
USDI	United States Department of Interior
USGS	United States Geologic Survey
WMIDD	Wellton-Mohawk Irrigation & Drainage District
WWDC	Wyoming Water Development Commission

TABLE OF CONTENTS

SUMMARY 1
CHAPTER 1 – INTRODUCTION 3
CHAPTER 2 – SALINITY CONDITIONS 5
CAUSES OF SALINITY 5
ECONOMIC EFFECTS OF SALINITY 6
HISTORICAL SALINITY CONDITIONS 7
FACTORS INFLUENCING SALINITY 8
Streamflow 8
Reservoir Storage 9
FUTURE WATER DEVELOPMENT 12
COMPLIANCE WITH THE SALINITY STANDARDS 15
SALINITY CONTROL 16
CHAPTER 3 – TITLE I SALINITY CONTROL PROGRAM 19
Wellton-Mohawk Irrigation and Drainage District (WMIDD) 20
CHAPTER 4 - TITLE II SALINITY CONTROL PROGRAM 21
U.S. Bureau of Land Management (BLM) 22
Program Administration 22
Basin Wide Activities 22
State Activities since last Progress Report 26
U.S. Department of Agriculture (USDA) 35
New Salinity Projects and Investigations 36
Monitoring and Evaluation 38
Active Salinity Control Projects 38
Bureau of Reclamation 46
Basinwide Salinity Control Program (Basinwide Program) 46
Basin State Program (BSP) 50
Paradox Valley Unit 53
Alternative Study 56
Colorado River Basin Salinity Control Program Summary Data 57
CHAPTER 5 - OTHER WATER QUALITY RELATED ISSUES 62
REFERENCES CITED 67
GENERAL REFERENCES 71
APPENDIX A 77
SALINITY MONITORING STATION INFORMATION 77
APPENDIX B 80
SALT LOAD 2014 UPDATE FOR THE 20 STATIONS 80
APPENDIX C 90
REGRESSION STATISTICS FOR 2014 SLOAD 90

APPENDIX D 119

20 Station Flow and Salt over Time **119**

TABLES

Table 1 – Quantified Sources of Salt Loading 6

Table 2 – Upper Basin Depletion Projections 14

Table 3 – Lower Basin Depletion Projections 15

Table 4 – Salinity Control Requirements through 2015 17

Table 5 – WMIDD Drainage Efficiency 20

Table 6 – Active Salinity Control Projects 38

Table 7 – USDA Salinity Control Unit Summary, 2015 46

Table 8 – Paradox Well Injection Evaluation 54

Table 9 – Summary of Federal Salinity Control Program, 2015 58

Table 10 – Summary of CRBSCP Basin Funds, 2005-2015 59

Table 11 – UCRB Agriculture Salinity Control Summary 61

Table A1 – Characteristics of the 20 Streamflow Gages 78

FIGURES

Figure 1 - Salinity Sources 5

Figure 2 –Salinity Damages 7

Figure 3 – Colorado River TDS 8

Figure 4 – Colorado River Flow and TDS 9

Figure 5 – Salinity below Glen Canyon Dam 9

Figure 6 – Lake Powell Forebay TDS 10

Figure 7 – Lake Powell Inflow and Outflow Salt Loading and Flow 11

Figure 8 – Lake Powell Inflow and Outflow TDS 11

Figure 9 – Historic and Modeled Consumptive Use 13

Figure 10 – Title I Salinity Control Projects 19

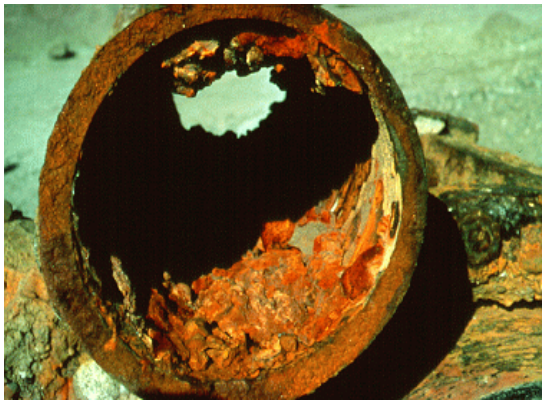
Figure 11 – Title II Salinity Control Projects 21

Figure 12 – Relationship between Range Runoff and Salt Loading 23

Figures Continued

Figure 13 – Colorado River Basin Range Status ……. 25
Figure 14 – Basin A …….. 28
Figure 15 – Basin B …….. 29
Figure 16 – Large Rock Barbs ……... 31
Figure 17 – Typical Grazing Exclosure …….. 33
Figure 18 – Henrys Fork Salinity ……..…. 36
Figure 19 – West Blacks Fork Salinity ……...…… 37
Figure 20 – Grand Valley Salinity …….. 39
Figure 21 – Lower Gunnison Salinity ……. 40
Figure 22 – Mancos River Salinity …….. 40
Figure 23 – McElmo Creek Salinity ……. 41
Figure 24 – Silt Salinity ……. 41
Figure 25 – Uinta Basin Salinity …….. 42
Figure 26 – Price San Rafael Salinity ……. 43
Figure 27 – Muddy Creek Salinity …….. 43
Figure 28 – Green River Salinity …… 44
Figure 29 – Manilla – Washam Salinity ……. 45
Figure 30 – Big Sandy Salinity ……. 45
Figure 31 – Paradox Valley ……. 53
Figure 32 – Schematic of Paradox Valley Project ……... 53
Figure 33 – Salt Load ……... 61
Figure 34 – Animas River …… 63
Figure 35 – Mussel Encrusted Chair, Lake Powell ……. 64
Figure 36 – Wheel Gate and Rock Wall with Mussels, Lake Powell ……. 65
Figure A1 – Colorado River Water Quality Monitoring 20 Stations Location ……. 77
Figure A2 – Colorado River Basin Flows and Salinity ……. 79
Figure D1 – Flow and TDS over Time for Sites 1-4 ……..…… 120
Figure D2 – Flow and TDS over Time for Sites 5-8 …….. 121
Figure D3 – Flow and TDS over Time for Sites 9-12 ……. 122
Figure D4 – Flow and TDS over Time for Sites 13-16 …….. 123
Figure D5 – Flow and TDS over Time for Sites 17-20 …….. 124

SUMMARY



Salinity damages to municipal water pipe.

The Colorado River and its tributaries provide water to about 35 - 40 million people and irrigation water to nearly 4.5 million acres of land in the United States (Moving Forward, 2015;). The river also serves about 3.3 million people and 500,000 acres in Mexico (Cohen, 2011). The effect of salinity is a major concern in both the United States and Mexico. Salinity damages in the United States are presently estimated to be about $382 million per year at 2014 salinity concentrations, which includes 1.3 million tons of implemented salinity controls. This biennial report on the quality of water in the Colorado River Basin is required by Public Laws 84-485, 87-483, and the Colorado River Basin Salinity Control Act (Salinity Control Act) (Public Law 93-320, as amended by Public Laws 98-569, 104-20, 104-127, and 106-459).

The Salinity Control Act authorizes the Secretaries of the U.S. Department of the Interior (Interior) and U.S. Department of Agriculture (USDA) to enhance and protect the quality of water available in the Colorado River for use in the United States and the Republic of Mexico.

Title I of the Salinity Control Act authorized the construction and operation of a desalting plant, brine discharge canal, and other features to enable the United States to deliver water to Mexico having an average salinity no greater than 115 parts per million (ppm) plus or minus 30 ppm over the annual average salinity of the Colorado River at Imperial Dam. The Title I program (administered by the Bureau of Reclamation [Reclamation]) continues to meet the requirements of Minute No. 242 of the International Boundary and Water Commission, United States and Mexico.

Salinity damages to crop production.

Title II of the Salinity Control Act authorizes the Secretary of the Interior (Secretary) and the Secretary of Agriculture to implement the Title II, Colorado River Basin Salinity Control Program (SCP). Through a broad range of specific and general salinity control measures the Salinity Control Program prevents further degradation of water quality to meet the objectives and standards set by the Clean Water Act. Salinity control measures implemented by Reclamation, Bureau of Land Management (BLM), and USDA - Natural Resources Conservation Service (NRCS)

through the Salinity Control Program are currently (2015) controlling over 1.3 million tons of salt per year from entering the Colorado River System.

The Colorado River Basin Salinity Control Forum (Forum) in accordance with the requirements of the Clean Water Act, prepared the "2014 Review, Water Quality Standards for Salinity, Colorado River System" (Review) (Colorado River Salinity Control Forum, 2014). The Review reported that by 2035 a target of 1.68 million tons per year of salt will need to be controlled from entering the Colorado River system in order to meet the water quality standards in the Lower Basin, below Lees Ferry, AZ. This program goal is the combined target for the Forum and participating agencies within Interior and USDA. In order to meet the 1.68 million tons of salt per year goal, it will be necessary to fund and implement potential new measures which ensure the removal of an approximate additional 340,000 tons by 2035.

With the reported existing salt controlled, and assuming no reduction of the existing salinity control projects, then over 17,000 tons of new or additional controls will need to be implemented each year to maintain the standards with increased future water development.

The Upper Colorado River Basin regularly experiences significant year to year hydrologic variability. During the recent 16-year period 2000 to 2015, however, the unregulated inflow to Lake Powell, which is a good measure of hydrologic conditions in the Colorado River Basin, was above average in only 3 out of the past 16 years. This has been the lowest 16-year period since the closure of Glen Canyon Dam in 1963, with an average unregulated inflow of 8.51 maf, or 79% of the 30-year average (1981-2010). For comparison, the 1981-2010 total water year average is 10.83 maf. The unregulated inflow during the 2000-2015 period has ranged from a low of 2.64 maf (24% of average) in water year 2002 to a high of 15.97 maf (147% of average) in water year 2011. The water year 2015 unregulated inflow volume to Lake Powell was 10.17 maf (94% of average), which, though still below average, was significantly higher than inflows observed in 2012 and 2013 (45% and 47% of average, respectively). At the end of water year 2015, total system storage in the Colorado River Basin was 30.3 maf (51% of 59.6 maf total system capacity). Since the beginning of water year 2000, total Colorado Basin storage has experienced year to year increases and decreases in response to wet and dry hydrology, ranging from a high of 94% of capacity at the beginning of 2000 to a low of 50% of capacity at the beginning of water year 2005. One wet year can significantly increase total system reservoir storage, just as persistent dry years can draw down the system storage.

Salinity concentration has varied during this recent period (with a downward trend), but has not exceeded the numeric salinity criteria on the Colorado River below Hoover Dam, Parker Dam and at Imperial Dam; 723, 747 & 879 mg/L respectively. Reclamation's short term future salinity modeling scenarios indicate that the numeric salinity criteria should be maintained even with an additional 1-2 years of drought. The salinity criteria could have been exceeded in 2005 - 2007 without the Salinity Control Program and other salt reductions. Nevertheless, salinity damages are still very high at the 2015 salinity levels.

CHAPTER 1 – INTRODUCTION

Reclamation prepared this report in cooperation with State water resource agencies and other Federal agencies involved in the Salinity Control Program. This Progress Report 25 is the latest in a series of biennial reports that commenced in 1963.

The authorization for these reports and the legal aspects can be found in Chapter 1 of prior Progress Reports http://www.usbr.gov/uc/progact/salinity/pdfs/PR24final.pdf

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CHAPTER 2 – SALINITY CONDITIONS

CAUSES OF SALINITY

The Colorado River System is naturally very saline. Historically at the United States Geologic Survey (USGS) gauge below Hoover Dam, between 1940 and 1980, an annual average of approximately 9.3 million tons of salt was carried down the river. From 2005 to 2015, an annual average of approximately 7.5 million tons of salt are being measured in the river, including years of high flows and drought, with the trend going down. The flow of the river dilutes this salt, and depending upon the quantity of flow, salinity can be relatively dilute or concentrated. Since climatic conditions directly affect the flow in the river, salinity in any one year may double (or halve) due to extremes in runoff. Because this natural variability is virtually uncontrollable, the seven Basin States adopted a non-degradation water quality standard.

Nearly half of the salinity concentration in the Colorado River System is from natural sources. Saline springs, erosion of saline geologic formations, and runoff all contribute to this background salinity. The EPA (EPA, 1971) estimated that the natural salinity in the Lower Colorado River at Imperial Dam was 334 milligrams per liter (mg/L). Irrigation, reservoir evaporation, and municipal and industrial (M&I) sources make up the balance of the salinity in the Colorado River Basin. Figure 1 shows the relative amount each source contributes to the salinity of the Colorado River, as estimated by the Environmental Protection Agency (EPA) in 1973. Table 1, on the following page, quantifies the salinity from several of the known sources.

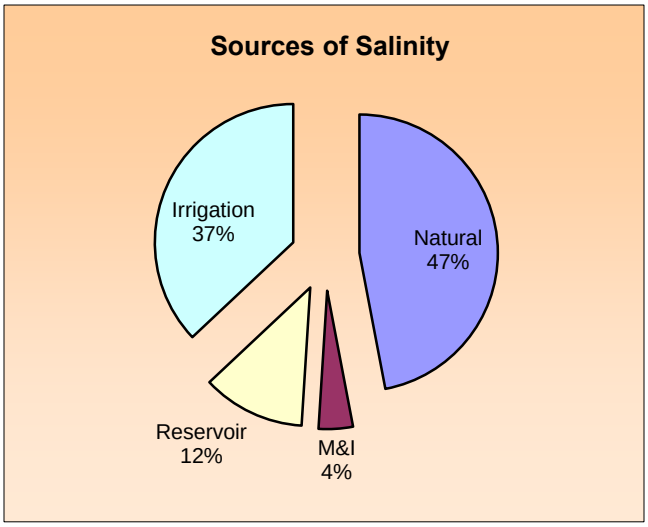

Figure 1 – Salinity Sources

Salinity of the Colorado River has increased due to the development of water resources in two major ways: (1) the addition of salts from water use and (2) the consumption (depletion) of water. The combined effects of water use and consumption have had a significant impact on salinity in the Colorado River Basin. The basin-wide drought, since 1999, has also had an influence on the present salinity of the Colorado River.

Any potential health concerns from the salinity levels in the Colorado River have previously been addressed in the health section of Progress Report 21 http://www.usbr.gov/uc/progact/salinity/pdfs/PR21.pdf

Table 1 – 1971 Quantified Sources of Salt Loading

Source	Type of Source	Salt Loading (tons per year)
Paradox Springs	Springs / point	205,000
Dotsero Springs	Springs / point	182,600
Glenwood Springs	Springs / point	335,000
Steamboat Springs	Springs / point	8,500
Pagosa Springs	Springs / point	7,300
Sinbad Valley	Springs / point	6,500
Meeker Dome	Springs / point	57,000
Other minor springs in the Upper Basin	Springs / point	19,600
Blue Springs	Springs / point	550,000
La Verkin Springs	Springs / point	109,000
Grand Valley	Irrigation / non-point	580,000
Big Sandy	Irrigation / non-point	164,000
Uncompahgre Project	Irrigation / non-point	360,000
McElmo Creek	Irrigation / non-point	119,000
Price-San Rafael	Irrigation / non-point	258,000
Uinta Basin	mostly irrigation / non-point	240,000
Dirty Devil River Area	Irrigation / non-point	150,000
Price-San Rafael Area	Irrigation / non-point	172,000
Other, non-regulated areas	Various	5,200,000
Total		8,724,000

Values listed are pre salinity control project loading

ECONOMIC EFFECTS OF SALINITY

Salinity related damages are primarily economical and due to reduced agricultural crop yields, corrosion, and plugging of pipes and water fixtures in housing and industry. Figure 2 breaks down the percentage of total damages. The seven Basin States have agreed to limit this impact and adopted numeric criteria, which require that salinity concentrations not increase (from the 1972 levels) due to future water development. Salinity levels measured in the river may be low or high due to hydrologic conditions, but the goal of the Water Quality Criteria for the Colorado River Basin and the Salinity Control Program is to offset (eliminate/reduce) the salinity effects of additional water development.

Reclamation has developed an economic model that calculates damages for a given level of salt. The Salinity Damages Model estimates the quantitative damages that are incurred in the metropolitan and agricultural areas in the lower Colorado Basin that receive

Colorado River water. The model estimates the impacts from salinity levels greater than 500 mg/L TDS on household water using appliances, damages in the commercial sector, industrial sector, water utilities, and agricultural crop revenues. It also estimates the additional costs related to meeting state wide water quality standards for ground water and recycled water use in the MWD service area.

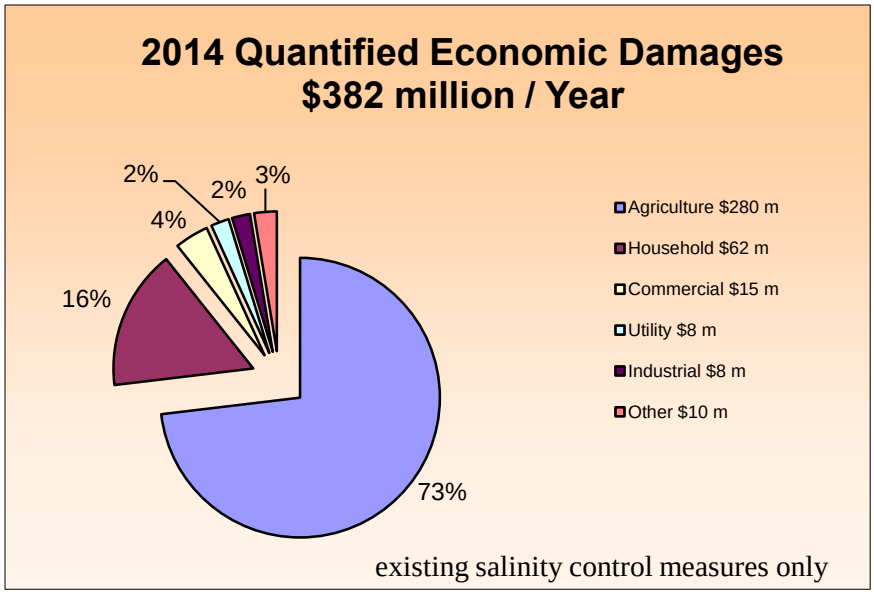

Figure 2 - Salinity Damages

In FY14 the Salinity Damages Model was updated with actual 2010 data and projections on 5-year intervals to 2040 (BOR, 2014).

HISTORICAL SALINITY CONDITIONS

Salinity in the Colorado River is monitored at 20 key stations throughout the Colorado River Basin. A map of station location is presented in Appendix A. Salt loads and concentrations are calculated from daily conductivity and flow records using methods developed jointly between Reclamation and USGS (Liebermann et al., 1986), Appendix B provides a methods summary. Historical annual streamflow, and salinity concentrations from 1940 through 2013 are included in graphical form in Appendix C. Monthly and annual data may be obtained by request from Reclamation, Salt Lake City, Utah or by going to Reclamation's Upper Colorado Regional Office Salinity Program web page; http://www.usbr.gov/uc/progact/salinity/index.html.

The salinity of the 3 lower basin compact points (Hoover, Parker and Imperial Dams) since 1940 is shown in Figure 3. As Figure 3 shows, the last time the TDS exceeded or reached the salinity criteria at any of the compact points, was in 1972 – the year that the salinity standard was established for the Colorado River.

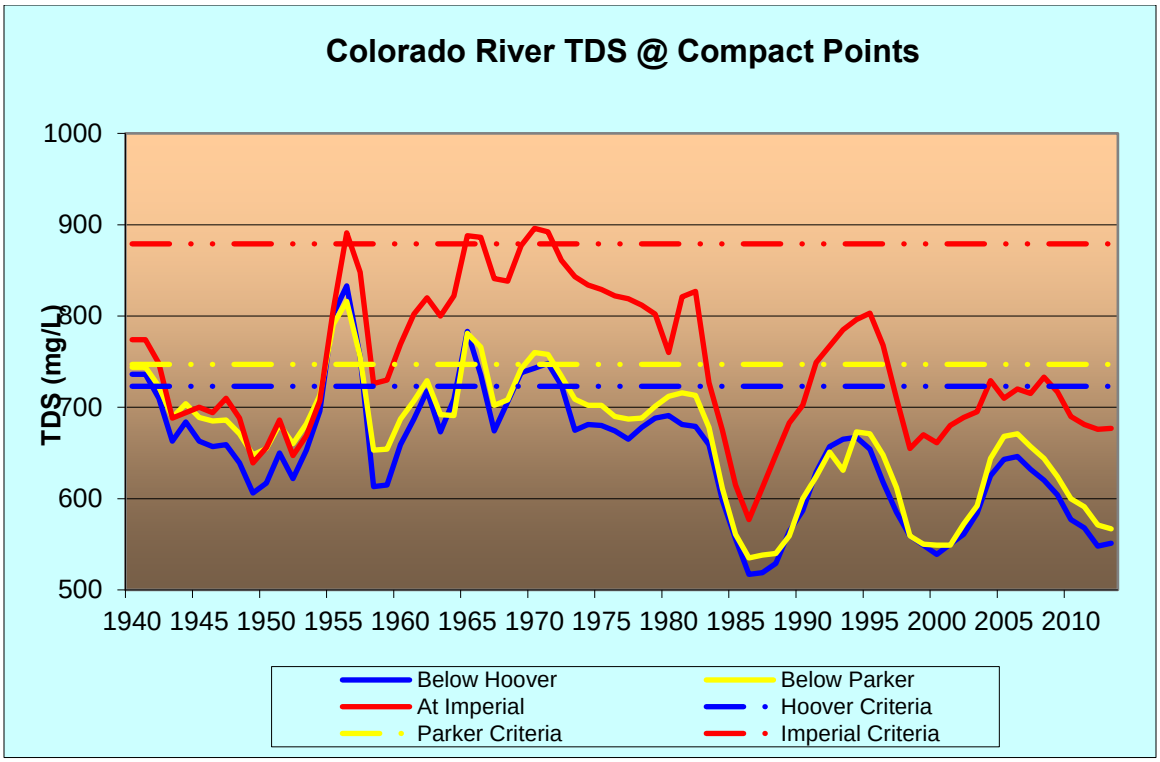

Figure 3 – Colorado River TDS

FACTORS INFLUENCING SALINITY

Stream flow, reservoir storage, water resource development, salinity control, climatic conditions, and natural runoff directly influence salinity in the Colorado River Basin. Before water development, the salinity of spring runoff was often below 200 mg/L throughout the Colorado River Basin. However, salinity in the lower mainstem was often well above 1,000 mg/L during the low flow months (most of the year), since no reservoirs existed to catch and store the spring runoff.

Streamflow

Streamflow directly influences salinity. For the most part, higher flows (or reservoir releases) dilute salinity. The top graph in Figure 4 shows streamflow at two key points in the mainstem. In 1983, Lake Powell (Glen Canyon Dam) filled for the first time and spilled.

This spill went through Lake Mead (Hoover Dam) and on downstream through Imperial Dam. In 1983 and on through 1987, flows in the system were again extremely high and sustained, reducing salinity to historic lows. As shown in the bottom graph of Figure 4, returning to average flows in the system after 1987 returned the salinity in the reservoir system to average levels.

Reservoir Storage

The Colorado River Storage Project Reservoirs produce not only major hydrologic modifications downstream, but they also significantly alter the salinity variability of the downstream river. The overall long term salinity effects of the reservoirs are beneficial and have greatly reduced the salinity peaks and annual fluctuation (Figure 5). The high concentration low flow waters are mixed with low concentration spring runoff, reducing the month-to-month variation in salinity below dams (Mueller et al., 1988). At Glen Canyon Dam, the pre and post dam peak monthly salinity has been reduced by nearly 600 mg/L. Similar effects can be seen below Flaming Gorge, Navajo, and Hoover Dams, greatly improving the quality of water during the summer, fall and winter.

Large reservoirs like Lake Powell selectively route less saline water while holding more saline waters during low inflow periods. The poorer quality waters are then slowly released after the inflows have begun to increase, which helps to prevent exceeding the salinity

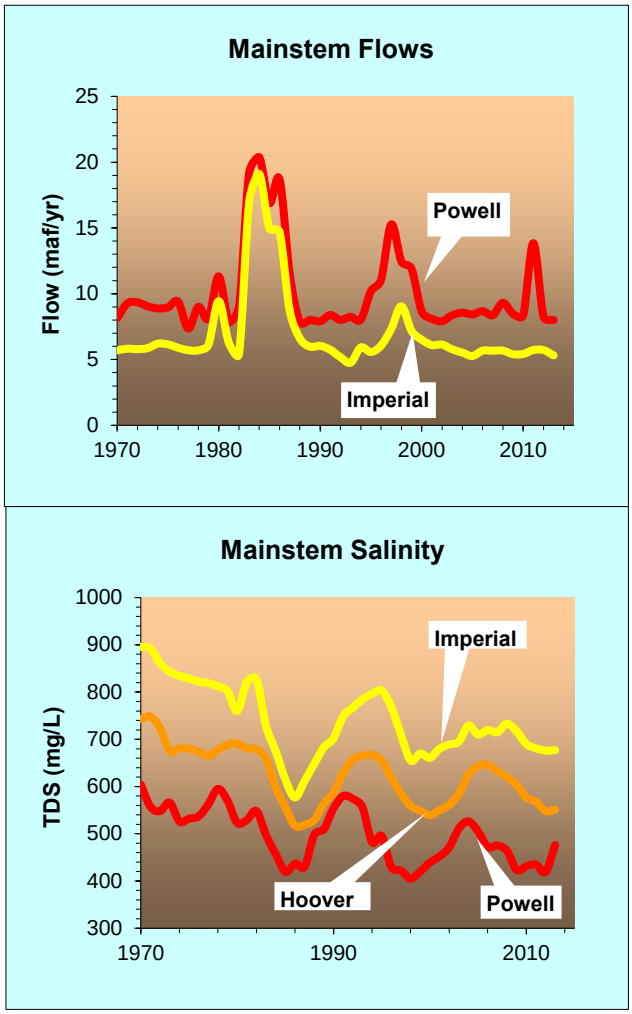

Figure 4- Colorado River Flow and TDS

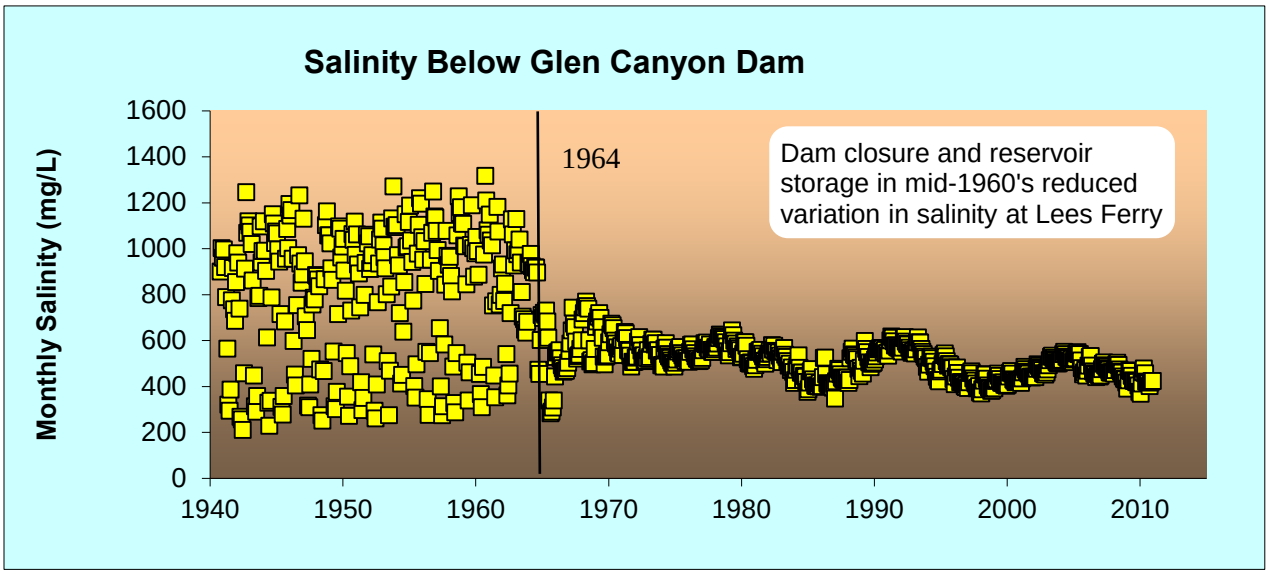

Figure 5 – Salinity below Glen Canyon Dam

criteria during drought years. The large reservoirs selectively retain higher salinity winter inflows in the bottom of the pool and route lower salinity overflow density currents from the spring runoff. The seasonal and long term effects of this selective retention and routing of salt has been shown below Glen Canyon Dam in Figure 5.

Figure 6 further displays this retention. Figure 6 is a long-term depth vs. time profile of salinity in the forebay of Glen Canyon Dam and is an illustrated history of the salinity. The Y (vertical) axis is depth in the water column and the X axis is time in years. The color scale is the change in salinity.

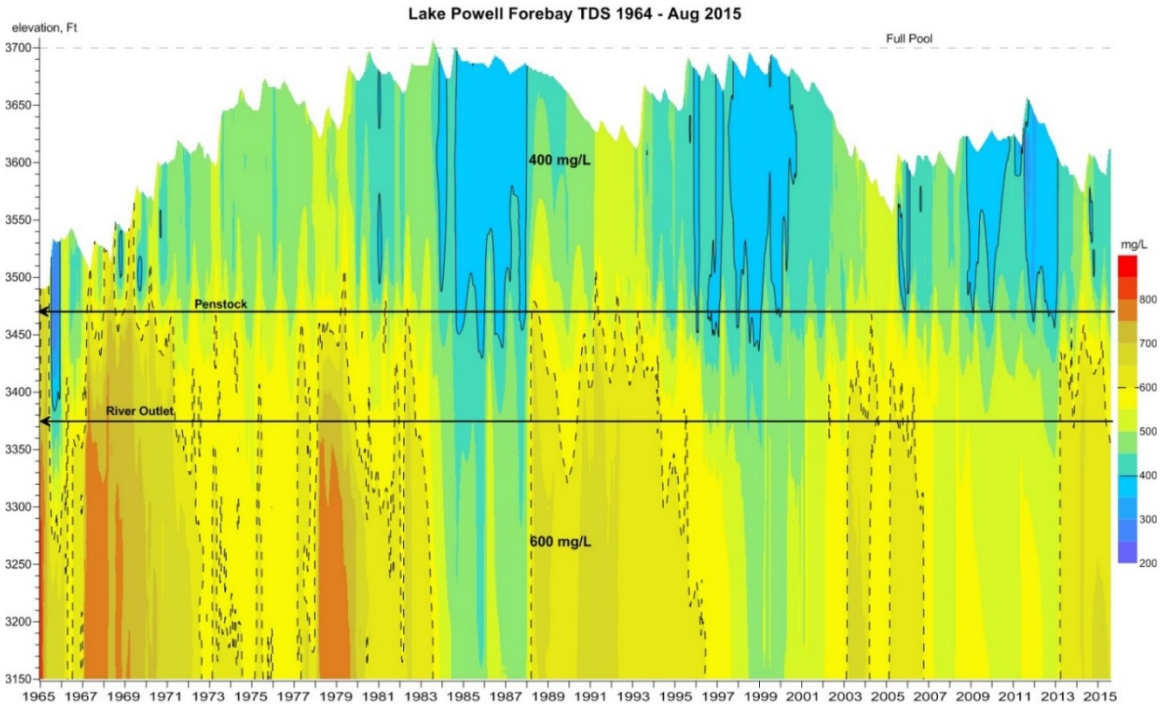

Figure 6 - Lake Powell TDS

Figures 6, 7 and 8 illustrate that Glen Canyon Dam causes Lake Powell to selectively retain higher salinity water during drier years of drought, and then routes it out with the increased mixing and shorter hydraulic retention times of wetter cycles as seen particularly in 1983 and 1999. During these wetter cycles there is a significant mixing and dilution of these previously stored salts.

There are 4 periods or trends, with regards to salt loads and concentration, which can be seen in the Colorado River salinity for the inflow to and outflow from Lake Powell which can be seen in Figures 7 & 8 (yellow and green trend lines). The overall inflow line (red) in Figures 7 & 8 is the sum of TDS for the inflow stations to Lake Powell; Colorado River at Cisco, Green River at Green River, UT, San Rafael River near Green River and

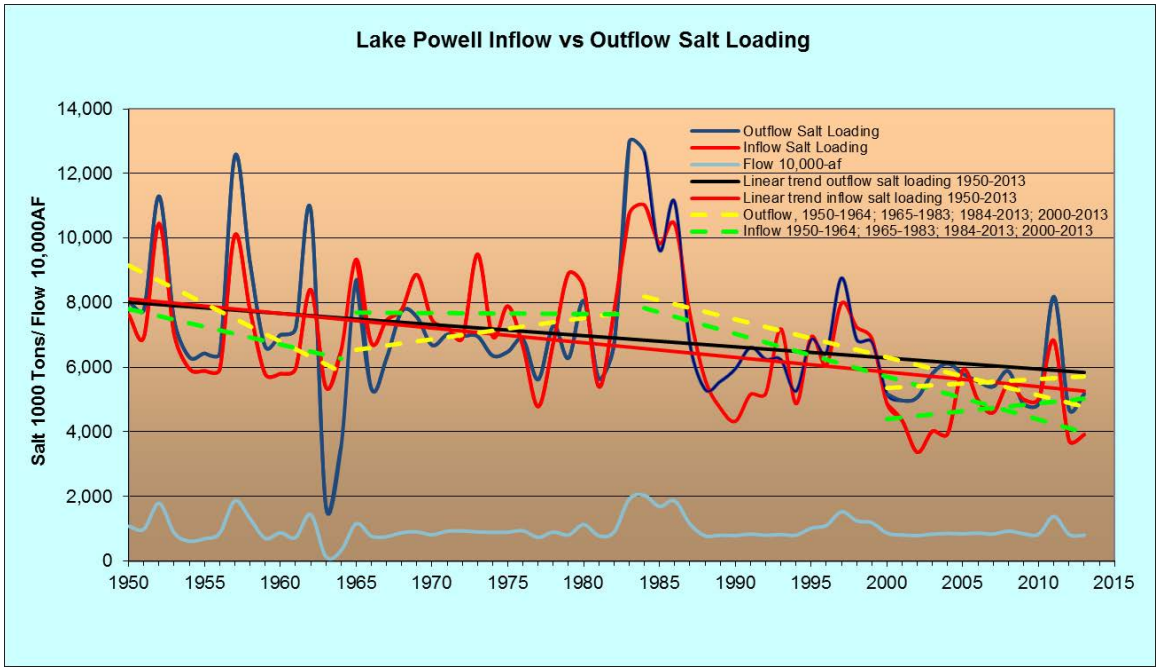

Figure 7 – Lake Powell Inflow and Outflow Salt Loading and Flow

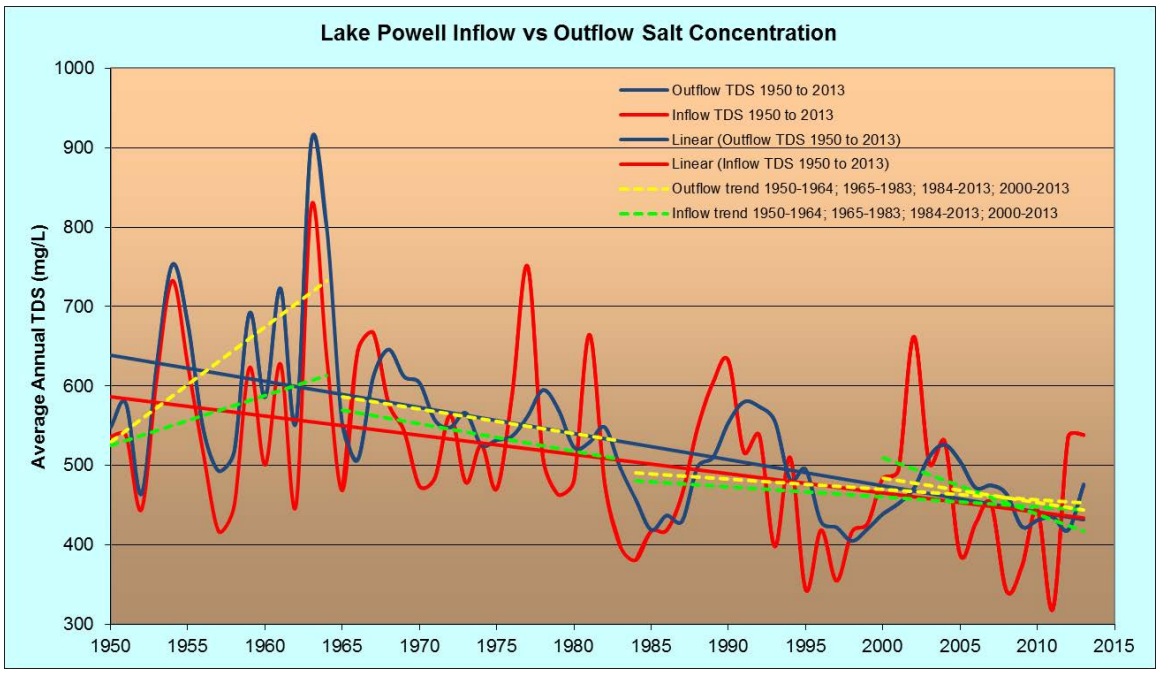

Figure 8 – Lake Powell Inflow and Outflow TDS

San Juan River near Bluff. The overall outflow line (blue) is the TDS load and dam period, 1950 – 1964, the average salinity trend was increasing with divergence between the average annual inflow and outflow salinity levels and the inflow concentration

generally being less than the outflow concentration. This difference between outflow and inflow may be impacted by the beginning hydraulic conditions, since the actual annual levels appear to track each other fairly closely.

Next there was the dam filling period where Lake Powell and the Upper Basin reservoirs were completed and filling, 1965-1983. The average annual salinity during this time decreased with a convergence occurring between the inflow and outflow concentrations.

The outflow concentration decreased more than the inflow concentration, which could be due to the reservoir storing the higher TDS waters. Then there was the period, 1983 to 2000, when the basin hydrology went through both wet and dry periods and the salinity control projects in the upper basin were coming online. The declining trend of the average annual salinity concentration over this time is seen to be constant between the inflow and outflow stations. Since 1980 there appears to be an equilibrium between the salt entering the reservoir and what is being released. The last period, since 2000, covers the basinwide drought. The trend shows that the inflow TDS has declined, while the outflow TDS from Lake Powell has stayed constant with the 1983 to present TDS trend.

Lake Powell (and other reservoirs in the basin) went through an initial filling salt leach out which actually began with temporary water retention behind the coffer dam during construction in the mid 1950's. Long-term linear regression trend lines on the inflow and outflow salinity concentrations at Lake Powell indicate that internal salt leaching seems to have declined to a minimum by the mid-1990's suggesting a long-term salinity leach out which is approaching a dynamic equilibrium (Figures 7 & 8, red and blue trend line).

The natural variation in salinity as well as the agricultural sources, energy development, and the municipal and industrial use impacts on salinity have been discussed in the prior Progress Report 24 http://www.usbr.gov/uc/progact/salinity/pdfs/PR24final.pdf

FUTURE WATER DEVELOPMENT

Tables 8 and 9 summarize the projected demand scenarios used by Reclamation to evaluate the effects of water use and depletions in the recently completed Colorado River Basin Study (Reclamation, 2012). These water demand estimates were compiled as an initial step in the evaluation process and have not yet been updated.

Table 8 summarizes the projected demand by water uses in the Upper Colorado River Basin as adopted for planning purposes in the *Colorado River Basin Water Supply and Demand Study, Technical Report C – Water Demand Assessment December 2012*. Figure 10 illustrates the historical annual consumptive use by water uses in the Upper Basin as reported in Reclamation's *Colorado River System Consumptive Uses and Losses Reports* (CUL), and the total projected demands by water uses in the Upper Basin that are included as input into Reclamation's Colorado River System Simulation (CRSS) model with 3 scenarios for projected water use (Technical Report C, 2012). The consumptive uses and projected demands shown in Figure 9 exclude evaporation losses from Lake Powell, Flaming Gorge Reservoir and the Aspinall Unit reservoirs, which along with

evaporation losses from Colorado River mainstem reservoirs in the Lower Basin are modeled within CRSS.

The annual depletions for the Lower Colorado River Basin shown in Table 9 include only depletions resulting from the use of water from the mainstem of the Lower Colorado River. Reclamation's CRSS model does not model or include as input consumptive uses made from tributaries to the Colorado River within the Lower Colorado River Basin. Fixed inflow values are used in the CRSS model for the Lower Basin tributaries. More detailed data on historical Colorado River Basin consumptive uses and losses (including tributary uses in the Lower Basin and reservoir evaporation losses) may be found in Reclamation's *Colorado River System Consumptive Uses and Losses Reports* or on the web at: www.usbr.gov/uc/library/envdocs/reports/crs/crsul.html

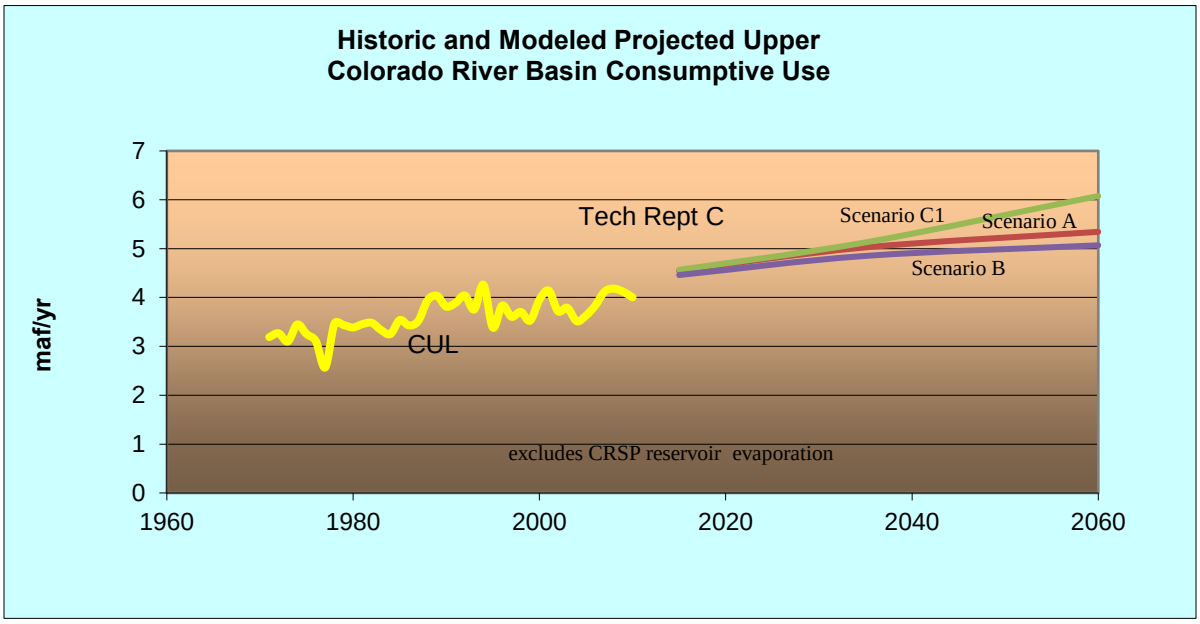

Figure 9 – Historic and Modeled Consumptive Use

Table 2 - Upper Basin Total Projected Depletion Demand Scenarios (1000 af/yr)

UPPER BASIN	2015[1]	2035[1]	2060[1]	2015[2]	2035[2]	2060[2]	2015[3]	2035[3]	2060[3]
Arizona									
Agricultural	0	0	0	0	0	0	0	0	0
Municipal and Industrial	2	2	2	2	2	2	2	2	2
Energy	0	0	0	0	0	0	0	0	0
Minerals	0	0	0	0	0	0	0	0	0
Fish, Wildlife and Recreation	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Tribal	44	43	43	38	55	71	44	43	43
Total Potential Colorado River Demand	46	46	46	40	57	73	46	46	46
Colorado									
Agricultural	1,875	1,875	1,875	1,875	1,791	1,728	1,875	1,875	1875
Municipal and Industrial	455	617	732	455	579	1,007	455	555	661
Energy	30	78	118	30	65	66	30	51	58
Minerals	32	59	60	32	65	66	31	59	60
Fish, Wildlife and Recreation	0	0	0	0	0	0	0	0	0
Tribal	0	0	0	0	0	0	0	0	0
Total Potential Colorado River Demand	2,391	2,629	2,784	2,391	2,535	2,979	2,391	2,540	2,653
New Mexico									
Agricultural	111	111	111	111	111	111	111	111	111
Municipal and Industrial	141	183	230	141	187	293	141	153	169
Energy	40	42	42	40	42	42	40	42	42
Minerals	0	0	0	0	0	0	0	0	0
Fish, Wildlife and Recreation	5	5	5	5	5	5	5	5	5
Tribal	303	363	367	309	413	529	303	363	367
Total Potential Colorado River Demand	600	703	754	606	758	979	600	673	693
Utah									
Agricultural	457	459	493	457	446	466	457	458	492
Municipal and Industrial	236	311	342	236	341	409	236	280	274
Energy	47	53	60	47	55	66	47	53	60
Minerals	0	0	0	0	0	0	0	0	0
Fish, Wildlife and Recreation	0	0	0	0	0	0	0	0	0
Tribal	259	259	259	272	299	337	170	241	259
Total Potential Colorado River Demand	999	1,082	1,154	1,012	1,141	1,277	911	1,033	1,084
Wyoming									
Agricultural	398	402	406	400	410	423	400	410	423
Municipal and Industrial	30	47	67	30	57	74	28	32	36
Energy	52	65	65	52	103	171	52	65	65
Minerals	29	42	59	34	57	91	29	42	59
Fish, Wildlife and Recreation	2	10	10	2	10	10	2	10	10
Tribal	0	0	0	0	0	0	0	0	0
Total Potential Colorado River Demand	511	566	606	518	637	769	512	559	592

Note 1: These demand scenarios do not attempt to interpret the Colorado River Compact, the Upper Colorado River Basin Compact, or any other element of the "Law of the River." These scenarios should not be construed as an acceptance of any assumption that limits the Upper Colorado River Basin's depletion.
Note 2: These demand scenarios are for planning purposes only. Their estimates do not constitute an endorsement of the Bureau of Reclamation's 2007 Hydrologic Determination and should not be construed as in any way limiting the Upper Division States use of Colorado River water in accordance with the Commission's resolution of 6/5/06.
Note 3: These demand scenarios exclude shared CRSP evaporation.
Option [1]. Scenario A; (Current projected use), continuation of growth, development patterns, and institutions follow long-term trends. *Colorado River Basin Water Supply and Demand Study. Technical Report C – Water Demand Assessment*.
Option [2]. Scenario C1; (Rapid Growth) Economic resurgence (population and energy) and current preferences toward human and environmental values (greatest water demand model). *Colorado River Basin Water Supply and Demand Study. Technical Report C – Water Demand Assessment.*
Option [3]. Scenario B; (Slow Growth) Slow growth with emphasis on economic efficiency (lowest water demand model). *Colorado River Basin Water Supply and Demand Study. Technical Report C – Water Demand Assessment*

Table 3 - Lower Basin Depletion Projections (1000 af/yr)

LOWER MAINSTEM	2015[1]	2035[1]	2060[1]	2015[2]	2035[2]	2060[2]	2015[3]	2035[3]	2060[3]
Arizona									
Agricultural	1,124	703	703	1.082	703	703	1,145	724	724
Municipal and Industrial	760	1,099	1,460	816	1,305	2,060	823	1,075	1,164
Energy	1	1	2	1	2	2	1	1	2
Minerals	42	54	55	42	53	54	42	60	60
Fish, Wildlife and Recreation	16	16	16	16	16	16	16	16	16
Tribal	997	1,216	1,215	1,013	1,288	1,337	881	1,100	1,100
Total Potential Colorado River Demand	2,940	3,088	3,447	2,967	3,364	4,170	2,906	2,975	3,064
California									
Agricultural	3,230	3,103	3,159	3,230	3,103	3,159	3,229	3,103	3,158
Municipal and Industrial	1,433	1,589	1,690	1,433	1,591	1,695	1,431	1,581	1,669
Energy	53	108	156	61	171	284	53	108	156
Minerals	0	0	0	0	0	0	0	0	0
Fish, Wildlife and Recreation	124	24	32	124	24	32	124	24	32
Tribal	92	92	92	92	92	92	92	92	92
Other	48	58	75	48	58	75	48	58	75
Total Potential Colorado River Demand	4,979	4,974	5,203	4,987	5,039	5,336	4,977	4,966	5,182
Nevada									
Agricultural	0	0	0	0	0	0	0	0	0
Municipal and Industrial	289	374	506	289	416	589	289	346	479
Energy	0	0	0	0	0	0	0	0	0
Minerals	0	0	0	0	0	0	0	0	0
Fish, Wildlife and Recreation	2	2	2	2	2	2	2	2	2
Tribal	9	9	9	9	9	9	9	9	9
Total Potential Colorado River Demand	300	385	517	300	427	600	300	357	490

Note: In the LC Basin, demands are from mainstem diversions of the Colorado River only. Does not include demands from diversions of Colorado River tributaries or evaporation from mainstem reservoirs.

Option [1]. Scenario A; (Current projected use), continuation of growth, development patterns, and institutions follow long-term trends. *Colorado River Basin Water Supply and Demand Study. Technical Report C – Water Demand Assessment*.
Option [2]. Scenario C1; (Rapid Growth) Economic resurgence (population and energy) and current preferences toward human and environmental values (greatest water demand model). *Colorado River Basin Water Supply and Demand Study. Technical Report C – Water Demand Assessment.*
Option [3]. Scenario B; (Slow Growth) Slow growth with emphasis on economic efficiency (lowest water demand model). *Colorado River Basin Water Supply and Demand Study. Technical Report C – Water Demand Assessment.*

COMPLIANCE WITH THE SALINITY STANDARDS

Reclamation and the Basin States conducted salt-routing studies for the *2014 Triennial Review of the Water Quality Standards for Salinity, Colorado River Basin*. As part of the triennial review process, Reclamation used the Colorado River Simulation System (CRSS) river system model to evaluate whether sufficient salinity control measures are in place to offset the effects of development. The information provided in the next two sections of the report was used to evaluate compliance with the water quality standards.

In response to the Clean Water Act, the States have adopted water quality (salinity) criteria for the Colorado River Basin and the Environmental Protection Agency (EPA)

has approved them at all three locations in the Lower Colorado River Basin. The standards call for maintenance of flow-weighted average annual salinity concentrations (numeric criteria) in the lower mainstem of the Colorado River and a plan of implementation for future controls.

The water quality standards are based on the *Water Quality Standards for Salinity, Including Numeric Criteria and Plan of Implementation for Salinity Control, Colorado River System*, prepared by the Colorado River Basin Salinity Control Forum, June 1975. The document was adopted by each of the Basin States and approved by EPA. A summary of the report follows:

The numeric criteria for the Colorado River System are to be established at levels corresponding to the flow-weighted average annual concentrations in the lower mainstem during calendar year 1972. The flow-weighted average annual salinity for the year 1972 was used. Reclamation determined these values from daily flow and salinity data collected by the USGS and Reclamation. Based on this analysis, the numeric criteria are 723 mg/L below Hoover Dam, 747 mg/L below Parker Dam, and 879 mg/L at Imperial Dam.

It should be recognized that the river system is subject to highly variable annual flow. The frequency, duration, and availability of carryover storage greatly affect the salinity of the lower mainstem; and, therefore, it is probable that salinity levels will exceed the numeric criteria in some years and be well below the criteria in others. However, under the above assumptions, the average salinity will be maintained at or below 1972 levels.

Periodic increases above the criteria as a result of reservoir conditions or periods of below normal long-time average annual flow also will be in conformance with the standards. With satisfactory reservoir conditions and when river flows return to the long-time average annual flow or above, concentrations are expected to be at or below the criteria level.

The standards provide for temporary increases above the 1972 levels if control measures are included in the plan. Should water development projects be completed before control measures, temporary increases above the criteria could result and these will be in conformance with the standard. With completion of control projects, those now in the plan or those to be added subsequently, salinity would return to or below the criteria level.

The goal of the Salinity Control Program is to maintain the flow-weighted average annual salinity at or below the numeric criteria of the salinity standards. The Program is not, however, intended to counteract the salinity fluctuations that are a result of the highly variable flows caused by climatic conditions, precipitation, snowmelt, and other natural factors.

SALINITY CONTROL

Existing salinity control measures prevent nearly 1.31 million tons of salt per year from reaching the river. In 2015 the Salinity Control Program for Reclamation has controlled approximately 570,000 tons of salt, while the NRCS program has reduced around

612,000 tons of salt, and the BLM has controlled an estimated 126,000 tons of salt per year from entering the Colorado River. In 2014 Triennial Review it was determined that salinity control units will need to prevent nearly 1.68 million tons of salt per year from entering the Colorado River by 2035, in order to meet the standard and keep the economic damages minimized. To reach this objective, as shown in Table 4, the Salinity Control Program needs to implement 372,000 tons of new controls beyond the existing 1,308,000 tons of salinity control presently in place (2015) as reported by Reclamation, NRCS & BLM. About 18,600 tons per year of new salinity control measures must be added each year if the Program is to meet the cumulative target of 1,680,000 tons per year by 2035, assuming no degradation of existing salinity projects.

To achieve this goal, a variety of salinity control methods are being investigated and constructed. Saline springs and seeps may be collected for disposal by evaporation, industrial use, or deep-well injection. Other methods include both on-farm and off-farm delivery system and irrigation improvements, which reduce the loss of water and reduce salt pickup by improving irrigation practices and by lining canals, laterals, and ditches.

Table 4 - Salinity Control Requirements and Needs Through 2035

Salinity control needs (2035)	1,680,000 tons
Measures in place (2014)	- 1,308,000 tons
Plan of Implementation Target	372,000 tons

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CHAPTER 3 – TITLE I SALINITY CONTROL PROGRAM

The Salinity Control Act, as amended, authorized the Secretary of the Interior (Secretary) to proceed with a program of works of improvement for the enhancement and protection of the quality of water available in the Colorado River for use in the United States and the Republic of Mexico. Title I enables the United States to comply with its obligation under the agreement with Mexico of August 30, 1973 (Minute No. 242 of the International Boundary and Water Commission, United States and Mexico [Minute No. 242]), which was concluded pursuant to the Treaty of February 3, 1944 (TS 994).

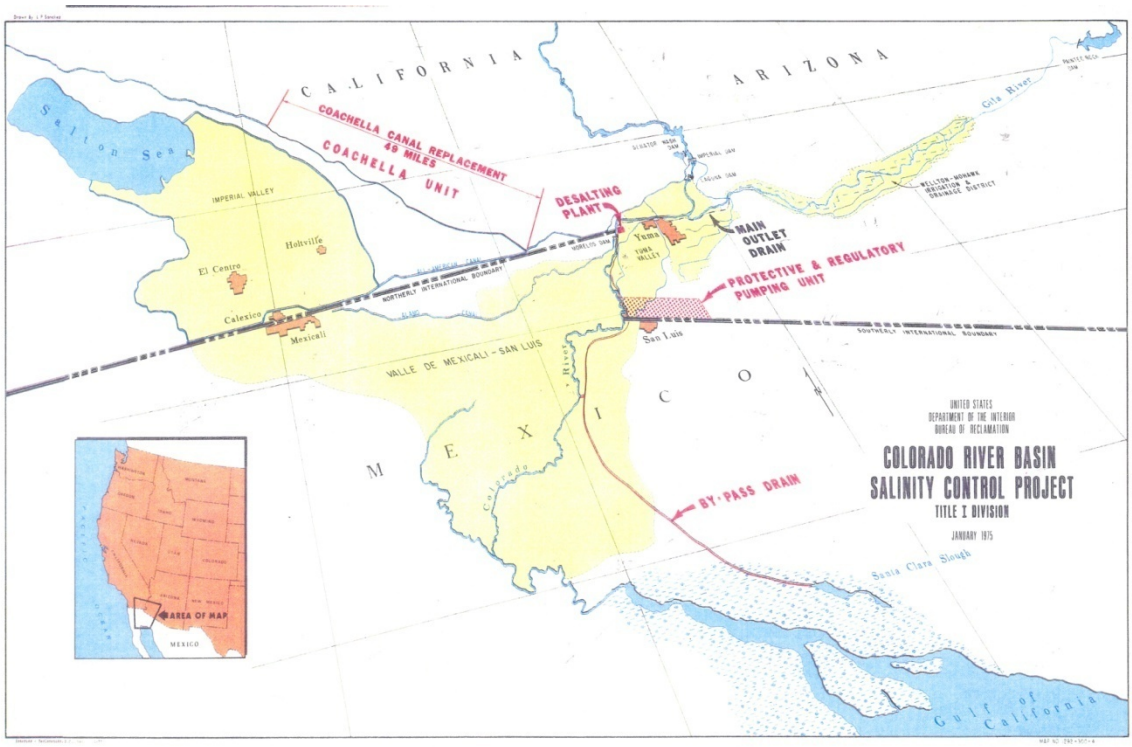

Figure 10 – Title I Salinity Control Projects

These facilities enable the United States to deliver water to Mexico with an average annual salinity concentration no greater than 115 parts per million (ppm) plus or minus 30 ppm (United States count) over the average annual salinity concentration of the Colorado River water at Imperial Dam.

The background and history of the Title I projects (Coachella Canal Lining, Protective and Regulatory pumping, Yuma Desalting Plant, Wellton-Mohawk Irrigation & Drainage District) can be found in Progress Report 22, chapter 4 at; http://www.usbr.gov/uc/progact/salinity/pdfs/PR22.pdf

Updates for the Title I projects since last Progress Report:

Coachella Canal

No new activity or change since last progress report.

Protective and Regulatory Pumping

No new activity or change since last progress report.

Yuma Desalting Plant

No new activity or change has occurred since the last progress report.

Wellton-Mohawk Irrigation and Drainage District (WMIDD)

Total crop acres have remained relatively stable since the early 1970's because more acreage is double-cropped than when the program was initiated. In particular, more vegetable crops are being grown in the district than in the past, with lettuce (iceberg and romaine) now the major crop. Irrigation efficiency levels and return flow levels for 1990-2014 are shown in Table 5.

With the use of monthly groundwater table monitoring using observation well measurements as well as input from land users, WMIDD is able to maintain a drainage-pumping program that sufficiently maintains the agriculture root zone. Land users continue to maintain water efficient farming techniques with the use of sprinkler, drip, dead level, high heads, and short runs.

Table 5 - WMIDD Irrigation Efficiency

Year	Drainage Return Flow (acre-feet)	Irrigation Efficiency, % (note: data provided by WMIDD)
1991	144,900	68.8
1992	116,200	70.4
1993	8,970	68.8
1994	49,820	65.4
1995	121,500	64.3
1996	119,600	60.4
1997	91,695	62.2
1998	98,972	61.9
1999	94,869	63.0
2000	110,287	59.7
2001	107,908	60.9
2002	119,410	61.2
2003	116,477	57.8
2004	106,002	63.3
2005	110,770	64.6
2006	103,810	62.3
2007	112,910	62.6
2008	120,190	63.0
2009	105,482	62.7
2010	111,170	66.1
2011	108,140	64.9
2012	115,630	64.1
2013	107,860	67.5
2014	111,390	64.6

CHAPTER 4 - TITLE II SALINITY CONTROL PROGRAM

Title II of the Salinity Control Act authorizes the Secretary of the Interior (Secretary) and the Secretary of Agriculture to implement a broad range of specific and general salinity control measures in an ongoing effort to prevent further degradation of water quality in the United States. These efforts are shown on the map below. The NRCS, Reclamation and BLM have a combined goal of controlling 1.68M tons of salt/per year, by the year 2035. These federal agencies are required to work together under the Salinity Control Act, as amended; with Reclamation being the lead federal agency. The Salinity Control Act also calls for periodic reports on this effort. The report is to include the effectiveness of the units, anticipated work to be accomplished to meet the objectives of Title II with emphasis on the needs during the 5 years immediately following the date of each report, and any special problems that may be impeding an effective salinity control program. Title II also provides that this report may be included in the biennial Quality of Water Colorado River Basin, Progress Report. New activities since the last progress report as well as ongoing and active projects are listed in this report.

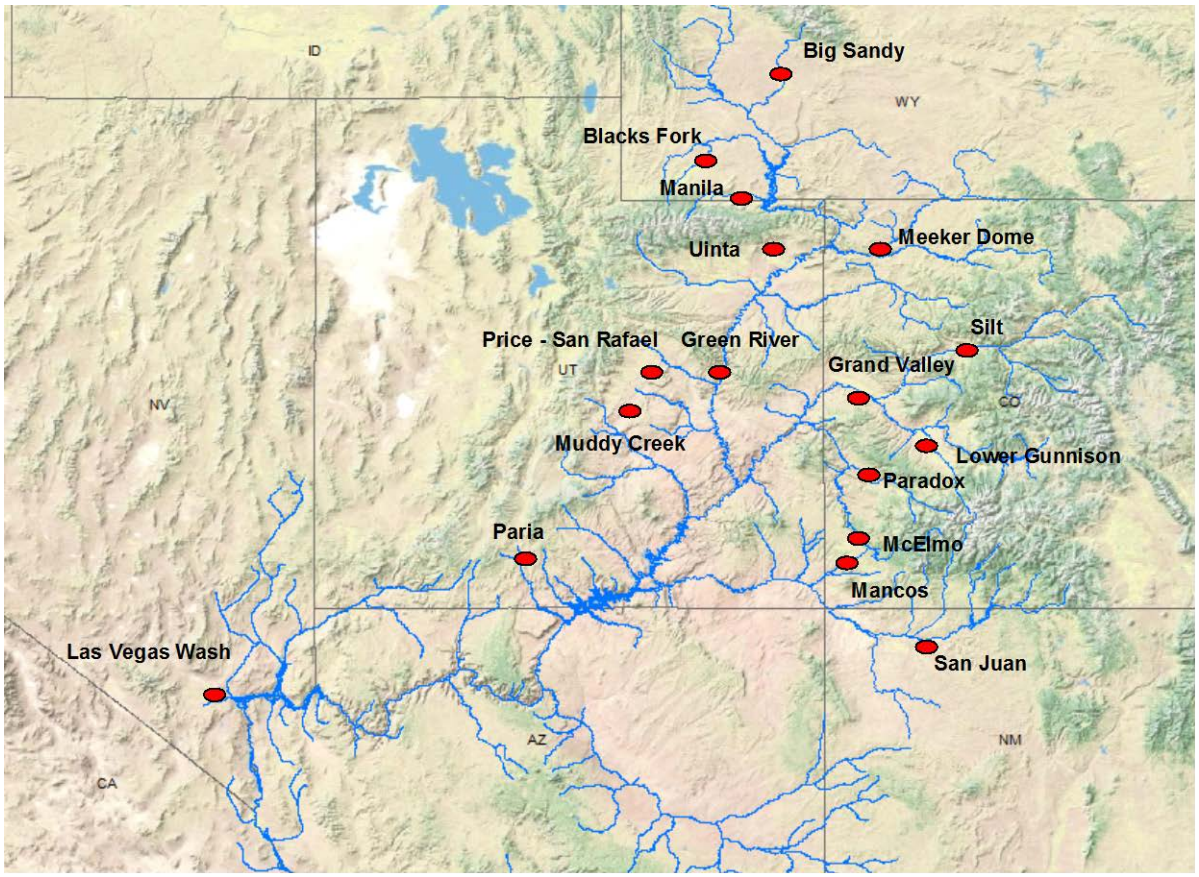

Figure 11 – Title II Salinity Control Projects

U.S. Bureau of Land Management (BLM)

The background for the BLM salinity program can be found in Progress Report 21 http://www.usbr.gov/uc/progact/salinity/pdfs/PR21.pdf

Reports from BLM State Offices reference many of the salinity activities that the BLM is engaged in with partner agencies to improve future ability to quantify salinity reductions. To address these challenges, the BLM is co-developing a system of tools/models: RHEM-APEX-AGWA ((Rangeland Hydrology and Erosion Model; Al-Hamdan et al., 2011); (Agricultural Policy EXtender model; Sharpley and Williams, 1990); (Automated Geospatial Watershed Assessment Tool; Hernandez et al, 2000)). The integration and linking of these tools/models was completed during FY2015.

Program Administration

The BLM established a Salinity Coordinator position in 2003. The BLM allocated $1,125,000 in FY2015 from its Soil/Water/Air (SWA) Program to support projects specifically relating to salinity control subactivity objectives. Projects funded in FY2015 are described below in the State Reports section. In addition to the funding allocated from the Salinity subactivity, millions of dollars are expended annually by other BLM programs and authorized users of public lands on watershed management, restoration, and mitigation activities that retain sediment/salt and/or reduce/retain erosion/sediment and salt transport efforts. The salinity coordinator's position is funded separately from the salinity funding. BLM allocates the funding to its field offices. The budget allocation is predominantly distributed to implementation projects with some funding still given to planning projects according to need and availability of personnel to successfully accomplish projects.

Basin Wide Activities

Included in the funded projects is the BLM contracted work with USDA-ARS for multiple rainfall sediment and salinity transport projects. Data are being collected from Utah, Colorado, and other locations and will continue to be collected through 2017. This work continues from the previous BLM funded work to collect physical data to validate the tools co-developed during FY2015. This tool can eventually be taught to field offices to answer the public's questions regarding salinity.

A new approach to establishing a baseline from which to move forward was funded by BLM in December, 2012. Due to the lapsed labor funds from the vacant Salinity Coordinator position, BLM invested $100,000 in a joint USDA ARS-USDOI BLM project to conduct a study to improve the current understanding and identify the gaps in knowledge regarding the sources and transport mechanisms in rangeland catchments that deliver TDS to streams. A literature review ensued that is discussed in detail in the USDA-ARS section. The BLM, Reclamation, and NRCS management practices were included in the search for their relationship to salinity reduction.

Thus far, the findings have demonstrated that: (1) TDS is a good surrogate of salinity; (2) It is generally accepted that practices that reduce soil erosion and sediment transport might also reduce salt loading; (3) Minimal literature exists on the relationship between rangeland management practices and runoff or sediment; (4) Limited literature found on direct impact of land management practices (i.e., gully plugs, contour farming, chaining); (5) Currently

relationship on salt-management practices inferred from assumed impact of practice on runoff and sediment loading (partly because of lack of supporting data) through changes in vegetation type and distribution, canopy and ground cover, and soil surface/hydraulic roughness; and, (6) Literature indicates that all practices that were evaluated for reducing salt loading have a defined lifespan and must be maintained (sediment removed from gully plug) or redone to be effective (contour furrow).

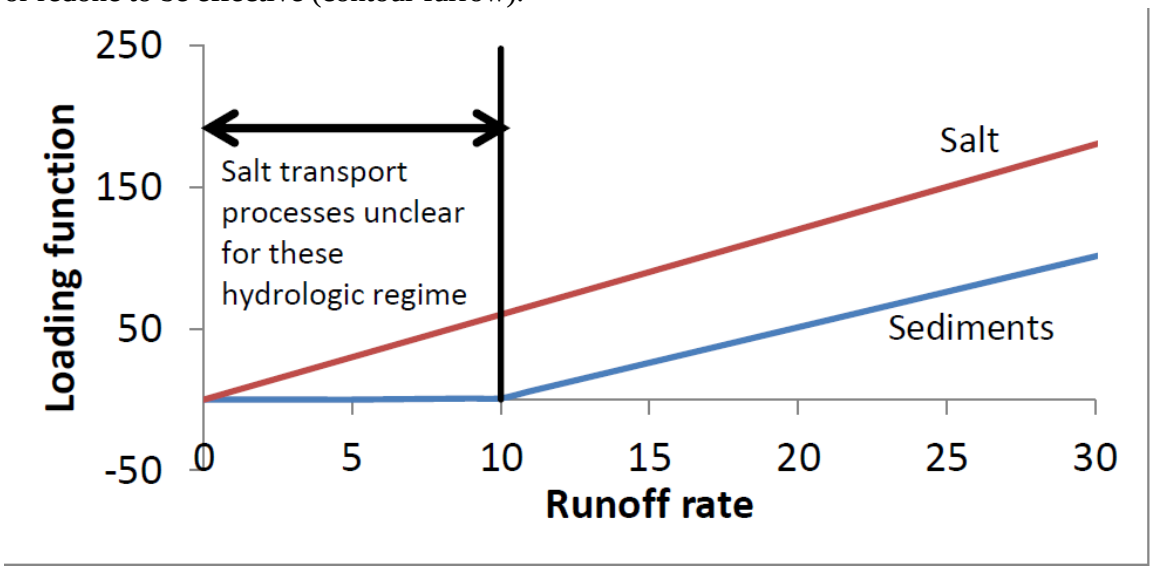

Figure 12 – Relationship between Range Runoff and Salt Loading

It has been assumed there is a hypothetical linear relationship between runoff and salt/sediments, Figure 13. This relationship needs to be quantified for various dominant Ecological Sites due to inherent difference in salts in the soils across the basin and will change as a function of vegetation type, density, and canopy and ground cover (i.e. management).

The BLM continues to co-develop a plot to watershed tool, which includes water quality, to quantify management actions of sediment, and/or salt retained, by program management across the CRB. The expected completion period is approximately 2018 and BLM expects to be able to report on the quantification of effectiveness at this time. The collaboration with USDA-ARS has already resulted in multiple publications, books, and conference presentations (see USDA-ARS section).

Eventually the tool will lead us from BLM and BLM-collaboration funded plot or sub-catchment scale to watershed and, if needed, to regional scale. Our rainfall/salinity projects will be included in the tool and will be utilized for the combination of linked models as well. The sources and inputs of salinity data are now being received from more than just the Salinity sub activity. Other programs that indirectly or directly have been affecting salinity in the CRB are: Recreation-OHV; Rangeland; Acid Mine Land; Riparian; Wild Horse and Burro Management; Fire and Revegetation Emergency Stabilization Recovery; Renewable Energy (rights-of-ways); Fluid Mineral (orphaned wells); Hazardous Fuels Reduction (Thinning Forests, Urban Interface); and, Forests and Wetlands (grazed, unmanaged lands, Christmas tree plots).

The BLM is not able to report reductions accomplished through many of these efforts to the Forum because of technical and programmatic issues, but is working to develop approaches needed to quantify reductions. Most programs should be integrated into the tool. This year's accomplishment report includes a limited number of programs.

Rangeland Program

The BLM has established and continues to improve upon its policies and practices to maintain and restore land-health based on key standards reflecting vegetation (erosion, conservation-sediment retained), ecological attributes, watershed function, and biotic integrity. So far the Land Health Standards have 90 standards that relate to assessing sediment retention/erosion.

Within the CRB, the numbers of BLM rangelands that are meeting all Rangeland Health Standards, as inventoried and reported last in 2012 are in the table below.
We start with the CRB and 472 rangeland allotments totaling 2,990,441 acres, already meeting or making significant progress toward the standards in the CRB (Figure 13).

Fuels Treatment Effectiveness Monitoring Program

Vegetation left on the ground inhibits the transport of sediment and salts. The BLM's Fuels Treatment Effectiveness Monitoring Program manages areas that are likely to intersect with wildfires leading to the destruction of vegetation and leaving paths for sediment and salinity surficial movement.

Within the Fuels Treatment Effectiveness Monitoring database (FTEM) and per IM-2015-001 which states that "offices will complete a fuels treatment effectiveness assessment and input appropriate information into FTEM for all wildfires which start in, burn into, or burn through any portion of a fuel treatment area that has been completed and reported in the Hazardous Fuels Module of the National Fire Plan Operations and Reporting System from fiscal year 2003 to present." Utah has 171 records where a record for example would be the Scipio Summit Wildfire in which there is 90 days to report it into the FTEM database. The records for Utah account for 21 percent of all of BLM's records. Since 2003, BLM has accomplished millions of acres of fuels management treatments including thinning, mastication, and lop and scatter. Wildfires have intersected many of these fuels treatments therefore, demonstrating fuels program effectiveness for a minimum of 17,363 acres (70.3 km^2) burned in Utah.

Emergency Stabilization and Rehabilitation Program

Another BLM Program that impacts sediment and salinity transport is the Emergency Stabilization and Rehabilitation. Plans after the Toquerville Fire, Utah, in FY2012 were approved for reseeding to minimize soil erosion at a cost of $478,000 over a 4 year period; it burned 113 acres of public land. The action plan would not only establish a desired plant community but also suppress invasive annuals that can create a burn/re-burn cycle. The plan investigates understory and recovery to minimize erosion and reestablishment, fences,

monitoring, soil stabilization, and road/trail diversions.

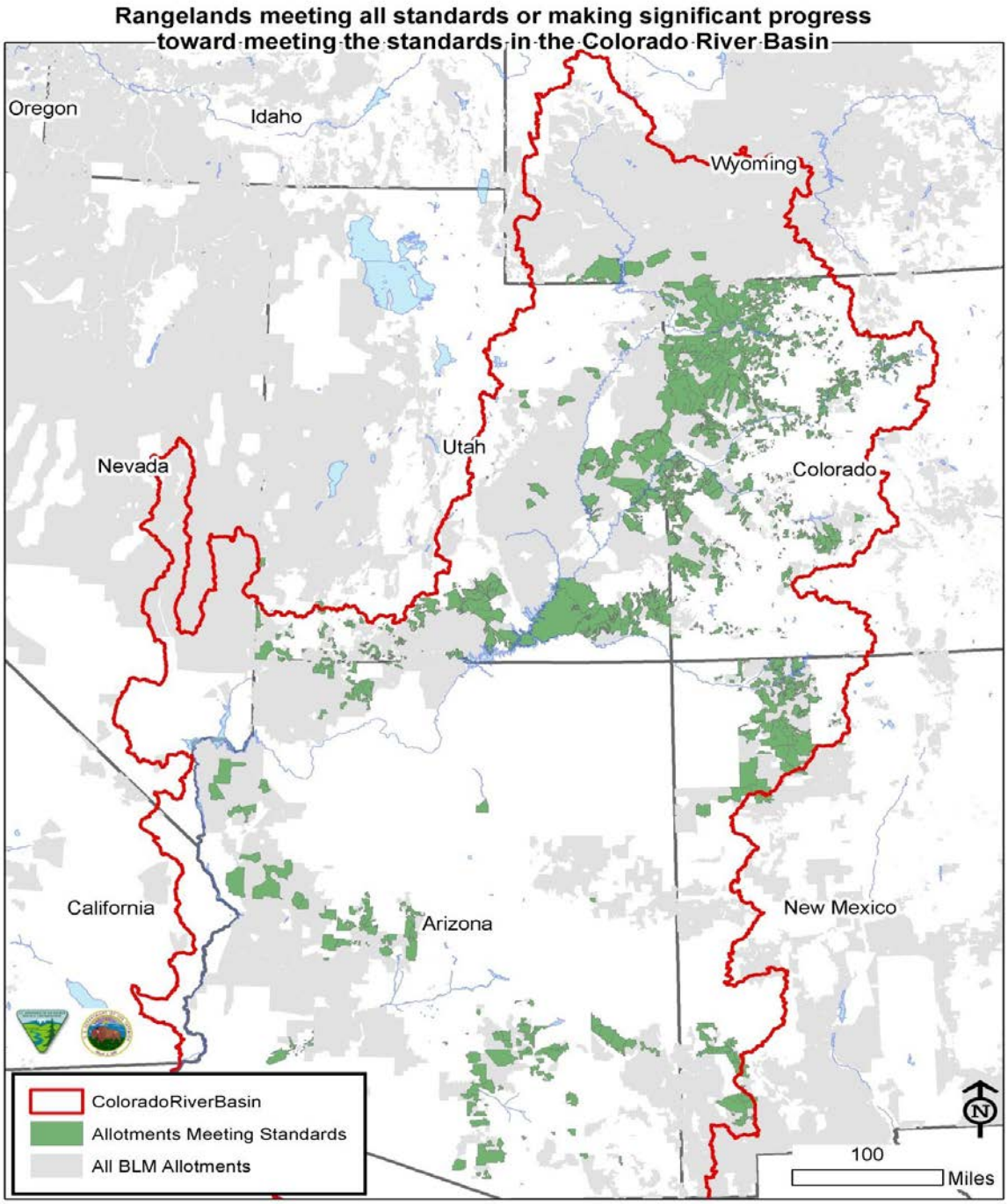

Figure 13 - Colorado River Basin Rangeland Status

***Standards for Rangeland Health are ecologically-based goals that conform to the Fundamentals of Rangeland Health found in 43 Code of Federal Regulations Subpart 4180. Fundamentals of Rangeland Health are fundamental requirements for achieving functional healthy public lands. The Fundamentals, and the Standards for Rangeland Health that conform to the Fundamentals, address the necessary physical components of functional watersheds, ecological processes required for healthy biotic communities, water quality standards, and habitat for threatened and endangered species or other species of special interest.**

Another fire in Utah (White Rock Fire) was approved for $1,636,000 in the BLM Program (FY2012): Emergency Stabilization and Rehabilitation. Its plan of actions over 3 years was to apply a seed mix aerially, then use chaining to cover the seed. All livestock were to be removed for two growing seasons so that the seeding could take effect. Based on site characterization of slope, topography, and ecology no additional measures were needed. The BLM was treating 3,542 acres that included 263 State acres and 212 private acres for a total of 4,017 acres for a total cost of $950,000.

While the monitoring data from the other programs continue to be updated and eventually reported, the total number of tons of salt retained by FY2015 Salinity sub activity accomplishments is 1,248. (Previous years accomplishments are being reviewed and recalculated.)

State Activities since last Progress Report

BLM State Offices submitted the following reports describing activities funded by the Salinity sub activity

Arizona

ASFO/Salinity Control Structures: Structures built to slow runoff, salinity, erosion to Colorado River are now degrading (50 year lifetime). Supports the Arizona Strategic Goal of Water for water quality. Project reports a minimum 312 tons of salt savings per year.

Mittry MSU Salinity Control: Riparian buffer established in 2014. Soils tested across 80 acres of land and Mittry Lake; soil data indicate decrease in salinity concentration. The buffer continues to be managed.

Colorado

Colorado River Salinity Summary of Monitoring Activities White River Field Office (2008-2015): The Colorado River Salinity funding (CRS Funds) for the White River have been used to augment existing USGS Streamflow monitoring sites, support USGS reports based on data collected, purchased equipment for BLM monitoring, and hire seasonal personal for field work. This funding resulted in an unprecedented amount of baseline data being collected and analyzed for the White River, Piceance Creek, and Yellow Creek drainages. The reports and data generated can be used to contributions of anthropogenic impacts to salinity in surface waters specifically, the salinity loads from the White River.

The BLM funded a data repository were completed to collect and assess existing water resource information (http://rmgsc.cr.usgs.gov/cwqdr/Piceance/). Data from the repository is being migrated to the Colorado Data Share Network (http://www.coloradowaterdata.org/). The aforementioned publication contributed invaluable data for WRFO's Resource Management Plan Amendment and Final Environmental Impact Statement (PRMPA/FEIS) impact analysis in-terms of the effects of oil/gas activities contribution to salinity including understanding processes of surface runoff and soil erosion's contribution to salinity loads in surface waters. The impact analysis also identified that freshwater use by oil and gas development within valid water rights may decrease surface flows in streams and increase the proportion of base flow from groundwater and thereby increase salinity concentrations in surface waters.

Accomplishments:

USGS Yellow Creek Streamflow Site:
1. Establishment of a new USGS streamflow site above Crooked Wash to bracket an area on the White River (White River Dome and Piceance and Yellow Creeks) known to be responsible for increasing salinity loads in the White River. Summary of all data available and funded by BLM is available at:
http://waterdata.usgs.gov/nwis/nwisman/?site_no=09306224&agency_cd=USGS.

2. Collection of additional water quality sampling in the White River, Piceance Creek and Yellow Creek. Water quality sampling and measurements were taken.

3. Six new streamflow measurement sites were established in the Mesa Verde Play Area and are maintained by the BLM to measure stream discharge, conductivity, air and water temperature and conduct water quality and macroinvertebrate sampling. Two precipitation measurement sites and one weather station were established and maintained by the BLM for this area.

4. Over 500 groundwater springs were inventoried over four seasons including the collection of field water quality parameters. Information from this inventory can be used to identify springs with high salinity and monitor future anthropogenic impacts.

Mancos Shale Oil and Gas Monitoring
The USGS in cooperation with the BLM will study the distribution, storage, and release of sediment, salinity, and selenium in area of Mancos Shale under two different land uses. The study will include 2 basins in Stinking Water Gulch near Rangely, CO, where one basin is dominated by oil and gas land use (Basin A) and the other basin is dominated by grazing/ranching land use (Basin B). The two basins are of similar size (~1.4 square miles) and similar slopes (~16 percent). This approach will provide insight into how different land uses effect the distribution, storage, and release of sediment, salinity, and selenium in surface-water systems.

Project Update:

2013 – Due to a shortage in funding at the district and field office level, the one-time funds were not applied to the project.

2014 – First year of funding applied to the project. Funds were used to conduct a field inventory with BLM and USGS staff in Rangley, CO. The USGS produced a statement of work. The statement of work includes 5 tasks and a peer reviewed publication. The USGS intends to seek additional funding in 2016 from the Salinity control forum to finish the project and produce the publication.

2015 – Existing remote sensing data will be used to evaluate the land use history of each basin and provide the timing and occurrence of changes in channel morphology (channel width, sinuosity, and drainage density).

Field work will be conducted in September to collecting cross section data. It will be used to understand differences in channel geometry to facilitate assessment of storage of sediment,

salinity, selenium for each basin. Up to 20 cross-sections in each of the basins will be surveyed using GNSS-RTK survey techniques to determine the cross sectional profile of the channel.

Figure 14 – Basin A

Figure 15 – Basin B

Water Quality Data

The Colorado River Valley Field Office:
This funding was essential to have water quality laboratory work completed and partially support one AmeriCorps Volunteer (hired in partnership with the Middle Colorado Watershed Council (MCWC)), who have been successful at on-the-ground watershed assessment work and target accomplishments.

A draft sampling and analysis plan has been written to address data gaps and initial field reconnaissance during the summer of 2015 included water quality sampling, discharge measurements, riparian and rangeland conditions assessments, and documenting historic mining impacts. A GIS analysis has been initiated to identify possible sources of selenium and other impaired parameters, and formulate potential restoration efforts that may address load reduction goals.

Overview of the Middle Colorado Watershed Boundary showing the Water Quality Impaired or Monitoring & Evaluation listed stream segments. In FY2014, BLM funding supported a comprehensive analysis of existing water quality data (2000-2013) and major findings and recommendations were published. In FY2015, BLM funding supported field reconnaissance

and baseline watershed assessment work in the Rifle Creek sub-basin, water quality sampling and lab analysis, where data gaps had been identified.
Water chemistry (salinity, conductivity, pH, DO, and TDS) was measured in the field to support data gaps and help direct which locations in-depth lab analysis may be important for future monitoring.

New Mexico
San Juan River Basin Erosion Reduction

Project Update:
Focus is on noxious weed removal that threatens native riparian habitat, cutting trees, and indicating lack of understory plant growth leading to loss of top soils due to rain/snowmelt events that lead to surface products in the stream. Sediment fences are being built, Youth Conservation Corps are involved to restore native vegetation, and soil erosion and salinity should be reduced. Work is progressing.

La Manga Canyon Watershed Improvement

Degraded rangelands including sagebrush grasslands and Pinyon/Juniper woodlands are on steep hillsides. The trees have minimal understory and excessive soil erosion. Sediment retention dams are being built with an estimated salt savings of 13.5 tons of salt per year with life expectancy of 10-12 years.

Brush clearing as directed from WO
To support brush clearing in conjunction with fire relief and revegetation to retain sediment/minimize erosion (also results in salinity reduction). Salt and sediment savings data unknown as of September 15, 2015.

Utah
Onion Creek Road Stabilization

Project Update:
Onion Creek Road is a dirt road maintained in Grand County, Utah which travels along Onion Creek for over 8 miles. The road prism is often located adjacent to or within the active channel, and involves 27 low water stream crossings. Grand County Road Department maintains this road regularly, providing access to private land and BLM recreation opportunities.

Onion Creek is a tributary to the Colorado River, with a relatively short distance from the La Sal Mountains to the Colorado River (14 miles). This situation lends itself to large flood events on a regular basis and the road is washed out repeatedly. Historically the Grand County Road Department would rebuild washed out portions of the road using material from the stream channel. This has led to many sections of destabilized stream banks which are even more susceptible to flooding damage.

In 1999, Onion Creek was listed by the State of Utah on the List of Impaired Waters as not meeting state water quality standards for stream temperature and Total Dissolved Solids (TDS). In 2002, the Utah Division of Water Quality completed a Total Maximum Daily Load analysis (TMDL) with management recommendations to improve water quality conditions.

These recommendations include restricting vehicle traffic within the stream channel, establishing vegetation on streambanks through plantings, and any work that will help improve stream channel morphology and riparian conditions.

As a result of the TMDL report, a cooperative effort began between the BLM, Grand County Road Department and the Utah Division of Water Quality (UDWQ) in 2002. Several streambank stabilization structures were constructed which were successful at protecting the road from flood damage during most storms. These gabion baskets and large boulder barbs are useful techniques that may be installed at up to 12 more unstable locations on the Onion Creek Road.

Figure 16 – Large rock barbs in foreground, gabion baskets in background

In September, 2013, a series of extreme flood events damaged the road and streambanks in many places, including previously stabilized sites. Although the road was temporarily relocated around new channel locations and erosion obstacles, the road and stream channel are both in highly unstable condition. The damage from the large 2013 floods has not been repaired, leaving several long stretches of road within the active channel (almost a mile in total). There are at least 10 sites where the road is unstable and ready to fail during the next flood event, causing significant erosion and sedimentation.

The Moab Field Office is actively coordinating with the Grand County Road Department and UDWQ to evaluate all potential road relocation options, to identify high priority sites for road stabilization work and to identify which stabilization structural designs are appropriate at these locations. BLM salinity funding in FY2014 was contributed to a new assistance agreement with the Grand County Road Department to conduct an in-depth engineering

feasibility study. The study has evaluated several different routes to avoid stream crossings, but those options are limited, extremely expensive, and have other resource concerns.

In FY2015, future stabilization work was necessary, as determined by the BLM and the Grand County Road Department, over the next year. Constructing one stabilization structure can cost up to $40,000 or more as all materials need to be hauled in from distant sources. Installing the simpler gabion structures can be an involved process as they need to be seated deep in the channel or sometimes bedrock. This funded work is expected to be completed in the fall of 2015. Additional stabilization work could continue over the next 5 years or more, as funding is available.

Ongoing Grazing Exclosure Project

Project update:
The Moab Field Office manages 315,000 acres of moderately saline soils, mainly derived from the Mancos Shale Formation. Grazing permits are authorized on these sensitive soils. In order to better understand the range of impacts from different grazing systems on saline soils, the BLM has been constructing grazing exclosures and conducting baseline data collection efforts as part of an extensive assessment of saline soils.

The Moab Field Office has an assistance agreement with the local Canyon Country Youth Corps (CCYC) to construct 3-to 5-acre grazing exclosures on moderately saline soils. Each year for the last 5 years, three or more exclosures have been constructed with the goal of at least one exclosure in each grazing allotment with more than 10 percent saline soils. The exclosures are located adjacent to long-term range study sites maintained as part of the grazing monitoring program. These sites are addressed in a National Environmental Policy Act (NEPA) document and undergo thorough archeological clearance before construction begins.

The Moab Field Office has established an Interagency Agreement (IGO) with the local USGS Biological Sciences Center and research ecologist and soil scientist Mike Duniway. Over the last several years, USGS staff has conducted intensive soil and vegetation studies both inside and outside of the exclosures to establish baseline conditions at this time. Detailed data collected includes: vegetation species composition, vegetation cover and density, soil crust cover and development stage, soil surface stability (slake tests), soil compaction, testing with impact penetrometer, detailed soil pedon data, canopy gap data, and chlorophyll A content in soil crusts. Soil pedon and composite soil surface samples from each trend plot will be archived for potential future analyses.

In FY2015, the USGS compiled, summarized, and analyzed data collected thus far by plot and across plots using an ecological site frame work. A summary report will be provided to BLM by Dec. 31, 2015. We are also collaborating on future analysis that incorporates finer temporal resolution and time frames through integration with remote sensing, analysis of historical trend data and photos, and other approaches as appropriate.

These studies will be repeated over time, every 3-5 years, to assess changes to soil and vegetation conditions. These data will help BLM manage these grazing allotments more efficiently to ensure good and stable watershed conditions and minimize salinity contributions to the Upper Colorado River Basin.

Figure 17 – Typical grazing exclosure in moderately saline soils

Ongoing Protection Fencing in Ten Mile ACEC

Project update:
The Ten Mile Wash Area of Critical Environmental Concern (ACEC) is located northwest of Moab and drains into the Green River. This 5,000-acre area contains perennial and intermittent stream flows that maintain ecological diversity in both upland and riparian zones. Ten Mile Wash is subject to extreme flooding, increasing potential safety hazards to vehicle and camping activities. The potential for floods is great because the Ten Mile Wash watershed basin drains 176,000 acres. The canyon bottoms are filled with moderately saline soils which are extremely mobile and are redistributed during flood events.

The Moab Field Office received funding in FY2015 for this project. This funding went to an assistance agreement with American Conservation Experience (ACE) to monitor 5,000 acres of Ten Mile ACEC which is constantly struggling with trespass cattle and illegal off-road travel. These actions are impacting the ecological values of the ACEC as well as the moderately saline soils throughout the canyon bottom.

Watershed Conditions are monitored and documented, while additional fencing needs and their construction are assessed. This is in a very remote area with little vehicle access, so all materials and tools need to be hand carried to each site.

Wyoming

High Desert District:

The following information is an estimate of the amount of salt retained on the landscape because of actions taken by the Rock Springs, Rawlins, Kemmerer, and Pinedale Field Offices in FY2015. The numbers presented are estimations for one potential outcome. As the actions taken are designed to prevent erosion and associated salinity increases they are estimates only. Soil surveys are presently being conducted but have not yet been completed. Exact areas and extent of existing disturbance are unknown.

Salinity sub activity funded two other projects to establish salinity baseline data prior to the development and installation of oil and gas pads in the Green River area and along specific Colorado Basin tributaries; however, the work completed is currently being reported under the State Reports, but will eventually be accounted for under the Basinwide Activity Section when the watershed tool is fully operational.

The two projects that the BLM Rawlins Office undertook for FY2015 included: the repair of a nonfunctioning reservoir and the stabilizing of a head cut. Exact measurements and salt savings for these projects are unknown. The amount of salt retained by a reservoir or a head cut structure is highly variable.

Nonpoint Sources

Nonpoint sources are addressed through regular maintenance of BLM roads and facilities as well as reclamation of well pads and other disturbances. During FY2015, this area has received unusually high amounts of precipitation. There have been increased levels of stream bank erosion. At the same time, broad scale vegetation cover has improved, which reduces nonpoint erosion and aids in grazing distribution.

The Wyoming Lands Conservation Initiative (WLCI) http://www.wlci.gov/ and Jonah Interagency Office (JIO) http://www.wy.blm.gov/jio-papo/index.htm provided funding for several projects http://www.wy.blm.gov/jio-papo/whatsgoingon.htm in the area that, while not focused directly on salt reductions, have the potential to reduce salt volumes by improving wildlife habitat and thus focus primarily on vegetation, which also benefits salinity. The volume and cost savings of these projects is currently unknown.

A variety of activities occurred as part of normal activities in FY 2015 that had the secondary impact of reducing nonpoint erosion on public lands. Because of the nature of these activities and nature of monitoring, exact volumes of salt saved and the efficiency of each activity are general estimates. All the tabulations below are for the Green River Basin southwestern corner of Wyoming that is covered the Rock Springs, Kemmerer, Pinedale, and portions of the Rawlins Field Offices.

The standard practices of road maintenance and grazing management help to reduce potential erosion. The costs and salt savings vary. These practices are key to broad scale erosion reduction and salt retention. The following assumptions were made for the calculations below: (a) an average work month costs $8,500; (b) soil averages estimated to be about 3 percent salt by weight for most soils in the area; (c) average bulk density of soil is 2.65 g/cc (165.4 lb/cu ft) (4,467 lb/cu yd).

1. Road Maintenance and Reclamation
(Approximately the same as 2006 - 2014). The road maintained was 350 miles long with approximately two work months used and two cubic yards of soil retained per mile of road maintained at a cost of $362 per ton of salt resulting in the retention of 47 tons of salt.

2. Reservoir Repair near Rawlins Field Office
The structure repair was required due to retaining sediment/salt. It required one week of work time and 100 cubic yards of soil at a cost of $317.14 per ton of salt resulting in 6.7 tons of salt retained.

3. Headcut
Structures mentioned in previous reports for this area are still operating and have not required any maintenance expenditures. Given that they are still preventing the upstream advancement of channel drops (head cuts), these structures could be considered to be highly cost efficient in preventing salinity contributions. The BLM is cooperating with the Wyoming Game and fish in the installation of a fish passage structure on private land in Trout Creek on Little Mountain, a tributary to Sage Creek, which contributes directly to Flaming Gorge. This structure will slow the upward progression of an existing head cut. This activity was designed as a fish passage and irrigation structure, not as an erosion reduction project. Given the unknown volume and content of the soil and rate of erosion, no calculations of soil salt content and volumes that will be retained by the structure were made.

The Rawlins Field office undertook one head cut repair. It required two work months and 1000 cubic yards of soil at a cost of $235 per ton of salt resulting in the retention of 67 tons of salt.

4. Grazing Management
(Same as 2006-2014). The area managed includes 28,000 acres of land and used 20 work months for grazing management. Based on livestock and the weather variables, the numbers provided can fluctuate. At a cost of $808 per ton of salt, the result was 208 tons of salt retained.

USDA – Natural Resources Conservation Service (NRCS)

The NRCS of the USDA conducts Colorado River Basin salinity control activities primarily under the authorities of the Environmental Quality Incentives Program (EQIP). EQIP was authorized with funding from the passage of PL104-127, Federal Agricultural Improvement Act of 1996, a.k.a. “1996 Farm Bill.”

EQIP has been reauthorized in each “farm bill” through 2018. Through EQIP, NRCS offers voluntary technical and financial assistance to agricultural producers, including Native American tribes, to reduce salt mobilization and transport to the Colorado River and its tributaries. Within the 12 approved salinity project areas, producers may be offered additional financial incentives to implement salinity control measures with the

primary goal of reducing offsite and downstream damages and to replace wildlife habitat impacted as a result of the salinity measures.

In FY 2015 $12 million was obligated into new land treatment contracts with agricultural producers in project areas in Colorado, Utah, and Wyoming. These new contracts, when fully implemented will provide more than 10,000 tons of annual salt control.

New Salinity Projects and Investigations

Henrys Fork (of the Green River), Wyoming

The Henrys Fork Salinity Control Project was adopted by NRCS in May 2013. This project area encompasses 69,929 acres in Sweetwater and Uinta Counties, Wyoming, and Daggett and Summit Counties, Utah. The entire Henrys Fork watershed is about 306,000 acres and is a tributary to the Green River which is a major tributary to the Colorado River.

Of the 20,709 irrigated acres within the project area, NRCS expects to improve on-farm irrigation application systems and reduce deep percolation and salt loading from about 14,000 acres, resulting in a salt load reduction of 6,540 tons annually. The first contract was developed on 141 acres in 2015.

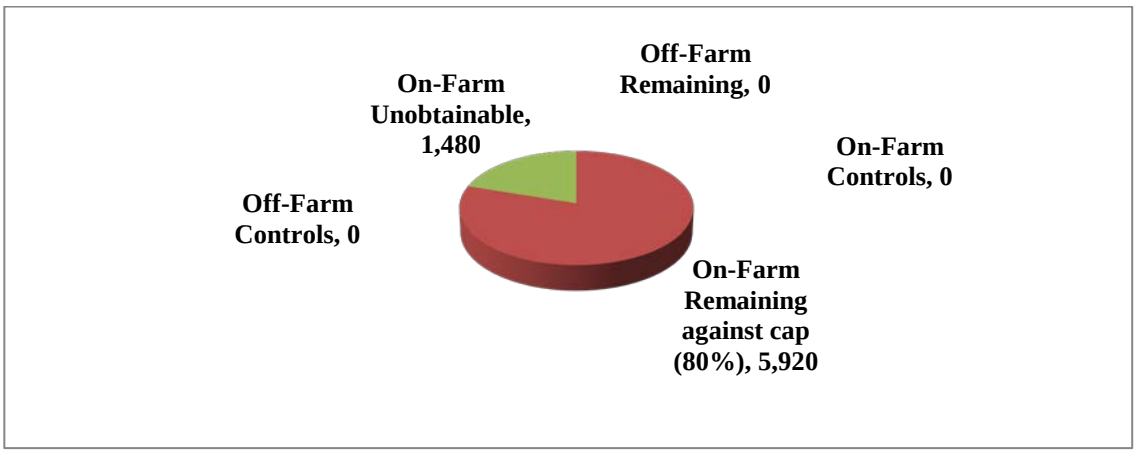

Figure 18 – Henrys Fork Salinity

West Black's Fork, Wyoming

An area of some 28,000 acres of irrigated pasture and hayland near Lyman, Wyoming, contribute salt to the Blacks Fork River, tributary to the Green River. While a large portion of the geology contributes little salt, about 10,000 acres may contribute significant amounts of salt from canal and ditch seepage and deep percolation from water applied to fields.

The Wyoming Water Development Commission provided a significant grant to the Austin-Wall Canal Company resulting in a comprehensive plan to modernize the

irrigated areas within their service area. NRCS anticipates that, in the near future, the Company will begin replacing earthen canals with buried pipelines that will provide pressure to operate sprinklers on the irrigated lands. NRCS intends to use its regular EQIP authority to assist producers in the area who want to modernize their irrigation systems. Such improved systems will provide significant salt control benefits.

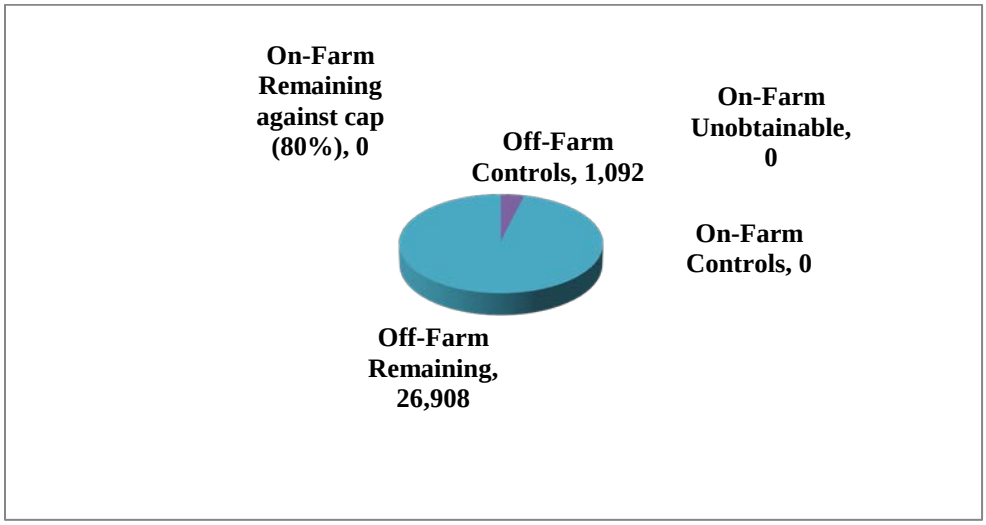

Figure 19 – West Black's Fork Salinity

San Juan Basin, New Mexico and Arizona

The first phase of the "Shiprock Pilot Project" to control salt was completed by the San Juan River Dineh Water Users, Inc. (SJRDWU, Inc.) in 2011. A leaky earthen lateral supplied water to 12 Navajo Nation farmers on 168 acres of cropland. The SJRDWU, Inc. completed the construction using their own resources and a grant from Reclamation. The SJRDWU, Inc. also reserved an eight acre parcel of land and has completed practices to replace wildlife habitat values that were lost due to the pipeline installation.

NRCS anticipates that the SJRDWU, Inc. will begin construction of a significant project with assistance from Reclamation in 2016. This project should enable NRCS to proceed with developing EQIP salinity projects with individual native farmers.

Areas Beyond Current Project Boundaries

NRCS has undertaken to identify salt loading and salinity control from irrigated crop, pasture and haylands scattered widely throughout the Upper Colorado River Basin but outside of the existing project areas. With the assistance of the USGS and Reclamation, NRCS has been able to make use of the SPARROW model to assess salt loads outside of the existing salinity project areas. While the assessment is ongoing and will require considerable refinement, preliminary analysis indicates that as much as 50,000 tons of salt control has occurred in Utah and Colorado outside the project areas.

In 2015, Colorado developed EQIP contracts with water quality benefits including salt control outside of the approved project areas but within the Colorado River Basin. Colorado, obligated slightly more than $1/2 million into 14 contracts on 500 acres in in Montrose, LaPlata, Garfield, and Eagle Counties. When fully implemented, these contracts will control about 800 tons of salt annually.

Monitoring and Evaluation

Project offices continue to monitor and evaluate the effectiveness and quantity of salinity control, wildlife habitat, and economic performance replacement in order to improve the overall performance and management of the program. Generally, the program continues to function effectively and economically, though the overall cost per ton of salt control continues to rise in some areas however, when adjusted for inflation the current cost effectiveness compares favorably with the projected costs at the time of the adoption of the respective projects. It is also noted that additional efforts are needed to identify and implement valuable, low-maintenance, sustainable wildlife habitat replacement. The individual Monitoring and Evaluation reports for FY 2014 for each project can be found on the world-wide-web at; http://www.usbr.gov/uc/progact/salinity/index.html

Active Salinity Control Projects

NRCS is providing technical and financial assistance to landowners and operators to implement on-farm salinity control measures in eleven approved project areas in three Upper Basin states.

Table 6 – Active Salinity Control Projects

Project Area			
State	Project	(Potential Irrigated Acres)	NRCS Servicing Office
Colorado	Grand Valley	50,000	Grand Junction
	Lower Gunnison River	171,000	Delta and Montrose
	McElmo Creek	29,000	Cortez
	Mancos Valley	11,700	Cortez
	Silt	7,400	Glenwood Springs
Utah	Uinta Basin	226,000	Roosevelt, Vernal
	Price/San Rafael Rivers	66,000	Price, Castle Dale
	Muddy Creek	6,000	Castle Dale
	Manila-Washam	8,000	Vernal
	Green River	2,600	Price
Wyoming	Big Sandy River	18,000	Rock Springs
	Henrys Fork	20,700	Lyman
	Total	**616,4700**	

Grand Valley, Colorado

Implementation has been underway in this unit since 1979 and NRCS considers that the salt control measures of the project have been successfully completed as planned. In 2010, a status report was compiled from field visits and observations. The report indicated that at least 12,000 irrigated acres are no longer in agricultural production. Of the remaining 44,700 acres still in production, 42,435 acres or 95 percent had received varying levels of treatment.

As of October, 2015 the salt reduction goal of 132,000 tons had been exceeded and more than 143,000 tons had been reported as controlled. In 2015, 10 new contracts were enacted on 175 acres that will deliver an additional 269 tons of salt control.

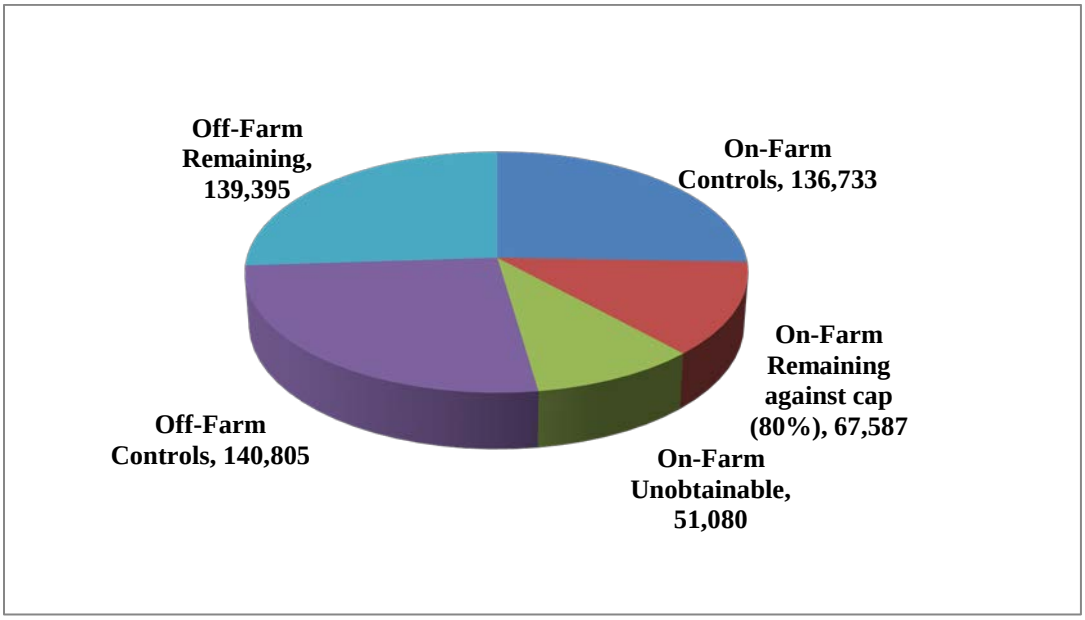

Figure 20 – Grand Valley Salinity

Lower Gunnison Basin, Colorado

This project encompasses the irrigated farmland in the Gunnison and Uncompahgre River valleys. With the expansion into the upper headwaters of the Uncompahgre River in 2010, implementation is now proceeding in Delta, Montrose, and Ouray Counties. Implementation was initiated in 1988 in this unit. About 64 percent of the salt control goal has been achieved.

Interest remains high in the project area. Forty four new contracts for about $3.9 M were developed in 2015 on 1,878 acres for planned salt control of 2,312 tons.

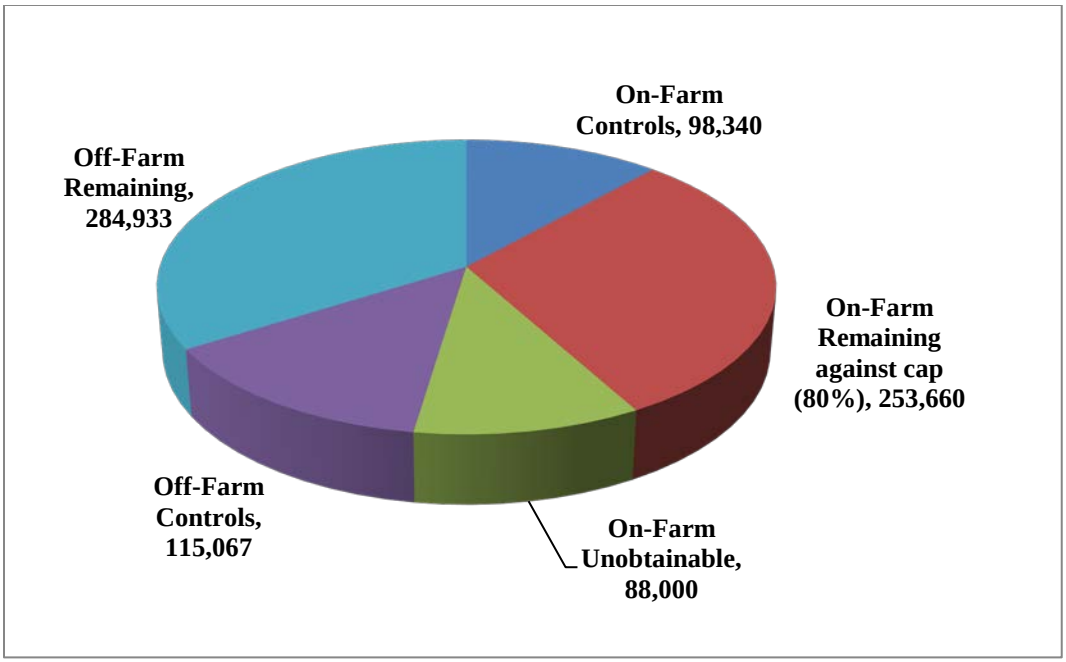

Figure 21– Lower Gunnison Basin Salinity

Mancos River, Colorado

This project, near the town of Mancos, Colorado, was initiated and approved for funding and implementation by NRCS in April 2004. Currently, about 108 contracts have been developed with EQIP and BSP funds. Five new contracts for $314,503 were developed on 59 acres in 2015. Planned salt control from these new contracts is 118 tons annually.

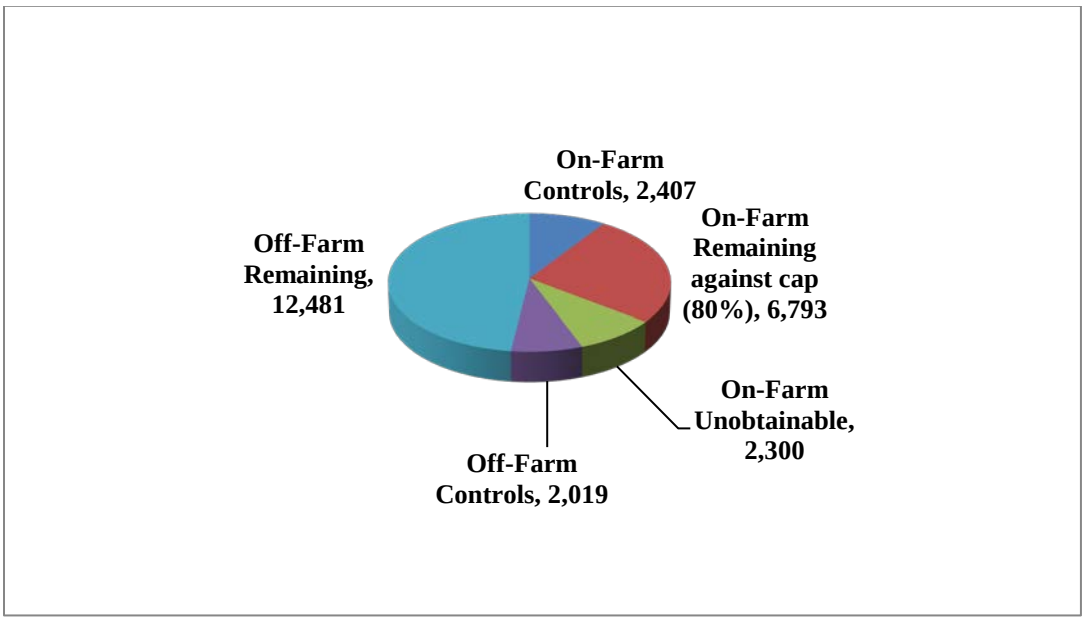

Figure 22 – Mancos River Salinity

McElmo Creek, Colorado

Implementation was initiated in this unit in 1990. Application of salinity reduction and wildlife habitat replacement practices continue to be implemented in this area with sprinkler systems, underground pipelines, and gated pipe being installed. In 2015, 32 new contracts were developed on 732 acres that will provide 952 tons of salt control when fully implemented. The project has attained slightly over 64 percent of its salt control goal.

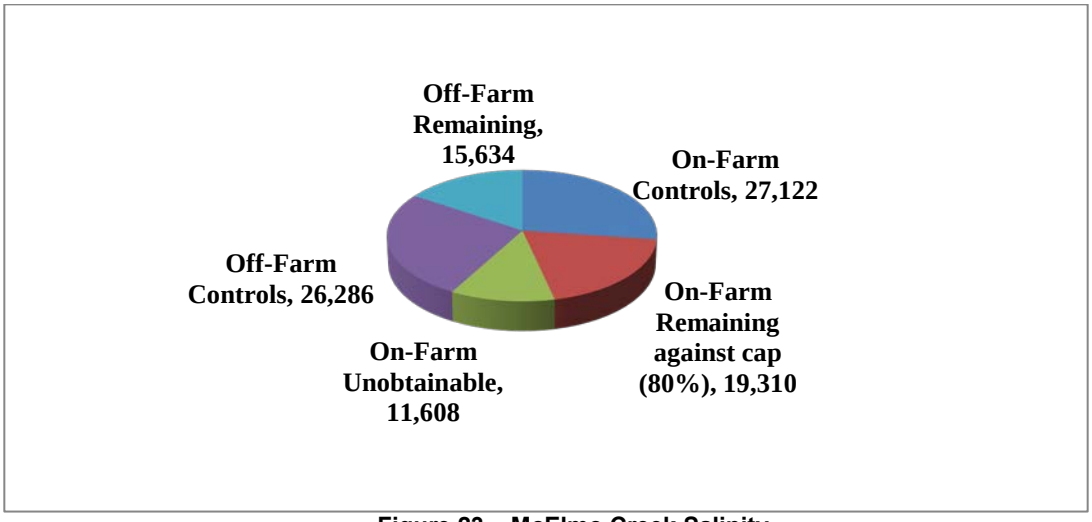

Figure 23 – McElmo Creek Salinity

Silt, Colorado

The first applications were funded in 2006. Currently, there are 50 active contracts on 951 acres in the project. When fully implemented, these contracts will control about 1,500 tons of salt annually.

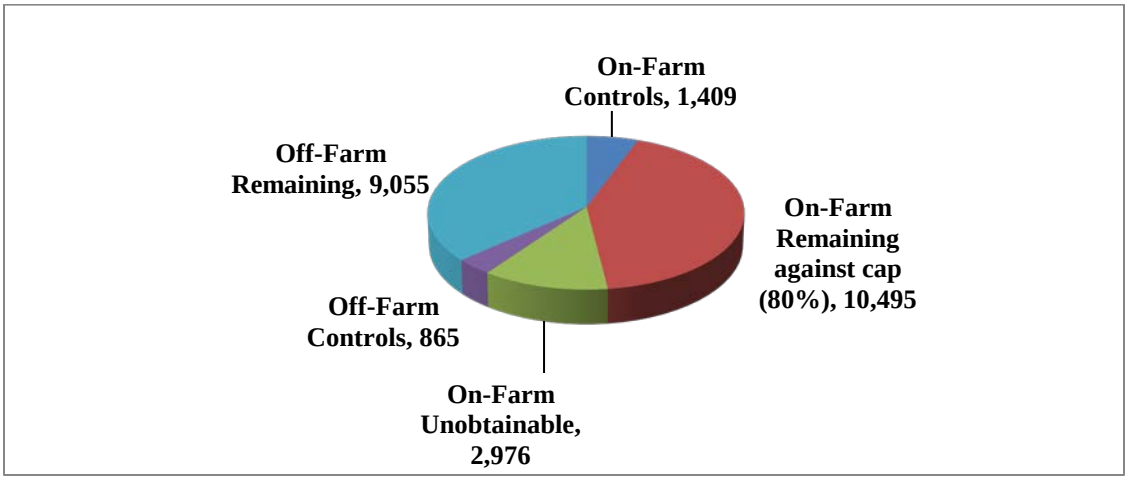

Figure 24 – Silt Salinity

Uinta Basin, Utah

Implementation began in this unit in 1980. The original salt control goal was reached several years ago but about 60,000 acres might still be improved. A predominant portion of the unimproved acres are within the jurisdiction of the Ute Indian Tribe. Opportunities for new contracts are diminishing as the project "matures." Sixteen new contracts were developed in 2015 on 560 acres for about $1.4 M. When fully implemented, these contracts will control 873 tons of salt annually. All irrigation improvements were either sprinklers, buried pipelines or a combination of the two.

A significant number of systems have reached or are nearing the end of their useful life. While these systems are a lower priority than first-time improvements, NRCS has begun providing incentives for replacement or up-grading.

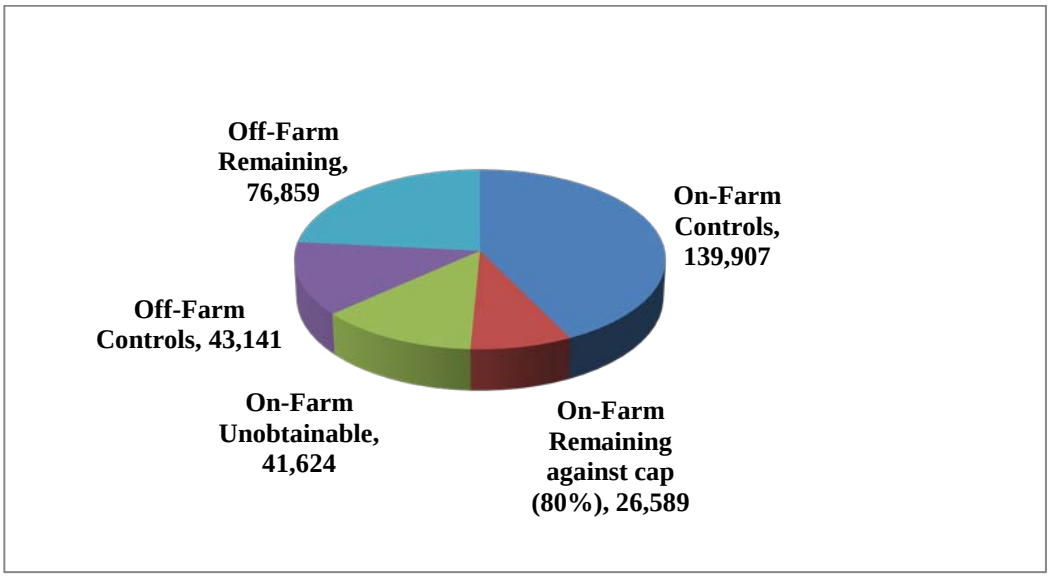

Figure 25 – Uinta Basin Salinity

Price-San Rafael, Utah

This project is approaching 70 percent achievement of its salt control goal. In 2015, 26 new contracts obligated about $2.2 M on 1,151 irrigated acres. When implemented, these measures will control about 4,400 tons of salt annually.

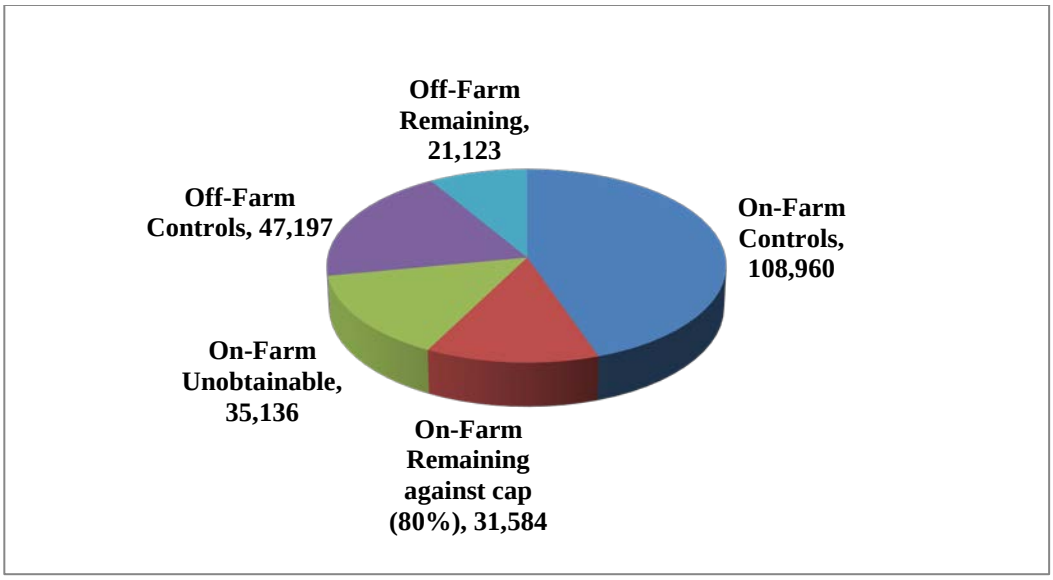

Figure 26 – Price San Rafael Salinity

Muddy Creek, Utah

There was one new contract developed in the Muddy Creek area in 2015, bringing the total to three contracts on 251 acres to control 358 tons of salt. On-farm progress in the project area awaits improvement and piping of the century-old earthen canal.

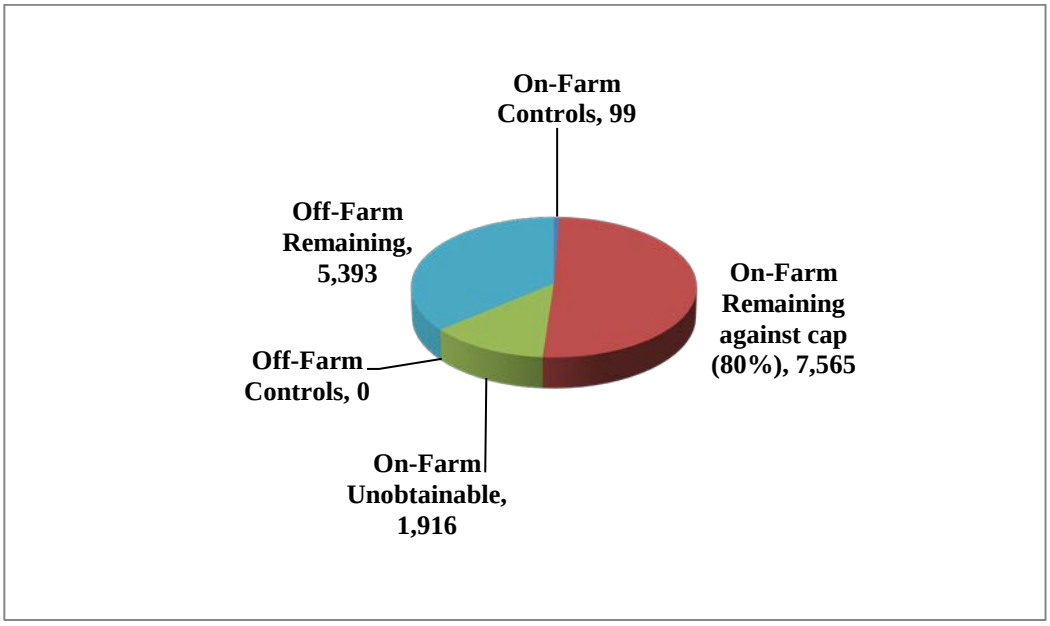

Figure 27 – Muddy Creek Salinity

Green River, Utah

One EQIP contract was developed in the project area in 2012 that will control 1,310 tons when fully implemented. Interest remains high but off-farm infrastructure improvements are needed to allow on-farm systems to operate properly and efficiently. Irrigation continues to expand, particularly on the plateau to the east of the Green River but, as all of the new irrigation systems are high-efficiency sprinklers, NRCS does not anticipate a significant increase in salt loading to the river. These expansions are not eligible for EQIP assistance.

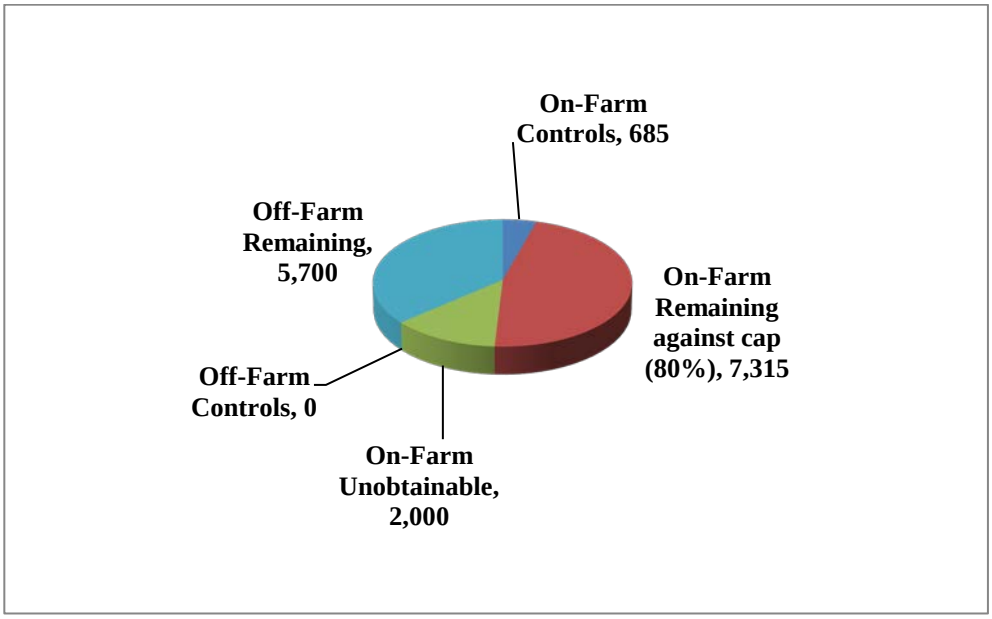

Figure 28 – Green River Salinity

Manila-Washam, Utah/Wyoming

Astride the Utah-Wyoming border, and adjacent to the shores of Flaming Gorge Reservoir, the Manila-Washam Project has achieved about 54% of its salt control goal. There are currently 51 contracts on 3,800 acres in various stages of implementation. All new irrigation systems have been some form of sprinkler system, such as side roll, pods, or center pivots. NRCS is also seeking opportunities for wildlife habitat replacement as the project is currently deficit.

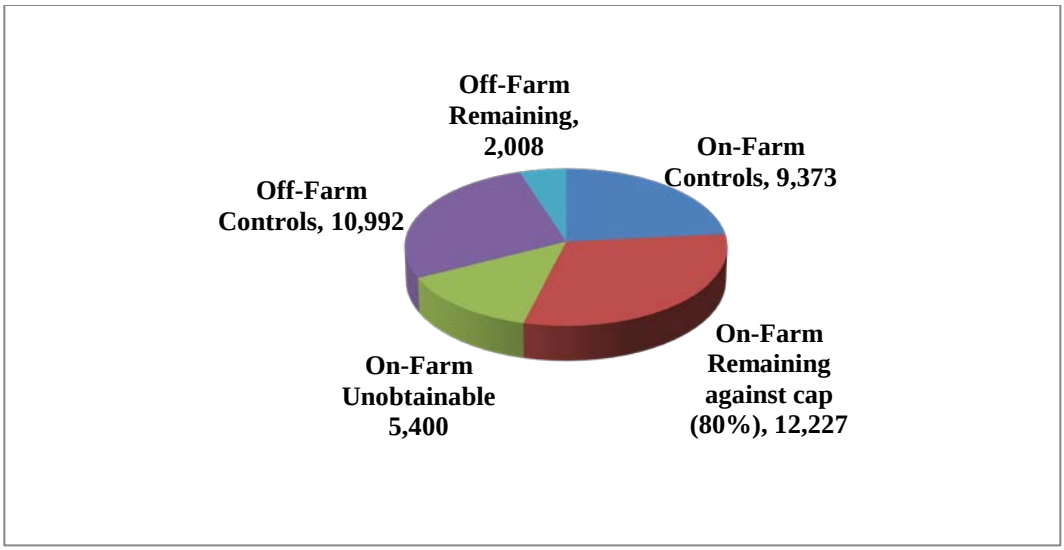

Figure 29 – Manila Washam Salinity

Big Sandy River, Wyoming

Implementation has been underway in this unit since 1988. Approximately 13,500 acres of the planned 15,700 acres have been treated (86 percent) and about 70 percent of the salt control goal has been reached. Producers also report that the water savings from improvements in irrigation systems now allows a full irrigation season of water for the entire irrigation district. In 2015, two new contracts were developed on 29 acres.

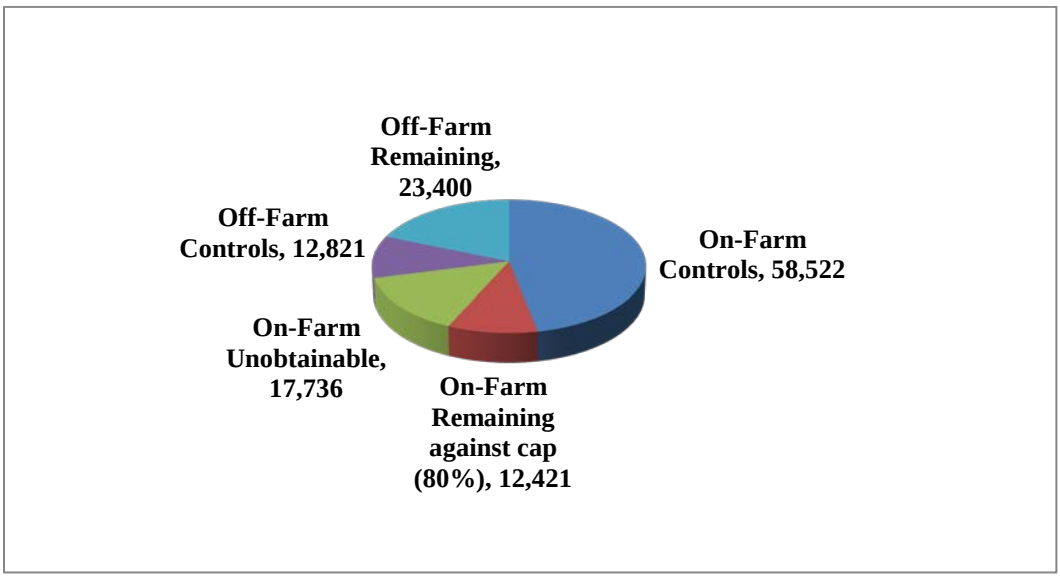

Figure 30 – Big Sandy Salinity

Table 7 - NRCS Salinity Control Unit Summary 2015

	[1]Controls	Potential	Percent	Costs	[2]Indexed	[3]Cost/ton
Unit	(tons)	(tons)	of Goal	(FA+TA)	cost/ton	FY2015
Mancos River, CO	4,426	11,940	37%	$7,037,014	$66	$192
Muddy Creek, UT	99	11,677	1%	$187,475	$75	$n/a
Manila-Washam, UT	10,417	17,430	60%	$8,463,894	$53	$52
Silt, CO	2,274	3,990	57%	$4,466,241	$92	$232
McElmo Creek, CO	29,455	46,000	64%	$26,141,274	$98	$134
Uinta Basin, UT	157,217	140,500	112%	$122,634,864	$133	$186
L. Gunnison, CO	119,057	186,000	64%	$86,080,081	$86	$164
Price/San Rafael, UT	80,114	146,900	55%	$56,605,330	$36	$44
Grand Valley, CO[3]	143,495	132,000	109%	$59,701,529	$39	$150
Big Sandy, WY	58,180	83,700	70%	$13,844,400	$39	$23
Green River, UT	685	6,540	10%	$430,964	$103	$32
Henry's Fork, UT	0	6,540	0%	0		
Totals	**605,419**	**793,217**	**76%**	**$385,593,066**		

[1]Includes Off-farm funded with EQIP or BSP funds, not selected thru Reclamation FOA
[2]Cost per ton based as projected in NEPA document indexed by Bureau of Labor Statistics Consumer Price Index
[3]Nominal cost of current year practice installation

Bureau of Reclamation

Basinwide Salinity Control Program (Basinwide Program)

One of the greatest advantages of the Salinity Control Program comes from the integration of Reclamation's program with NRCS's program. Water conservation within irrigation projects on saline soils is the single most effective salinity control measure found in the past 30 years of investigations. By integrating NRCS's on-farm irrigation improvements with Reclamation's off-farm improvements, significantly higher efficiencies can be obtained. If landscape permits, pressure from piped delivery systems (laterals) may be used to drive sprinkler irrigation systems at efficiency rates far better than those normally obtained by flood systems. Reclamation now has much greater flexibility (in both timing and funding) to work with NRCS to develop these types of projects.

Another significant advantage of the Basinwide Program is that projects are "owned" by the proponent, not Reclamation. The proponent is responsible to perform on its proposal. Costs paid by Reclamation are controlled and limited by an agreement.

Funding Opportunity Announcement (FOA)

Applications to reduce salinity contributions to the Colorado River were solicited through a FOA for both the Basinwide Program and BSP. The FOA was released on April 27, 2015, and closed on July 17, 2015. Reclamation's Grants Officer received the applications and reviewed for responsiveness to the requirements as described in the FOA. The 28 acceptable applications were forwarded onto an Application Review Committee (ARC) for a detailed review.

The ARC was composed of Reclamation personnel, a member from the NRCS, and three advisors from the Colorado River Basin States. Reclamation convened a meeting of the ARC on August 3-5, 2015. The 28 applications totaling over $75 million came from all four Upper Basin States.

After reviewing and ranking the applications, the ARC recommended to the Grants Officer the awarding of about 15 projects totaling about $43.5 million. Ten projects totaling about $36 million and controlling over 31,000 tons of salt will be awarded cooperative agreements through Reclamation's Basinwide Program. Five projects totaling about $7.5 million and controlling over 5,600 tons of salt will be awarded agreements through the BSP. Reclamation executed most of the agreements in fiscal year 2016. The average cost effectiveness of the selected Basinwide Program projects is $48.72 and the average cost effectiveness of the selected BSP projects is $54.65

All salinity projects are required to replace incidental wildlife habitat losses concurrent with construction of salinity features and maintain this habitat for the life of the project.

Price – San Rafael River Basins, Utah

Huntington Cleveland Irrigation Company (HCIC) Project: The Project is located in northern Emery County, Utah, around the towns of Huntington, Lawrence, Cleveland, and Elmo. Approximately 350 miles of open earthen canals and laterals are being replaced with a pressurized pipeline distribution system (Distribution System) to accommodate sprinkler irrigation on about 16,000 acres. The Project, scheduled to be completed in 2016, will result in the annual reduction of 59,000 reportable tons of salt in the Colorado River at an anticipated cost of approximately less than $100/ton. Of the 59,000 tons of salt, 13,000 are attributed to the Off-Farm Distribution System and 46,000 tons are attributed to the On-Farm Distribution System and the on-farm salinity control measures (sprinklers).

Cottonwood Creek Irrigation Improvement Project: The $6,509,548 Cottonwood Creek Irrigation Improvement Project is located in Emery County, west of Castledale, Utah Construction began in May 2011, and the project was operational for the 2013 irrigation season. This project replaced approximately 31 miles of earthen canals and laterals with a pressurized pipeline system resulting in a reduction of 2,094 reportable tons of salt in the Colorado River. It is expected that the pressurized pipeline will induce on-farm improvements resulting in the annual reduction of an additional 9,100 reportable tons of salt. It is anticipated that the project will result in the total annual reduction of 11,194 reportable tons of salt in the Colorado River at an anticipated cost of approximately $59

per ton of salt. Construction is complete and the canals will be taken out of service in the fall of 2015 when all of the farms will be converted to sprinkler irrigation.

Blue Cut/Mammoth Unit, Cottonwood Creek Consolidated Irrigation Company Salinity Project: The $5,500,000 Blue Cut/Mammoth Unit, Cottonwood Creek Irrigation Company Irrigation Project was selected from the applications received in the 2012 FOA. A cooperative agreement was executed in August 2013. The Blue Cut phase has completed construction with on-farm improvements ongoing. The Mammoth phase of this project has begun and construction began in December of 2014. This project will replace approximately 45.6 miles of earthen canals and laterals with a pressurized pipeline system resulting in the reduction of 3,789 reportable tons per year of salt in the Colorado River at an anticipated cost of approximately $67.57 per ton of salt. The pressurized pipeline will serve 5,680 acres resulting in additional on farm salt savings.

Manila-Washam Salinity Area, Utah

South Valley Lateral Salinity Project: This project is located in Daggett County south of the town of Manila, Utah. It was selected from the applications received in the 2012 FOA and was submitted by the Sheep Creek Irrigation Company. A cooperative agreement was executed in May of 2013, for the amount of $4,026,264.75. This project will replace approximately 27,400 feet of earthen laterals with irrigation pipe resulting in the annual reduction of 3,373 reportable tons of salt in the Colorado River at an anticipated cost of approximately $55.57 per ton of salt. The project began in the fall of 2014. Project completion is scheduled for spring of 2016.

West Blacks Fork Salinity Area, Wyoming

Austin/Wall Off-Farm Irrigation Project: This project is located in Uintah County in the vicinity of Lyman, Wyoming. It was selected from the applications received in the 2012 FOA and was submitted by the Austin/Wall Irrigation District. A cooperative agreement was executed in May 2013, for the amount of $1,350,000. This project will replace approximately 32,000 feet of earthen canal and laterals with irrigation pipe resulting in the annual reduction of 1,092 reportable tons of salt in the Colorado River at an anticipated cost of approximately $57.55 per ton of salt. The project is scheduled to begin construction in the fall of 2015, and be completed in the spring of 2016.

Big Sandy Project, Sweetwater County, Wyoming

Eden Valley, Farson/Eden Pipeline Project: This project was selected in the 2008 FOA. A Cooperative Agreement was executed in February of 2009, for the amount of $6,453,072. This project will replace approximately 24 miles of earthen laterals with irrigation pipe resulting in the annual reduction of 6,594 reportable tons of salt in the Colorado River at an anticipated cost of approximately $52.57 per ton of salt. Laterals E-7, E-8, and E-13 are completed, and work on the West Side Canal was completed and operational in the spring of 2014. Some habitat work is still pending.

Gunnison Basin, Colorado

Uncompahgre Valley Water Users Association (UVWUA) Phase 5 Project: As a result of the 2010 FOA, the UVWUA was awarded a $4.3 million cooperative agreement for Phase 5 of the East Side Lateral (ESL). This phase involves an additional 19 miles of laterals under the Selig and East Canal systems and the reduction of about 5,034 tons of salt loading annually. Construction began in November 2011 and was completed in 2015.

UVWUA Phase 7 Project: As a result of the 2010 FOA, the UVWUA was awarded a $3.2 million cooperative agreement for Phase 7 of the ESL. This phase involves an additional 12.7 miles of laterals under the Selig and East Canal systems and the reduction of about 3,029 tons of salt loading annually. The cost is estimated at $52.11 per ton of salt. Construction began in the fall of 2012 and will continue through 2016.

UVWUA Phase 8 - East Side Laterals (ESL) Project: As a result of the 2012 FOA, the UVWUA was selected to be awarded a $3.5 million cooperative agreement for Phase 8 of the ESL. This phase involves an additional 14.1 miles of laterals under the South Canal, East Canal and the Loutzenhizer systems and the reduction of about 3,307 tons of salt loading annually. The cooperative agreement was executed in FY 2014, with construction beginning in the summer of 2015, and continuing through 2016.

Lower Stewart Pipeline Project: Awarded from the 2010 FOA, this project involves piping a portion of the Stewart Ditch & Reservoir Company (SDRC) existing unlined canals in a tributary to the North Fork of the Gunnison River near Paonia, Colorado. In September 2011, Reclamation entered into an agreement to provide up to $6.0 million to pipe 11.5 miles of existing canals with an expected salt load reduction of about 5,892 tons/year. Construction began in the fall of 2012, and was completed during the winter of 2014/2015.

Minnesota Canal Salinity Control Piping Project Phase II: Awarded from the 2012 FOA, this project involves piping the Minnesota Extension portion of the Minnesota Canal & Reservoir Company (MCRC) existing unlined canals in a tributary to the North Fork of the Gunnison River near Paonia, Colorado. In June of 2013, Reclamation entered into an agreement to provide up to $3.03 million to pipe 3.8 miles of existing canals with an expected salt load reduction of about 2,328 tons/year. Construction began in the fall of 2014 with an anticipated completion in the fall of 2015.

Clipper Irrigation Salinity Control – Project 4: Awarded from the 2010 FOA, this project involves piping a portion of the Crawford Clipper Ditch existing unlined canals in a tributary to the Cottonwood Creek drainage of the Gunnison River near Hotchkiss, Colorado. In September 2012, Reclamation entered into an agreement to provide up to $1.21 million to pipe 3.5 miles of existing canals with an expected salt load reduction of about 1,427 tons/years. Construction began in 2014 and is anticipated to be completed in the fall of 2015.

Slack/Patterson Laterals Piping Project: Awarded from the 2012 FOA, this project involves piping of the Slack and Patterson Laterals portion of the Roger's Mesa Water Distribution Association's existing, unlined laterals supplied by Fire Mountain Canal and Leroux Creek, a tributary to the North Fork of the Gunnison River near Hotchkiss, Colorado. In June 2013, Reclamation entered into an agreement to provide up to $3.39 million to pipe 9.1 miles of existing laterals with an expected salt load reduction of about

3,345 tons/year. Construction will begin in the fall of 2014 with an anticipated completion in the fall of 2015.

Cattleman's Harts, Hart/McLaughlin, Rockwell, Poulsen Ditch's: Awarded from the 2012 FOA, this project involves piping a portion of the Cattleman's earthen laterals, operated by the Cedar Canyon Iron Springs Irrigation Company and supplied by Crystal Creek, a tributary to the Gunnison River near Crawford, Colorado. In July 2013, Reclamation entered into an agreement to provide up to $2.01 million to pipe 6.3 miles of existing laterals with an expected salt load reduction of about 1,855 tons/year. Construction will begin in the fall of 2014 with an anticipated completion in 2016.

In order to complete the Lower Gunnison Basin mapping project, Reclamation submitted a funding modification in 2013 to the existing, financial assistance agreement with the Colorado State Soil Conservation Board. This additional funding is being used to complete the remaining, off-farm ditch mapping in the Colona and Ridgway areas. In cooperation with irrigation entities, quality assurance checks are also being performed on previously mapped and newly mapped systems in the Lower Gunnison Basin. Quality assurance has been completed and the remaining mapping is anticipated to be completed in the winter of 2015/16.

Grand Valley, Colorado

Grand Valley Irrigation Company (GVIC) Canal Improvement Grant 2010: As a result of selection under the 2010 FOA, the GVIC was awarded a $2.8 million cooperative agreement to line about 1.9 miles of their main canal and pipe about 4,100 ft of ditch within the Grand Valley. A salt loading reduction of approximately 1,749 tons annually is expected. The canal lining will consist of a PVC membrane with a shotcrete cover and the pipe will be concrete. Construction began in December 2011, and will continue through 2015.

Grand Valley Irrigation Company (GVIC) Canal Improvement Grant 2012: As a result of selection under the 2012 FOA, the GVIC was awarded a $4.9 million cooperative agreement to line about 2.4 miles of their main canal within the Grand Valley. A salt loading reduction of approximately 4,001 tons annually is expected. The canal lining will consist of a PVC membrane with a shotcrete cover. The cooperative agreement was executed in FY 2014 and construction will begin in December 2014, and will continue through 2017.

Basin State Program (BSP)

Reclamation has determined that state agricultural (ag) agencies within the upper Basin states to be appropriate partners and has executed cooperative agreements to utilize the services of these state ag agencies to assist in seeking and funding cost-effective activities and projects to reduce salinity in the Colorado River system by improving water management and increasing irrigation efficiencies. Interagency agreements have been executed with the NRCS in the states of Colorado, Utah, and Wyoming to provide the technical assistance for the BSP.

Colorado State Conservation Board (CSCB)

In Colorado, the BSP is delivered through six local Conservation Districts that operate within the boundaries of the approved salinity control areas in the state. These salinity control areas include the Silt Mesa, Grand Valley, Lower Gunnison, McElmo Creek, and Mancos River salinity areas. The Bookcliff, Mesa, Delta, Shavano, Dolores, and Mancos Conservation Districts receive funds from the CSCB that in turn receives Financial Assistance (FA) funding based upon a contract agreement with Reclamation.

The projects are planned, designed and certified by NRCS or District employees. Thirteen District employees are paid from BSP Technical Assistance (TA) funding earned by NRCS in Colorado and provided to the CSCB and Conservation Districts.

All projects are planned, designed and certified based upon current NRCS Standards and Specifications. Each participant signs and Operation and Maintenance (O&M) agreement to remain in effect for the life of the irrigation and wildlife improvements installed (usually 25 years). Each participant is required to perform proper Irrigation Water Management on the fields in which irrigation improvements were installed. The projects are planned and contracted using the current NRCS EQIP payment schedule.

Applications are competitively screened and prepared by the NRCS. Applications are funded in order of the best cost effectiveness. All applications meeting NRCS planning standards that result in an annualized cost per ton of less than $150/ton and that were also not eligible for EQIP are considered for funding depending upon funds available. The cost effectiveness and salt loading data used for these calculations are standardized for all salinity control areas in the State of Colorado by the NRCS.

Progress in Colorado:

BSP Projects:
Reclamation has provided $5,960,000 in funding to Colorado. Nine EQIP-like BSP projects have been obligated totaling $1,239,206. These projects will result in salt control of 2,155.9 tons and treat and/or serve 611.5 acres at an average cost effectiveness of $51.37/ton. One of the approved projects is a wildlife habitat improvement project. Two projects were approved in the Grand Valley Area, and seven projects were approved in the Lower Gunnison area.

Grand Valley Wildlife Project:
The Colorado State Conservation Board has contracted with Colorado Parks and Wildlife (CPW) to fund approximately 491 acres of wildlife improvements along the Colorado River in the Grand Valley for a cost of $804,415, utilizing BSP special funding received from Reclamation in 2013. This project is now under construction, with all the brush control work now completed. $129,019 has been expended in this project to date. This project has been planned and designed as a joint effort with CPW, FWS, and NRCS. Completion of this project will satisfy the remaining acres of replacement habitat required in the Grand Valley salinity unit.

Reclamation Funding Opportunity Announcement (FOA):
Colorado was pleased to be involved in the 2012 and 2015 FOA process. The expansion of the ranking and selection criteria to include projects funder 1,000 tons of salt control

allowed more coordination with EQIP and BSP on-farm salinity control improvements. Colorado has contracted with three of the Reclamation projects approved through the FOA process, for a total cost of approx. $2.3M.
Construction has been completed for the irrigation portion in the Forked Tongue/Holman Ditch and Bostwick Park FOA projects. Construction of the required wildlife habitat features for these projects is underway and will be completed by October. Construction will continue in the Clipper Zanni Project in October 2015.

Ditch Mapping:
Colorado received $34,000 in special BSP funding to complete ditch mapping activities in Ouray County in the Lower Gunnison area, and to review and complete data for ditch mapping previously completed in other portions of the Lower Gunnison area. This project has been completed.

Utah Department of Agriculture and Food (UDAF)

With the BSP agreement in place with Reclamation, UDAF, working through NRCS's EQIP program has funded 3 projects for $3,452,009.00. One project came to UDAF through Reclamation's 2012 FOA. This project is with Sheep Creek Irrigation Company, Manila, Utah and is a canal piping project that will retain 2,220 tons of salt per year at a cost of $2,897,129.18. The other projects will treat 417 acres and control 1,083 tons of salt with a combined cost of $471,879.00. All 3 projects are essentially completed with minor clean-up and restoration planting in Sheep Creek and Irrigation Water Management for the on farm work.

From Reclamation's 2015 FOA, UDAF received two projects totaling $2,924,479 that will be expended over the next 2 years.

As requested by Reclamation, UDAF had contracted with Emery County Water Conservancy District for data collection of a long term study at Desert Lake, Emery County. UDAF paid Emery County Water Conservancy $11,368.85. This study has concluded and the contract with Emery has been closed.

UDAF has paid the Uintah basin salinity coordinator $38,537.96 during the past federal FY using BSP funds. The coordinator has been successful in helping several irrigation companies to submit successful applications for the 2015 FOA. These projects are competitive because of the coordinator's efforts to confederate historically opposing companies into accepting unified systems that improve each company. Improvements with the Ute Tribe have also been made and it is anticipated that in future FOA's the tribe will submit applications. UDAF feels that using BSP funds for this position has greatly benefited the Salinity Control Program in the Uintah Basin area.

Wyoming Water Development Commission (WWDC)
A new agreement has been put in place with the Wyoming Water Development Commission that will end in 2020. The agreement is similar to the agreements with Utah and Colorado and has a value of $2,800,000 of which $310,000 has been obligated. This

agreement will allow Wyoming to accept work from the 2015 FOA and any future EQIP pass-offs. From the 2015 FOA, WWDC received one project totaling $2,024,413 from BSP funds and an additional $2,024,413 from the WWDC. This project will take approximately 3 years to complete.

Paradox Valley Unit

The Paradox Valley Unit was authorized for investigation and construction by the Salinity Control Act. The unit is located in southwestern Colorado along the Dolores River in the Paradox Valley, formed by a collapsed salt dome (Figure31). Groundwater in the valley comes into contact with the top of the salt formation where it becomes nearly saturated with sodium chloride. This project intercepts extremely saline brine (260,000 mg/l total dissolved solids) before it reaches the Dolores River and disposes of the brine by deep well injection (injection interval about 14,000 feet below ground surface.

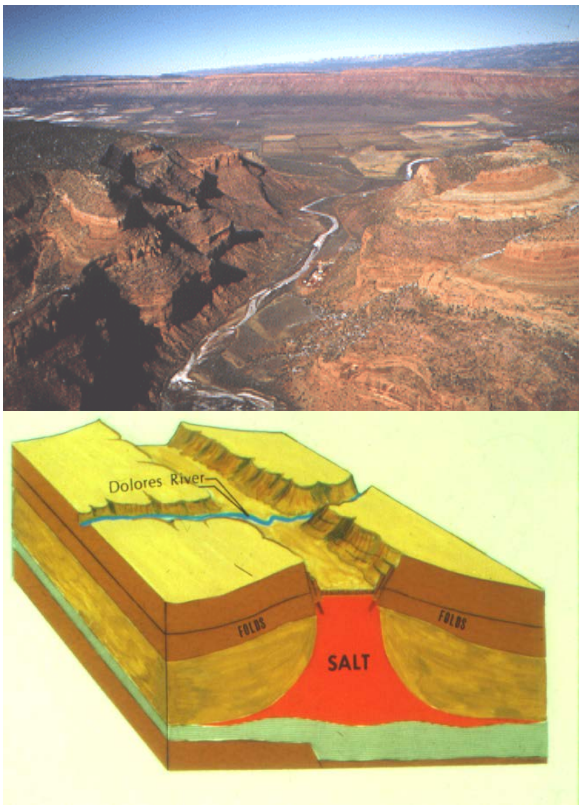

Figure 31 – Paradox Valley

The project continues to intercept and dispose of 100,000+ tons of salt annually (Figure 32). The pressure necessary to inject the brine into the disposal formation at 14,000 feet is increasing. Induced seismicity and the increasing pressure necessary to inject the brine into the disposal formation at are the limiting factors of the project. As the formation fills with brine, the pressure necessary to inject increases (Table 8).

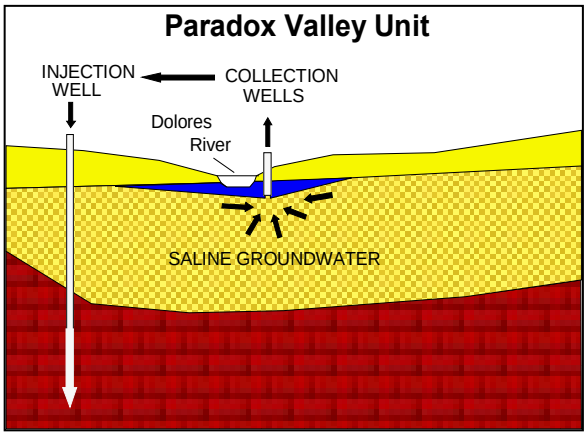

Figure 32 - Schematic of Paradox Project.

As the pressure increases, the potential for increased seismicity may exist. In January 2013, a M4.4 earthquake occurred that caused Reclamation to modify injection operations which included a new shut down schedule and injection rate reduction. Those modifications have significantly decreased the injection pressure which could result in additional life of the well. The current projected life of the well remains at 3 to 5 years. (Table 8).

Table 8 - Paradox Well Injection Evaluation

Injection Period	Operational Days[1]	Pressure Start	High Pressure During Period	Injection Period Net Pressure Change	Tons of Salt Injected[2]	No. of Induced Seismic Events		Maximum Magnitude of Induced Seismic Events	Estimated Tons of Salt Entering the River[3]
Jan-May '02[4]		148	1609	4432		52,860	25	2.9	8,469
June-Dec '02[5]		178	929	4593	161	58,953	34	2.2	8,333
Jan-May '03[5]		144	1172	4627	34	53,173	27	2.1	18,037
June-Dec '03[5]		184	1154	4675	48	59,530	106	2.3	11,185
Jan-May '04[6]		140	1201	4640	-35	51,449	47	2.4	20,225
June-Dec '04[7]		160	1091	4541	-99	51,589	57	3.9	6,442
Jan-May '05[5]		140	1038	4736	195	55,024	69	2.4	14,011
June-Dec '05[8]		148	1203	4750	14	46,551	31	2.6	38,582
Jan-June '06[9]		138	375	4680	-70	44,779	10[10]	2.4	53,039
July-Dec '06[5]		162	1084	4797	117	56,920	13[10]	2.1	18,605
Jan-June '07[5]		159	1066	4796	-1	56,068	7[10]	1.1	19,728
July-Dec '07[5]		163	1232	4712	-84	57,395	31	2.6	11,279
Jan-June '08[11]		160	1152	4813	101	54,720	47	1.3	15,305
July-Dec '08[5]		162	1263	4822	9	56,734	61	2.1	16,378
*Jan-Mar '09[5]		84	1246	4756	-66	29,163	20	2.6	22,029
Apr-Sept '09[12]		160	1157	4891	135	55,083	70	2.7	16,507
Oct '09-Mar '10[5]		153	970	4930	39	51,589	91	2.9	32,876
Apr '10-Sep '10[5]		162	1347	4990	60	55,747	75	2.7	17,223
Oct '10-Mar '11[5]		161	1378	5000	10	55,501	43	2.9	22,916
Apr '11-Sep '11[13]		158	1276	5102	102	54,422	63	2.7	11,591
Oct '11-Mar '12		162	1282	5115	6	56,531	59	2.5	21,003
Apr '12-Sep '12		161	1417	5108	-7	55,605	116	1.9	5,507

1. Operational days include partial days of operation which accounts for variations in tons of salt injected
2. Tons of salt injected based on 260,000 mg/L. Brine concentration varies slightly due to seasonal and environmental fluctuations
3. Tons of salt entering the river based on regression equations (Ken Watts, USGS Administrative Report – "Estimates of Dissolved Solids Load of the Dolores River in Paradox Valley, Montrose County, CO, 1988-2009, August 5, 2010"). The 2010 FAR contained erroneous estimated tons of salt entering the river.
4. Begin 100% brine injection
5. No problems
6. Down from 3/1/04 through 3/7/04 for mechanical problems
7. Implemented quarterly 10-day shutdown schedule from 9/22 to 10/22; M3.9 earthquake on 11/7; plant shut down until 11/18; discontinued 10-day shutdown schedule
8. Down from 11/13/05 through 12/31/05 for mechanical problems
9. Down from 1/1/06 through 1/19/06 and 2/16/06 through 3/2/06 for mechanical problems
10. Seismic data for 2006 and the first half of 2007 is likely incomplete due to seismic network problems
11. Down from 4/16-17/08 for mechanical problems
12. Down from 5/18-19/09 for mechanical problems
13. Down from 9/18-9/20 for communication link failure.

* *Biannual shutdown schedule changed from winter/summer to spring/fall*

Injection Month	Min Injection Pressure	Max Injection Pressure	Monthly Pressure Change	Tons of Salt Injected[1]	Estimated Salt Load in tons[3]	# of Induced Seismic Events	Max Mag of Seismic Events	No. of Seismic Events in Past 12 Months	No. of Seismic Events in Past 12 Months, M ≥ 0.5
Jan-13	2,733	5,111		8,115	263	23	4.4	209	69
Feb-13	893	2,733	-2,378	0	1,324	9	1.7	213	70
Mar-13	500	893	-1,840	0	2,600	35	1.2	228	64
Apr-13	390	4,250	3,357	4,064	3,351	9	0.7	215	60
May-13	3,290	4,452	202	8,752	1,535	13	1.8	209	58
Jun-13	3,948	4,685	233	8,311	2,089	7	0.8	187	52
Jul-13	4,143	4,740	55	8,457	1,823	5	1.2	158	47
Aug-13	4,218	4,722	-18	8,629	289	4	0.5	155	47
Sep-13	3,513	4,770	48	7,557	659	2	0.3	141	43
Oct-13	3,683	4,770	0	9,610	195	6	1.2	126	35
Nov-13	4,208	4,803	33	8,814	577	5	0.7	127	36
Dec-13	4,195	4,758	36	8,713	778	6	0.8	121	34
Jan-14	4,202	4,739	-19	8,584	681	2	0.3	100	19
Feb-14	4,187	4,745	6	7,760	925	6	1.7	97	20
Mar-14	4,193	4,757	12	8,713	1,275	4	1.5	66	22
Apr-14	4,206	4,772	15	8,159	675	1	0.9	59	19
May-14	4,215	4,775	3	8,711	258	7	1.2	53	18
Jun-14	4,217	4,769	-6	8,381	186	0	N/A	46	16
Jul-14	4,218	4,778	9	8,428	236	5	2.3	46	17
Aug-14	4,212	4,781	3	8,645	-300	0	N/A	43	16
Sep-14	4,206	4,772	-9	8,215	-832	3	1.8	43	16
Oct-14	4,215	4,776	4	8,773	758	8	1.0	46	17
Nov-14	4,223	4,773	-3	8,297	2,992	3	1.1	44	18
Dec-14	4,205	4,778	5	8,272	4,202	6	0.4	44	17
Jan-15	4,202	4,766	-12	8,731	3,246	8	1.0	49	19
Feb-15	4,202	4,754	-12	7,775	4,353	3	1.1	46	17
Mar-15	4,228	4,766	12	8,457	6,282	0	N/A	42	14
Apr-15	4,196	4,760	-6	8,230	3,959	10	0.6	51	15

May-15	4,190	4,763	3	8,512	1,708	11	0.7	55	14
Jun-15	4,209	4,761	-2	8,279	174	16	0.9	71	16
Jul-15	4,227	4,777	16	8,637	-336	18	1.1	84	15
Aug-15	4,164	4,797	20	8,614	-478	9	1.6	93	18
Sep-15	4,239	4,787	-10	8,124	810	13	1.0	104	20
Oct-15	3,598	4,767	-20	7,863	733	7	0.9	103	21
Nov-15	4,206	4,737	-30	8,594	2,361	12	1.0	112	22
Dec-15	4,195	4,754	17	8,494	2,976	16	0.8	122	23
Jan-16	4,194	4,762	8	8,671	3,484	14	1.6	129	25
Previous 12 Months			8	100,250	26,026	129	1.6		
Previous 24 Months			17	201,335	39,647	180	2.3		

[1]Tons of salt injected based on 260,000 mg/l. PVB concentration varies slightly due to seasonal and environmental fluctuations.

[2]Estimated salt load based on regression equations (Ken Watts, USGS Administrative Report - "Estimates of Dissolved Solids Load of the Dolores River in Paradox Valley, Montrose County, Colorado, 1988 through 2009, dated August 5, 2010") and provisional data provided by USGS. Some daily EC and streamflow discharge values are estimates.

Alternative Study

At the request of the Salinity Control Forum, Reclamation initiated an Alternative Study/EIS Process to evaluate alternative methods for salt disposal at Paradox. A Notice of Intent was published in the Federal Register on September 10, 2012, and public scoping meetings were held in Paradox, Montrose, and Grand Junction in 2012. Reclamation prepared a Scoping Summary Report in early 2013. Reclamation continues to have meetings and discussions on the Alternatives Study with the BLM, EPA, Colorado Department of Public Health and Environment, and other stakeholders.

A Request for Information for commercial salinity control alternatives was published in 2015 to identify potential alternatives other than deep well injection and evaporation. One response was received for a brine crystallization process and a contract to evaluate that proposal is currently underway to determine its technical and economic viability.

A panel of experts was convened in March and presented a list of questions regarding the operation, regulation and design of evaporation ponds. A final report was received in July with the results of that meeting and recommendations on how to proceed. In response to the board’s recommendations, Reclamation has initiated several investigations including an ecological Risk Assessment to evaluate the Migratory Bird issue, evaporation pan tests to provide information on pond size, and a pond optimization study to investigate pond operation.

Preliminary evaporation pond cost estimates have been developed, but will be largely dependent on site selection and regulatory requirements. A Request for Information for commercial salinity control alternatives was published in 2015 to identify potential alternatives other than deep well injection and evaporation. One response was received for a brine crystallization process and a contract to evaluate that proposal is currently underway to determine its technical and economic viability.

A panel of experts was convened in March and presented a list of questions regarding the operation, regulation and design of evaporation ponds. A final report was received in July with the results of that meeting and recommendations on how to proceed. In response to the board's recommendations, Reclamation has initiated several investigations including an ecological Risk Assessment to evaluate the Migratory Bird issue, evaporation pan tests to provide information on pond size, and a pond optimization study to investigate pond operation.

Colorado River Basin Salinity Control Program Summary Data

The following tables summarize the Salinity Control Program using the latest available data.

Table 9 – Summary of Federal Salinity Control Programs (2015)

Salinity Unit		Tons / Year Removed
MEASURES IN PLACE BY RECLAMATION		
Basinwide Program		214,700
Basin States Program	1/	16,500
Meeker Dome		48,000
Las Vegas Wash Pitman		3,800
Grand Valley		122,300
Paradox Valley	2/	100,700
Lower Gunnison Winter Water (USBR)		41,400
Dolores		23,000
Reclamation Subtotal		**570,000**
MEASURES IN PLACE BY NRCS/BSP	3/	
Grand Valley		143,500
Price-San Rafael		80,100
Uinta Basin		157,200
Big Sandy River		58,200
Lower Gunnison		119,100
McElmo Creek		29,500
Mancos		4,400
Muddy Creek		100
Manila		10,400
Silt		2,300
Green River		700
Tier 2	4/	6,800
NRCS/BSP Subtotal		**612,000**
MEASURES IN PLACE BY BLM		
Nonpoint Sources	5/	111,600
Well-Plugging		14,600
BLM Subtotal		**126,000**
Measures in Place Total		**1,308,000**
GOALS TO REACH TARGET		
Reclamation Basinwide Program		222,000
NRCS Program		150,000
Goals Subtotal		**372,000**
Target Total (Measures in Place + Goals)		1,680,000
Target by 2035		**1,680,000**

1/ Off-farm projects funded by the BSP

2/ Paradox injection well capacity estimated to decline beginning in 2020; assumed continuation of well or alternative control methods after 2020

3/ May include off-farm controls that were not goaled.

4/ Measures in areas outside approved projects.

5/ BLM non-point source are estimates.

Table 10 – Summary of Colorado River Basin Salinity Control Program Appropriations and Cost Share from the Basin Funds (2005 thru 2015)

TOTAL PROGRAM ($1,000)

Unit	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	**Subtotal**
Grand Valley O&M	863	1,223	1,340	1,125	1,757	1,021	1,373	1,289	1,515	1,885	2,247	15,638
Paradox Valley O&M	2,536	2,423	2,633	3,621	3,121	3,764	3,660	3,236	3,124	3,501	3,575	35,194
Lower Gunnison O&M	0	0	0	0	0	0	0	0	0	0	0	0
McElmo Creek (Dolores) O&M	623	739	419	559	603	676	491	480	563	479	576	6,208
USBR Basinwide Program	11,776	12,103	12,770	11,406	24,686	9,577	12,104	11,854	12,399	10,021	10,419	139,115
Subtotal (USBR Program)	15,797	16,487	17,162	16,711	30,167	15,038	17,629	16,860	17,600	15,887	16,816	196,155
NRCS Program	28,039	28,194	26,466	22,803	23,346	20,833	23,403	22,121	19,077	20,697	21,751	256,730
BLM (no Basin Funds)	800	751	800	800	800	800	800	800	800	800	800	8,751
Total	44,636	45,432	44,428	40,314	54,313	36,671	41,832	39,781	37,477	37,384	39,367	461,636

Appropriations Expended ($1,000)

Unit	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	**Subtotal**
Grand Valley O&M	647	917	1,005	844	1,318	766	1,030	967	1,133	1,414	1,685	11,726
Paradox Valley O&M	1,902	1,817	1,975	2,716	2,341	2,823	2,745	2,427	2,343	2,626	2,681	26,396
Lower Gunnison O&M	(2)	0	0	0	0	0	0	0	0	0	0	(2)
McElmo Creek (Dolores) O&M	436	517	293	391	422	473	344	336	394	335	403	4,344
USBR Basinwide Program	8,243	8,472	8,939	7,984	17,280	6,704	8,473	8,298	8,679	7,015	7,293	97,380
Subtotal (USBR Program)	11,226	11,723	12,212	11,935	21,361	10,766	12,592	12,028	12,549	11,390	12,062	139,844
NRCS Program	19,627	19,736	18,526	15,962	16,342	14,583	16,382	15,485	13,354	14,488	15,226	179,711
Total	30,853	31,459	30,738	27,897	37,703	25,349	28,974	27,513	25,903	25,878	27,288	319,555

UPPER BASIN FUND COST SHARE PAYMENTS ($1,000)

Unit	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	**Subtotal**
Grand Valley O&M	32	46	50	42	66	38	52	48	57	71	84	586
Paradox Valley O&M	95	91	99	136	117	141	137	121	117	131	134	1,319
Lower Gunnison O&M	0	0	0	0	0	0	0	0	0	0	0	0
McElmo Creek (Dolores) O&M	28	33	19	25	27	30	22	22	25	22	26	279
USBR Basinwide Program	530	545	575	513	1,111	431	545	533	558	451	469	5,981
Subtotal (USBR Program)	685	715	742	716	1,321	641	756	725	757	675	713	8,165
NRCS Projects	1,262	1,269	1,191	1,026	1,051	937	1,053	995	858	931	979	11,552
Total Payment	1,947	1,983	1,934	1,743	2,371	1,578	1,809	1,720	1,616	1,606	1,692	19,717

LOWER BASIN FUND COST SHARE PAYMENTS ($1,000)

Unit	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	**Subtotal**
Grand Valley O&M	183	260	285	239	373	217	292	274	325	401	477	3,326
Paradox Valley O&M	539	515	560	770	663	800	778	688	664	744	760	7,481
Lower Gunnison O&M	0	0	0	0	0	0	0	0	0	0	0	0
McElmo Creek (Dolores) O&M	159	188	107	142	154	172	125	122	144	122	147	1,582
USBR Basinwide Program	3,003	3,086	3,256	2,908	6,295	2,442	3,087	3,023	3,162	2,555	2,657	35,474
Subtotal (USBR Program)	3,884	4,049	4,207	4,060	7,485	3,631	4,281	4,107	4,294	3,822	4,041	47,863
NRCS Projects	7,150	7,190	6,749	5,815	5,953	5,312	5,968	5,641	4,865	5,278	5,547	65,468
Total	11,034	11,239	10,956	9,874	13,438	8,944	10,249	9,748	9,159	9,100	9,587	113,331

Table 11 - UCRB Agriculture Salinity Control Summary (tons) - 2015

Project Area	Total Salt Load	Total Ag. Load	Total Controls	Remaining Ag. Load
Big Sandy	157,500	124,900	70,480	54,400
Grand Valley	580,000	535,500	275,624	259,876
Green River	15,700	15,700	657	15,043
Lower Gunnison	1,440,000	840,000	114,476	725,524
Mancos	43,000	26,000	25,331	669
Manila	49,000	40,000	9,643	30,357
McElmo	164,075	99,960	38,713	61,247
Muddy Creek	90,000	14,980	71	14,909
Price-San Rafael	430,000	244,000	77,695	166,305
Rifle - Silt	NA	24,700	56,793	-32,093
Uinta	500,000	328,120	196,153	131,967
Total	3,469,275	2,293,860	865,636	1,428,224

1. Off-farm load shown only. On-farm loads have not been estimated for the San Juan and Paria areas
2. Agricultural load for Paria only represents the conveyance systems which were piped as part of the Tropic Project
3. Areas outside existing project boundaries.

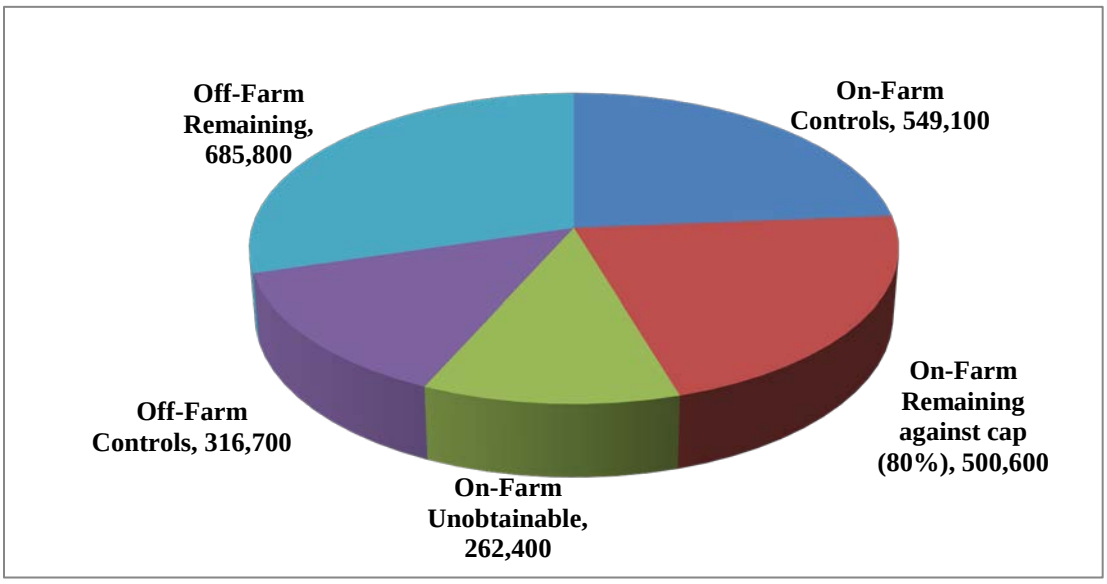

Figure 33 – Salt Load

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CHAPTER 5 - OTHER WATER QUALITY RELATED ISSUES

Gold King Mine Spill

On August 5, 2015, EPA was conducting an investigation of the Gold King Mine (GKM) near Silverton, Colorado. While excavating above the old adit, pressurized water began leaking above the mine tunnel, spilling about three million gallons of water stored behind the collapsed material into Cement Creek, a tributary of the Animas River. (EPA) On August 8, the USGS measured increased flows for several hours using a stream gauge. This measurement resulted in a provisional calculated flow volume of 3,043,067 gallons or 9.34 acre feet (af) discharged from the Gold King Mine. This flow went down Cement Creek into the Animas River and then into the San Juan River headed to Lake Powell and the Colorado River.

Mine River Waste
Flows Down the Animas River

Figure 34- Animas River

The major concern of this unintended discharge was the metals (lead, chromium, cadmium, mercury, arsenic, zinc, copper, iron, manganese and aluminum) which were in the mine wastewater and their potential impact to water users downstream. The acid mine drainage (AMD) plume was being monitored in real time primarily by the color of the water and its pH or acidity. Other samples were taken for metal content but could not be used to monitor the AMD in real time since those samples had to be sent to a lab for analysis. The pH of the AMD near the mine was less than 5, which is fairly acidic, and kept most of the metals in a dissolved state within the AMD. Once the AMD plume reached and mixed with the Animas and especially the San Juan Rivers the buffering capacity of those alkaline waters, > 7 pH, increased the pH of the AMD water. When the AMD plume reached the San Juan River it could no longer be tracked by the color of the water, since the San Juan River is very high in suspended sediments and thus has a high turbidity. The pH was also not useable as an indicator of the spill plume once it reached the lower Animas River and entered the San Juan River since all water testing showing pH levels of 8 – 8.1, which is the normal pH of those rivers, so tracking the AMD plume down the San Juan River became almost impossible using the color and pH of the water. The base flow out of Navajo Reservoir, upstream on the San Juan River from the confluence with the Animas River, during this time was 650 cfs (1,288 af/day) and Reclamation increased the flow out of Navajo Reservoir for 2 days to 1,300 cfs (2,577

af/day) to help dilute the AMD. The 9.3 af of the AMD plume was less than 2% of the daily flow in the San Juan River which also made tracking the AMD plume even harder to follow once it reached the San Juan River, due to the dilution effect.
According to the EPA, as the dissolved metals in the acidic waters of the mine entered into the alkaline water of the Animas and San Juan rivers naturally occurring chemical reactions changed the soluble metals into an insoluble or solid form which would then precipitate or drop out of the water column and mix with the river sediment. It was estimated by the EPA that 2/3 of the metals precipitated out over 200 km of the Animas River streambed and 1/3 reached the San Juan River.

Monitoring of the water and sediment will continue to verify there is no long term impact along the lower Animas and San Juan Rivers or into Lake Powell.

Dreissenid Mussels in the Upper Colorado River Basin

A fairly recent problem, which has the potential to affect the water quality in the Colorado River basin, is the introduction of dreissenid mussels. The dreissenid mussels (quagga and zebra) were first found in the Great Lakes area in 1988. The quagga mussels travel either downstream with the water current or via watercraft movement and were first found in the Colorado River basin at Lake Mead in 2007. The quagga mussels found in 2007 were adults and well established, so they probably were introduced into Lake Mead around 2005. Since 2007, quagga mussels in the lower Colorado River basin have become well established.

Figure 35 – Mussel encrusted chair from Lake Powell

Prior to quagga mussels being found in Lake Mead, scientists originally thought that Lake Powell would be the first western water body to become infested. In order to keep this from happening the National Park Service (NPS) Glen Canyon National Recreation Area (GLCA) started a campaign to keep the mussels out of Lake Powell beginning around 2000 with education and boat inspections being the primary activity. However, the Reclamation lab in Denver was getting random and inconclusive results of mussels in water samples after 2007. Since there was no conclusive positive results (both positive microscopy and PCR), NPS didn't accept the Denver lab results and established their own mussel sampling and lab using both microscopy and DNA at Lake Powell.

Mussel larvae, or veligers, were first confirmed in Lake Powell in late 2012, by NPS after routine water monitoring tests discovered mussel DNA in water samples taken just upstream from Glen Canyon Dam. Adult mussels were first reported in March 2013 when a local marine services business discovered 4 adult mussels on a boat that had been pulled for service. Adult mussels continued to be found on moored boats and marina structures at Wahweap and Antelope Point Marinas. Adult mussels have also been found attached to submerged canyon walls in and around Wahweap Bay and on fixed wheel gates on the Glen Canyon Dam penstocks, when they have been pulled for maintenance in the last couple of years. The majority of mussels are found in the southern end of the reservoir but veligers and adults are now being found farther up reservoir.

The impacts that the mussels will have at Lake Powell are yet to be seen as their overall population is still fairly low, but with increasing populations increased problems will be encountered. At the lower end of the reservoir, near the dam, when the female mussels are spawning concentrations of veligers in the water have been found to be greater than 100,000 per liter. Problems caused by high numbers of mussels include; plugging of the infrastructure and piping of Glen Canyon Dam, the water intake for the Navajo Power Plant, City of Page water delivery, and the yet to be built Lake Powell Pipeline to St. George. Other impacts could negatively impact the recreational activities on the beaches with the sharp mussel shells and smell when the mussels die as the water level fluctuates, boat engine overheating and increased fuel consumption from mussels on the boat hulls. As the mussels filter the water they will also reduce the amount of phytoplankton in the water column which is the base food source for the reservoir fishery, and potentially shift the algal community into a blue green algae base, which has the potential for releasing toxic byproducts.

Figure 36- Wheel gate from Glen Canyon Dam and rock wall with mussels.

Since Lake Powell is popular with boaters and surveys have shown that when boaters leave Lake Powell that they like to boat at other waters in and out of the Colorado River Basin, another concern is the potential for the spread of these mussels into new waters. The NPS and State of Utah are working hard to educate boaters and decontaminate boats, if necessary, to reduce the chance of moving quagga mussels to other non-infested waters in the area.

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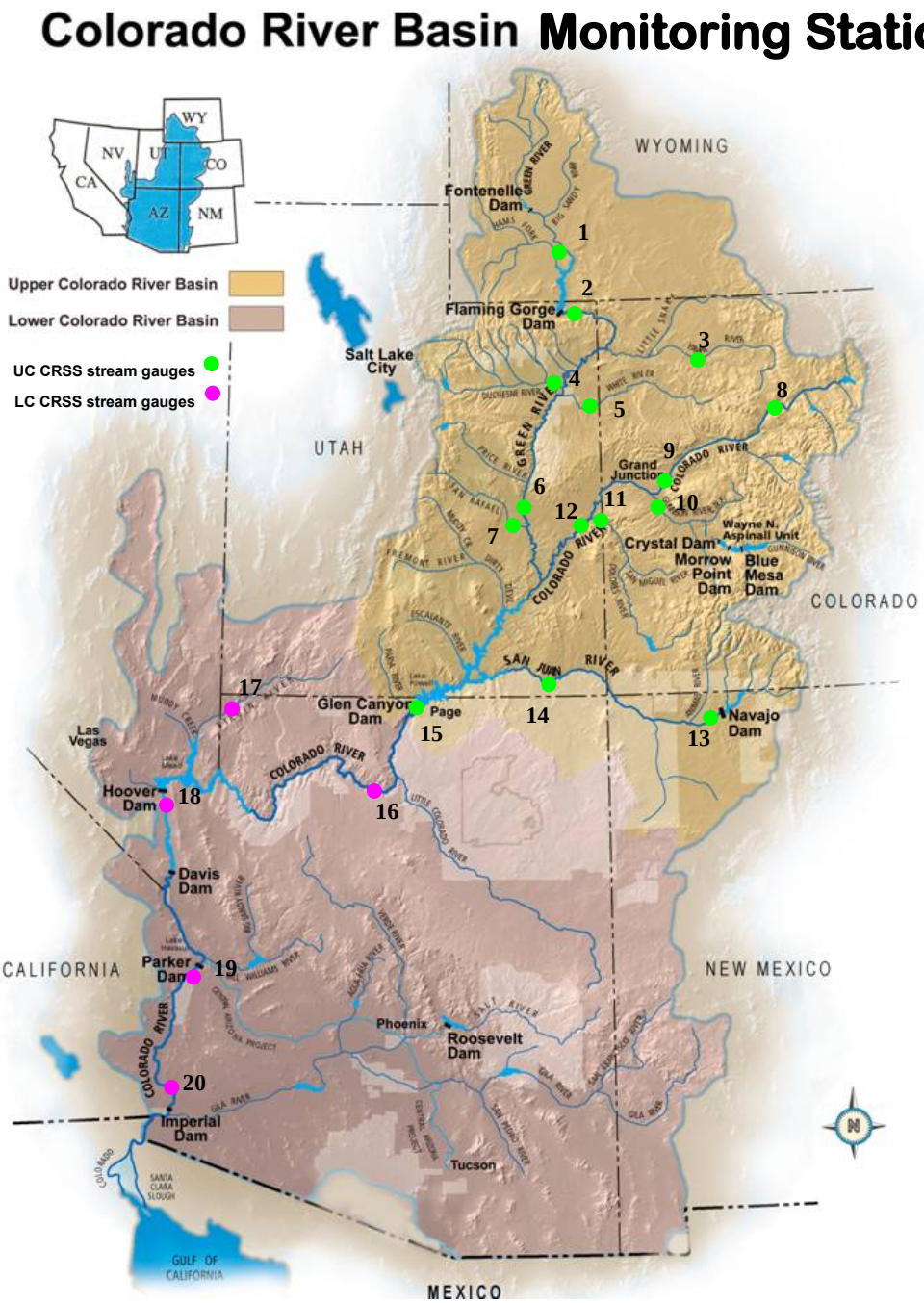
APPENDIX A

SALINITY MONITORING STATION INFORMATION



1. Green River nr Green River, WY
2. Green River nr Greendale, UT
3. Yampa River nr Maybell, CO
4. Duchesne River nr Randlett, UT
5. White River nr Watson, UT
6. Green River nr Green River, UT
7. San Rafael River nr Green River, UT
8. Colorado River nr Glenwood Springs, CO
9. Colorado River nr Cameo, CO
10. Gunnison River nr Grand Junction, CO
11. Dolores River nr Cisco, UT
12. Colorado River nr Cisco, UT
13. San Juan River nr Archuleta, NM
14. San Juan River nr Bluff, UT
15. Colorado River @ Lees Ferry, AZ
16. Colorado River nr Grand Canyon, AZ
17. Virgin River @ Littlefield, AZ

Numeric Criteria Stations

18. Colorado River below Hoover Dam
19. Colorado River below Parker Dam
20. Colorado River @ Imperial Dam

Figure A1 - Colorado River Basin 20 Stream Gage Locations

Table A1. Characteristics of the 20 Salinity Streamflow-gaging Stations in the Colorado River Basin.
[NA, indicates not applicable; Latitude and Longitude datum: NAD83; Elevation datum: NGVD29.]

U.S. Geological Survey streamflow-gaging station number	U.S. Geological Survey streamflow-gaging station name	Site short name	Latitude, in decimal degrees	Longitude, in decimal degrees	Elevation, in feet above sea level	Drainage area, in square miles
09217000	Green River near Green River WY	GRWY	39.5589	-107.2909	5,760	4,556
09234500	Green River near Greendale, UT	GDALE	39.2391	-108.2662	4,814	7,986
09251000	Yampa River near Maybell, CO	YAMPA	38.9833	-108.4506	4,628	7,923
09302000	Duchesne River near Randlett, UT	DUCH	38.7972	-109.1951	4,165	4,580
09306500	White River near Watson, UT	WHITE	38.8105	-109.2934	4,090	24,100
09315000	Green River at Green River, UT	GRUT	41.5164	-109.4490	6,060	14,000
09328500	San Rafael River near Green River, UT	SANRAF	40.9083	-109.4229	5,594	19,350
09071750	Colorado River above Glenwood Springs, CO	GLEN	40.5027	-108.0334	5,900	3,383
09095500	Colorado River near Cameo, CO	CAMEO	40.2103	-109.7814	4,756	3,790
09152500	Gunnison River near Grand Junction, CO	GUNN	39.9789	-109.1787	4,947	4,020
09180000	Dolores River near Cisco, UT	DOLOR	38.9861	-110.1512	4,040	44,850
09180500	Colorado River near Cisco, UT	CISCO	38.8583	-110.3701	4,190	1,628
09355500	San Juan River near Archuleta, NM	ARCH	36.8019	-107.6986	5,653	3,260
09379500	San Juan River near Bluff, UT	BLUFF	37.1469	-109.8648	4,048	23,000
09380000	Colorado River at Lees Ferry, AZ	LEES	36.8647	-111.5882	3,106	111,800
09402500	Colorado River near Grand Canyon, AZ	GRCAN	36.1014	-112.0863	2,419	141,600
09415000	Virgin River at Littlefield, AZ	VIRGIN	36.8916	-113.9244	1,764	5,090
09421500	Colorado River below Hoover Dam, AZ-NV	HOOVER	36.0153	-114.7386	675	171,700
09427520	Colorado River below Parker Dam, AZ-CA	PARKER	34.2956	-114.1402	301	182,700
09429490	Colorado River above Imperial Dam, AZ-CA	IMPER	32.8837	-114.4674	183	188,500

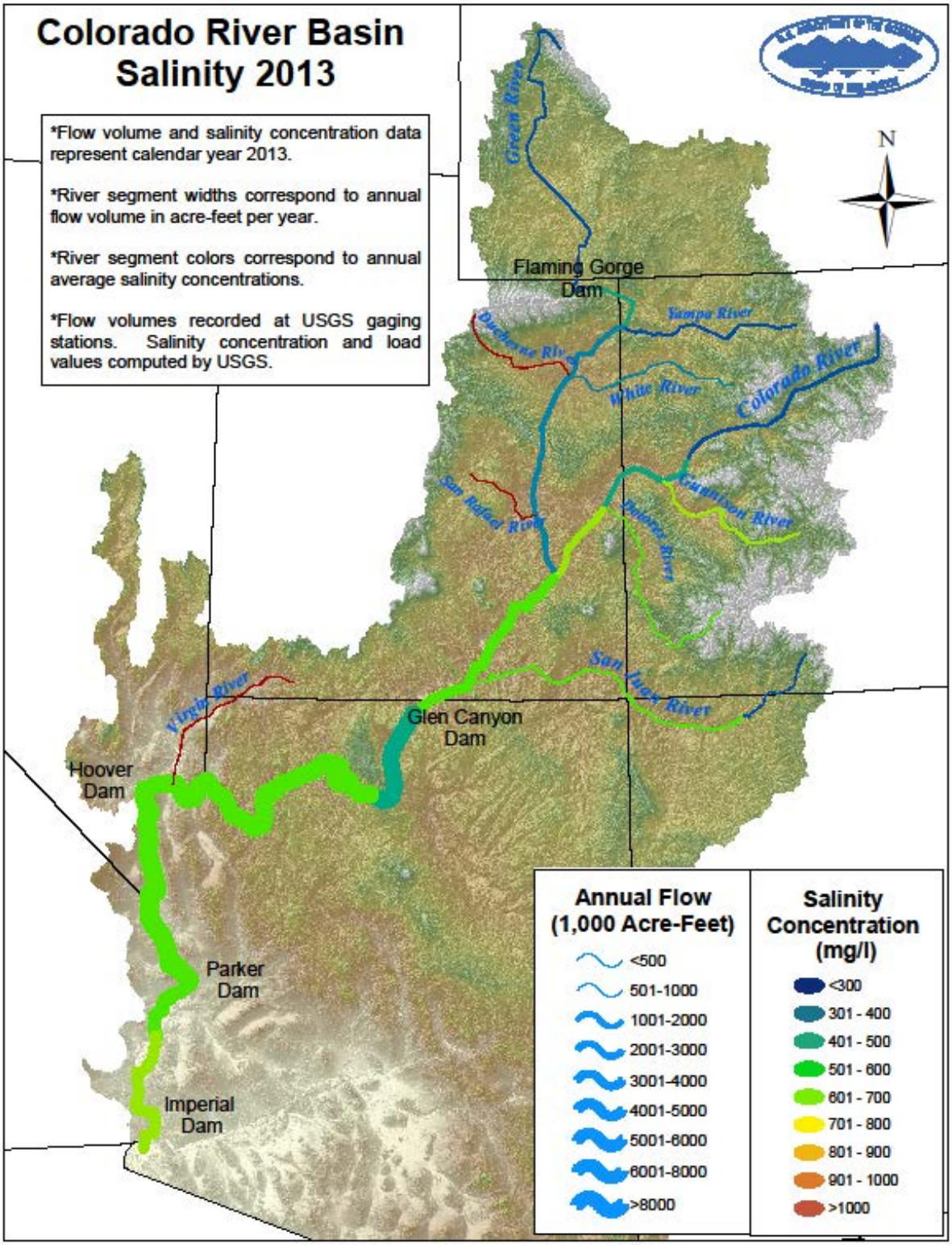


Figure A2 - Colorado River Basin Flows and Salinity

APPENDIX B

SALT LOAD 2014 UPDATE FOR THE 20 STATIONS

(Updates calendar years 2010 through 2013)

STATION CLASSIFICATIONS

U.S. Geological Survey
Colorado Water Science Center
Western Colorado Office

September 3, 2014

INTRODUCTION

Methodology

Three Statistical Analyses System (SAS) computer programs, FLAGIT, DVCOND, and SLOAD are used to estimate dissolved-solids concentrations and loads from existing data. The program FLAGIT retrieves data from the daily-values (DV) file and water-quality file (QW) of the U.S. Geological Survey's National Water Data Storage and Retrieval System (WATSTORE) (Hutchinson, 1975), examines the data, deletes incomplete observations, and flags possible errors in the remaining observations. FLAGIT also produces the data base used by the programs DVCOND and SLOAD. The program DVCOND fills in missing values in the daily specific-conductance record by linear interpolation. DVCOND needs to be used only when the flow at a streamflow-gaging station is extensively regulated.

The program SLOAD derives regression relations from water-quality data, modeling dissolved solids and six major ions as functions of specific conductance and discharge (Q). SLOAD then applies these relations to the daily specific conductance and discharge data and computes daily loads of dissolved solids and the other six major ions. The computed daily loads are summed by month and by year. Monthly and annual dissolved-solids and major ion concentrations are computed from the monthly and annual loads and streamflows. Monthly, annual, and seasonal concentrations and loads, in addition to regression statistics, are printed and saved on SAS data sets. Separate versions of SLOAD enable annual summation either by water year (WY) or calendar year (CY) (Lieberman and others, 1987).

The computerized method can be used for streamflow-gaging stations that have a complete record of DV Q and periodic QW analyses. The reliability of the estimate is considerably increased if DV specific conductance (SC) also is available. Water-quality analysis that includes total dissolved solids (TDS) with major ion analysis (also referred to as sum of constituents or SOC/SUM; herein referred to as SOC) is preferred over residue on evaporation at 180 degrees Celsius (ROE). SOC enables SLOAD calculations of the 8 major constituents normally present in natural streams: Calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^{+}), potassium (K^{+}), silica (Si), chloride (Cl^{-}), sulfate (SO_4^{2-}), and carbon, expressed as carbonate equivalent (Liebermann and others, 1987).

Classification Criteria

The 20 stations are classified A, B, or C, according to the quantity and quality of available data for the salt-load computations. Optimal data collection at each station includes daily mean streamflow, daily mean SC, and at least 6 water quality samples per WY which include TDS. SC may be monitored continuously with an instrument (daily mean) or sampled once per day by an observer (instantaneous). Continuous monitoring for daily mean SC by instrument is the preferred method.

Types of Specific Conductivity

Specific Conductivity at the sites is classified into several types:

- Daily – mean daily SC collected by instrumentation. To be considered “daily”, the record may have up to 60 missing days of SC per water year which are spread out in small groups over the year.
- Intermittent – mean daily SC which has more than 60 missing days per water year spread out over the water year.
- Seasonal – mean daily SC has been continuously shut off during the winter (November through March typically), with more than 60 missing days.
- Instantaneous – single SC values which have been manually collected by an observer. Usually spaced several days apart, and may be missing during winter months.

CLASS A

For Class A, adequate data must be available for salt-load computation using SLOAD. Site data includes:

- 6 or more QW samples per WY which include some type of TDS (ROE, SOC, or Calculated). SLOAD automatically discards QW records without any type of TDS.
- Daily Q (SLOAD allows no days with missing Q).
- Mean daily SC from instrumentation. The SC record must be "daily", and must have no more than 60 total days of missing values for the WY.

CLASS B

Salt-load computation is possible using SLOAD, but limited data availability could be contributing to error in salt load estimate. Even though the site has daily Q and daily SC, if there are fewer than 6 QW observations, the site will be Class B. Site data includes:

- There are fewer than 6 QW samples per WY which include some type of TDS.
- Daily Q (SLOAD allows no days with missing Q). Missing Q values may be interpolated from surrounding values.
- SC may be mean daily (with up to 60 missing days), seasonal, intermittent (more than 60 missing days), instantaneous from observers, or non-existant.

CLASS C

Inadequate data exists for SLOAD salt-load computation. Site data includes:

- Some QW records may exist, but none have TDS, hence they are not usable.
- SC may or may not exist, but is not used.
- Salt concentration and load are calculated from regression analysis of old data (Q and TDS).

Improvements and Declines in Class

The classification is shown by year for each site in the tables. This is helpful to see the trend in classifications.

A judgment call must be made for the final year classification. The final year has incomplete data, and the data have not been finalized by USGS. The final year classification will be shown as "provisional" if the criteria for the class are being met as of the cutoff date for the data. For example, if sufficient QW records exist to suggest that 6 observations will be made by the end of the WY, and if daily SC is being recorded, then A (provisional) will be given. The pattern of QW observations for the previous years is taken to project the QW for the final year. The final year will not be shown as provisional if no daily SC is being recorded, (the class is clearly B), or, if no QW records are available, (the class is clearly C).

#1 GRWY - STATION 09217000, Green River near Green River, WY

Water Year	2010	2011	2012	2013	2014 (thru 5-31)
QW Observations	12	12	12	12	8 (thru 5-08)
Daily Q	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)
SC	None	None	None	None	None
ROE TDS samples	12	12	12	12	8
SOC TDS samples	12	11	12	12	8
Class by Year	**B**	**B**	**B**	**B**	**B (provisional)**
Classify Notes	No SC	No SC	No SC	No SC	No SC

Operation is by USGS for daily Q, daily SC, and periodic QW.

#2 GDALE - STATION 09234500, Green River near Greendale, UT

Daily Q only, no SC until WY 2013, no QW with TDS until WY 2012. Due to insufficient data, SLOAD computations cannot be run for this station. Salt loads were calculated using a linear regression equation derived from old Q and TDS data (1/1990 through 8/2000.) SLOAD analysis should be possible in 2016 if current data collection is continued.

Water Year	2010	2011	2012	2013	2014 (thru 5-31)
QW Observations	9	12	12	13	7 (thru 5-15)
Daily Q	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)
SC	None	None	Starts 8/10 (314 missing)	Daily (8 missing)	Daily (5 missing)
ROE TDS samples	0	0	1	9	5
SOC TDS samples	0	0	1	9	5
Class by Year	**C**	**C**	**B**	**A**	**A (provisional)**
Classify Notes	No SC or TDS	No SC or TDS	TDS < 6 / yr		

Operation is by USGS for daily Q.

#3 YAMPA – STATION 09251000, Yampa River near Maybell, CO

Water Year	2010	2011	2012	2013	2014 (thru 5-31)
QW Observations	6	6	6	6	3 (thru 5-19)
Daily Q	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)
SC	Daily (44 missing)	Daily (34 missing)	Daily (16 missing)	Daily (23 missing)	Daily (33 missing)
ROE TDS samples	0	0	0	0	0
SOC TDS samples	6	6	6	6	3
Class by Year	**A**	**A**	**A**	**A**	**A (provisional)**
Classify Notes	Missing SC < 60 / yr	Missing SC < 60 / yr	Missing SC < 60 / yr	Missing SC < 60 / yr	Missing SC < 60 / yr

Operation is by USGS for daily Q, daily SC, and periodic QW.

#4 DUCH – STATION 09302000, Duchesne River near Randlett, UT

Water Year	2010	2011	2012	2013	2014 (thru 5-31)
QW Observations	8	18	8	11	9
Daily Q	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (56 missing)
SC	Daily (5 missing)	Daily (59 missing)	Daily (0 missing)	Daily (18 missing)	Daily (21 missing)
ROE TDS samples	6	8	8	9	5
SOC TDS samples	8	8	8	9	5
Class by Year	**A**	**A**	**A**	**A**	**A (provisional)**
Classify Notes	Missing SC < 60 / yr	Missing SC < 60 / yr	Missing SC < 60 / yr	Missing SC < 60 / yr	Missing SC < 60 / yr

Operation is by USGS for daily Q, daily SC, and periodic QW.

#5 WHITE – STATION 09306500, White River near Watson, Utah

Water Year	2010	2011	2012	2013	2014 (thru 5-31)
QW Observations	10	9	9	12	8
Daily Q	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (84 missing)
SC	None	None	None	None	None
ROE TDS samples	9	8	8	9	5
SOC TDS samples	9	8	8	9	5
Class by Year	**B**	**B**	**B**	**B**	**B (provisional)**
Classify Notes	No SC	No SC	No SC	No SC	No SC

Operation is by USGS for daily Q and periodic QW.

#6 GRUT – STATION 09315000, Green River at Green River, UT

Water Year	2010	2011	2012	2013	2014 (thru 5-31)
QW Observations	8	9	13	8	3
Daily Q	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)
SC	None	None	None	None	None
ROE TDS samples	8	9	9	8	3
SOC TDS samples	8	9	9	8	3
Class by Year	**B**	**B**	**B**	**B**	**B (provisional)**
Classify Notes	No SC	No SC	No SC	No SC	No SC

Operation is by USGS for daily Q and periodic QW.

#7 SANRAF – STATION 09328500, San Rafael River near Green River, UT

Water Year	2010	2011	2012	2013	2014 (thru 5-31)
QW Observations	8	11	10	9	4
Daily Q	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)
SC	None	None	None	None	None
ROE TDS samples	8	9	9	8	3
SOC TDS samples	7	9	9	8	3
Class by Year	B	B	B	B	B (provisional)
Classify Notes	No SC	No SC	No SC	No SC	No SC

Operation is by USGS for daily Q, daily SC, and periodic QW.

#8 GLEN – STATION 09071750, Colorado River above Glenwood Springs, CO

This station has an SC monitor but no stream gage. Flow is computed as the difference between station 09085100 (Colorado River below Glenwood Springs, CO) and station 09085000 (Roaring Fork River at Glenwood Springs, CO).

Water Year	2010	2011	2012	2013	2014 (thru 5-31)
QW Observations	6	6	6	6	3
Daily Q	Estimated (0 missing)	Estimated (0 missing)	Estimated (0 missing)	Estimated (0 missing)	Estimated (0 missing)
SC	Daily (32 missing)	Daily (15 missing)	Daily (2 missing)	Daily (0 missing)	Daily (0 missing)
ROE TDS samples	0	0	0	0	0
SOC TDS samples	6	6	6	6	3
Class by Year	A	A	A	A	A (provisional)
Classify Notes	Missing SC < 60 / yr	Missing SC < 60 / yr	Missing SC < 60 / yr	Missing SC < 60 / yr	Missing SC < 60 / yr

Operation is by USGS for estimated Q, daily SC and periodic QW.

#9 CAMEO - STATION 09095500, Colorado River near Cameo, CO

Water Year	2010	2011	2012	2013	2014 (thru 5-31)
QW Observations	5	5	7	5	4
Daily Q	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)
SC	Daily (34 missing)	Daily (38 missing)	Daily (59 missing)	Daily (46 missing)	Daily (2 missing)
ROE TDS samples	0	0	0	0	0
SOC TDS samples	4	5	6	5	3
Class by Year	B	B	A	B	B (provisional)
Classify Notes	QW observations < 6	QW observations < 6	QW observations > 6	QW observations < 6	

Operation is by USGS for daily Q, daily SC, and periodic QW.

#10 GUNN - STATION 09152500, Gunnison River near Grand Junction, CO

Water Year	2010	2011	2012	2013	2014 (thru 5-31)
QW Observations	5	7	9	9	5
Daily Q	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)
SC	Daily (9 missing)	Daily (37 missing)	Daily (7 missing)	Daily (60 missing)	Daily (9 missing)
ROE TDS samples	0	0	0	0	0
SOC TDS samples	5	7	8	9	**2**
Class by Year	**B**	**A**	**A**	**B**	**A (provisional)**
Classify Notes				Missing SC >59 / yr	

Operation is by USGS for daily Q, daily SC, and periodic QW.

#11 DOLOR - STATION 09180000, Dolores River near Cisco, UT

Water Year	2010	2011	2012	2013	2014 (thru 5-31)
QW Observations	8	8	11	8	5
Daily Q	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)
SC	Daily (12 missing)	Daily (29 missing)	Daily (0 missing)	Daily (26 missing)	Daily (7 missing)
ROE TDS samples	8	8	9	8	4
SOC TDS samples	7	8	9	8	4
Class by Year	**A**	**A**	**A**	**A**	**A (provisional)**
Classify Notes	Missing SC < 60 / yr	Missing SC < 60 / yr	Missing SC < 60 / yr	Missing SC < 60 / yr	Missing SC < 60 / yr

Operation is by USGS for daily Q, daily SC, and periodic QW.

#12 CISCO - STATION 09180500, Colorado River near Cisco, UT

Water Year	2010	2011	2012	2013	2014 (thru 5-31)
QW Observations	8	8	12	8	4
Daily Q	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)
SC	Daily (13 missing)	Daily (2 missing)	Daily (13 missing)	Daily (11 missing)	Daily (6 missing)
ROE TDS samples	7	8	9	8	2
SOC TDS samples	8	8	9	8	2
Class by Year	**A**	**A**	**A**	**A**	**A (provisional)**
Classify Notes	Missing SC < 60 / yr	Missing SC < 60 / yr	Missing SC < 60 / yr	Missing SC < 60 / yr	Missing SC < 60 / yr

Operation is by USGS for daily Q, daily SC, and periodic QW.

#13 ARCH - STATION 09355500, San Juan River near Archuleta, NM

Due to improvements in QW observations starting in 2009, it was possible to use SLOAD for the update in 2014.

Water Year	2010	2011	2012	2013	2014 (thru 5-31)
QW Observations	3	4	5	4	1
Daily Q	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)
SC	None	None	None	None	None
ROE TDS samples	3	4	4	3	1
SOC TDS samples	1	3	3	3	1
Class by Year	B	B	B	B	B (provisional)
Classify Notes					

Operation is by USGS for daily Q and periodic QW.

#14 BLUFF - STATION 09379500, San Juan River near Bluff, UT

Water Year	2010	2011	2012	2013	2014 (thru 5-31)
QW Observations	9	9	9	9	3
Daily Q	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)
SC	Daily (9 missing)	Daily (6 missing)	Daily (1 missing)	Daily (30 missing)	Daily (9 missing)
ROE TDS samples	9	9	8	9	2
SOC TDS samples	9	9	8	9	2
Class by Year	A	A	A	A	A (provisional)
Classify Notes	Missing SC < 60 / yr	Missing SC < 60 / yr	Missing SC < 60 / yr	Missing SC < 60 / yr	Missing SC < 60 / yr

Operation is by USGS for daily Q, daily SC, and periodic QW.

#15 LEES - STATION 09380000, Colorado River at Lees Ferry, AZ

Water Year	2010	2011	2012	2013	2014 (thru 5-31)
QW Observations	4	4	5	14	10
Daily Q	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)
SC	Daily (16 missing)	Daily (0 missing)	Daily (2 missing)	Daily (0 missing)	Daily (0 missing)
ROE TDS samples	4	4	4	14	9
SOC TDS samples	4	4	5	14	9
Class by Year	B	B	B	A	A (provisional)
Classify Notes	TDS samples < 6	TDS samples < 6	TDS samples < 6		

Operation is by USGS for daily Q, daily SC, and periodic QW.

#16 GRCAN - STATION 09402500, Colorado River near Grand Canyon, AZ

Daily Q only, no SC or QW. There has been no water quality sampling since late 1980's. Salt loads are computed with a special version of SLOAD by using the load at station 09380000 (Colorado River at Lees Ferry, AZ) and the flow difference between the 2 stations.

Water Year	2010	2011	2012	2013	2014 (thru 5-31)
QW Observations	None	None	None	None	None
Daily Q	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)
SC	None	None	None	None	None
ROE TDS samples	0	0	0	0	0
SOC TDS samples	0	0	0	0	0
Class by Year	**C**	**C**	**C**	**C**	**C**
Classify Notes	No SC or QW	No SC or QW	No SC or QW	No SC or QW	No SC or QW

Operation is by USGS for daily Q.

#17 VIRGIN - STATION 09415000, Virgin River at Littlefield, AZ

Water Year	2010	2011	2012	2013	2014 (thru 5-31)
QW Observations	4	4	4	4	2
Daily Q	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)
SC	None	None	None	None	None
ROE TDS samples	2	4	4	4	2
SOC TDS samples	2	4	4	4	2
Class by Year	**B**	**B**	**B**	**B**	**B (provisional)**
Classify Notes	No SC, TDS samples < 6	No SC, TDS samples < 6	No SC, TDS samples < 6	No SC, TDS samples < 6	No SC, TDS samples < 6

Operation is by USGS for daily Q and periodic QW.

#18 HOOVER – STATION 09421500, Colorado River below Hoover Dam, AZ-NV

Water Year	2010	2011	2012	2013	2014 (thru 5-31)
QW Observations	11	11	11	11	6
Daily Q	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)
SC	Daily (1 missing)	Daily (0 missing)	Daily (3 missing)	Daily (11 missing)	Daily (51 missing)
ROE TDS samples	11	11	11	11	6
SOC TDS samples	11	11	11	11	6
Class by Year	**A**	**A**	**A**	**A**	**A (provisional)**
Classify Notes	Includes USBR data	Includes USBR data	Includes USBR data	Includes USBR data	Includes USBR data

Operation is by USGS for daily Q and periodic QW and by Reclamation for daily SC and periodic QW.

#19 PARKER - STATION 09427520, Colorado River below Parker Dam, AZ-CA

Daily SC data provided by Reclamation was available for the first time for the 2014 update.

Water Year	2010	2011	2012	2013	2014 (thru 5-31)
QW Observations	29	28	31	37	24 (thru 5/21)
Daily Q	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)
SC	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (2 missing)	Yes (0 missing)
ROE TDS samples	29	28	31	37	23
SOC TDS samples	29	28	31	37	23
Class by Year	**A**	**A**	**A**	**A**	**A**
Classify Notes	Includes USBR data	Includes USBR data	Includes USBR data	Includes USBR data	Includes USBR data

Operation is by USGS for daily Q and periodic QW and by Reclamation for daily SC and periodic QW.

#20 IMPER - STATION 09429490, Colorado River above Imperial Dam, AZ-CA

Water Year	2010	2011	2012	2013	2014 (thru 5-31)
QW Observations	30	27	26	27	17
Daily Q	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)
SC	Daily (0 missing)	Daily (0 missing)	Daily (0 missing)	Daily (0 missing)	Daily (0 missing)
ROE TDS samples	30	27	26	27	16
SOC TDS samples	4	4	10	27	16
Class by Year	**A**	**A**	**A**	**A**	**A (provisional)**
Classify Notes	Includes USBR data	Includes USBR data	Includes USBR data	Includes USBR data	Includes USBR data

Operation is by USGS for daily Q and quarterly QW, and by BOR for daily SC and additional periodic QW.

APPENDIX C

REGRESSION STATISTICS FOR 2014 SLOAD

Updates CY 2010-2013

1. STATION 09217000 (GRWY) Green River near Green River, WY

STATION 09217000 Green River near Green River, UT UPDATE 2014
SUMMARY OF QW OBSERVATIONS, BY 3-YEAR SLIDING GROUP

Obs	WATER YEAR	# OF QW OBSV.	% P70300 SUBST.	% P00060 SUBST.
1	2010	36	2.8	0.0
2	2011	36	2.8	0.0
3	2012	36	2.8	0.0
4	2013	32	0.0	0.0
5	2014	32	0.0	0.0

STATION 09217000 Green River near Green River, UT UPDATE 2014
REGRESSION STATISTICS, BY 3-YEAR SLIDING GROUPS
REGRESSION #1: VARIABLE = e**A * DISCHARGE**B
REGRESSION #2: VARIABLE = e**C * DISCHARGE**D * COND**E
VARIABLE=(mg/L), except for SALT LOAD (tons/day)
DISCHARGE=(cfs) COND=(uMHOS/cm)

GROUP=2010

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
1	SALT LOAD	36	0.78425	0.16147	1.17013	0.79566	35	0.99398	0.02779	-6.70133	0.96864	1.08661
2	Calcium	35	0.04699	0.16402	4.51269	-0.09299	34	0.89891	0.05508	-3.10829	0.07752	1.04790
3	Magnesium	35	0.15118	0.14546	3.90034	-0.15674	34	0.94655	0.03765	-3.01949	-0.00206	0.95171
4	Chloride	35	0.15812	0.26883	3.59769	-0.29748	34	0.87079	0.10842	-8.48670	-0.02928	1.66499
5	Sulfate	35	0.36880	0.22813	7.66155	-0.44527	34	0.95446	0.06322	-3.12322	-0.20500	1.48452
6	Carbonate	35	0.01276	0.12104	4.71130	-0.03514	34	0.85332	0.04804	-0.77306	0.08783	0.75372
7	Sodium +K	35	0.45037	0.18611	6.42602	-0.43018	34	0.84514	0.10134	-1.14891	-0.26330	1.04559

GROUP=2011

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
8	SALT LOAD	36	0.78425	0.16147	1.17013	0.79566	35	0.99398	0.02779	-6.70133	0.96864	1.08661
9	Calcium	35	0.04699	0.16402	4.51269	-0.09299	34	0.89891	0.05508	-3.10829	0.07752	1.04790
10	Magnesium	35	0.15118	0.14546	3.90034	-0.15674	34	0.94655	0.03765	-3.01949	-0.00206	0.95171
11	Chloride	35	0.15812	0.26883	3.59769	-0.29748	34	0.87079	0.10842	-8.48670	-0.02928	1.66499
12	Sulfate	35	0.36880	0.22813	7.66155	-0.44527	34	0.95446	0.06322	-3.12322	-0.20500	1.48452
13	Carbonate	35	0.01276	0.12104	4.71130	-0.03514	34	0.85332	0.04804	-0.77306	0.08783	0.75372
14	Sodium +K	35	0.45037	0.18611	6.42602	-0.43018	34	0.84514	0.10134	-1.14891	-0.26330	1.04559

GROUP=2012

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
15	SALT LOAD	36	0.85861	0.14919	0.59168	0.87741	36	0.99573	0.02633	-6.81492	0.98229	1.08946
16	Calcium	35	0.00027	0.15896	3.89778	-0.00614	35	0.88938	0.05370	-3.58966	0.10098	1.09975
17	Magnesium	35	0.05876	0.13644	3.35825	-0.08021	35	0.93607	0.03611	-3.22095	0.01392	0.96635
18	Chloride	35	0.07972	0.25476	2.73525	-0.17642	35	0.81714	0.11532	-8.65506	-0.01347	1.67300
19	Sulfate	35	0.28603	0.21921	6.81453	-0.32645	35	0.92314	0.07304	-3.52812	-0.17849	1.51912
20	Carbonate	35	0.00102	0.11360	4.40280	0.00853	35	0.81362	0.04983	-0.71469	0.08174	0.75165
21	Sodium +K	35	0.41100	0.17753	5.85872	-0.34892	35	0.79389	0.10664	-1.29045	-0.24665	1.05006

GROUP=2013

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
22	SALT LOAD	32	0.81897	0.11376	0.04654	0.95683	31	0.82824	0.11414	-0.90112	1.05703	0.04376
23	Calcium	32	0.05132	0.12479	3.06838	0.11478	31	0.12035	0.12429	1.92540	0.23530	0.05310
24	Magnesium	32	0.00009	0.10274	2.77827	0.00389	31	0.05116	0.10340	2.01162	0.08400	0.03629
25	Chloride	32	0.00021	0.15073	1.56809	-0.00864	31	0.04453	0.15237	0.51796	0.10131	0.04950
26	Sulfate	32	0.06829	0.16188	5.76621	-0.17331	31	0.13065	0.16122	4.28457	-0.01536	0.06720
27	Carbonate	32	0.01730	0.09181	4.13016	0.04818	31	0.02058	0.09369	3.90781	0.06979	0.01205
28	Sodium +K	32	0.20091	0.13475	5.29398	-0.26719	31	0.22743	0.13693	4.42363	-0.17509	0.04012

2. STATION 09234500 (GDALE) Green River near Greendale, UT, NO REGRESSION STATS

This site has daily Q, no daily SC, and periodic QW observations. There are no TDS measurements included in the QW records prior to 2012, therefore there is insufficient data for SLOAD computations. Salt loads were calculated using a linear regression equation derived from old data (01/1990 through 08/2000.) See spreadsheet gdale_regression_2014.xlsx. If current QW sampling continues with TDS, there should be possible an SLOAD calculation in 2016.

3. STATION 09251000 (YAMPA) Yampa River near Maybell, CO

STATION 09251000 Yampa River near Maybell, CO UPDATE 2014
SUMMARY OF QW OBSERVATIONS, BY 3-YEAR SLIDING GROUP

Obs	WATER YEAR	# OF QW OBSV.	% P70300 SUBST.	% P00060 SUBST.
1	2010	17	0.0	0.0
2	2011	17	0.0	0.0
3	2012	17	0.0	0.0
4	2013	15	0.0	0.0
5	2014	15	0.0	0.0

STATION 09251000 Yampa River near Maybell, CO UPDATE 2014
REGRESSION STATISTICS, BY 3-YEAR SLIDING GROUPS
REGRESSION #1: VARIABLE = e**A * DISCHARGE**B
REGRESSION #2: VARIABLE = e**C * DISCHARGE**D * COND**E
VARIABLE=(mg/L), except for SALT LOAD (tons/day)
DISCHARGE=(cfs) COND=(uMHOS/cm)

GROUP=2010

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
1	SALT LOAD	17	0.92766	0.32294	0.56887	0.87050	17	0.99928	0.03334	-7.45796	1.02395	1.14446
2	Calcium	17	0.15501	0.23837	4.12354	-0.07685	17	0.90085	0.08452	-1.47070	0.03009	0.79762
3	Magnesium	17	0.12689	0.35907	3.65154	-0.10304	17	0.97388	0.06429	-5.18290	0.06585	1.25960
4	Chloride	17	0.79302	0.28465	5.12268	-0.41942	17	0.96487	0.12138	-1.35649	-0.29555	0.92379
5	Sulfate	17	0.07684	0.46778	5.25035	-0.10159	17	0.97970	0.07180	-6.30568	0.11933	1.64765
6	Carbonate	17	0.40007	0.21064	5.09804	-0.12948	17	0.80251	0.12509	0.78851	-0.04709	0.61445
7	Sodium +K	17	0.52397	0.34288	5.24684	-0.27080	17	0.96312	0.09879	-2.98003	-0.11352	1.17298

GROUP=2011

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
8	SALT LOAD	17	0.92766	0.32294	0.56887	0.87050	17	0.99928	0.03334	-7.45796	1.02395	1.14446
9	Calcium	17	0.15501	0.23837	4.12354	-0.07685	17	0.90085	0.08452	-1.47070	0.03009	0.79762
10	Magnesium	17	0.12689	0.35907	3.65154	-0.10304	17	0.97388	0.06429	-5.18290	0.06585	1.25960
11	Chloride	17	0.79302	0.28465	5.12268	-0.41942	17	0.96487	0.12138	-1.35649	-0.29555	0.92379
12	Sulfate	17	0.07684	0.46778	5.25035	-0.10159	17	0.97970	0.07180	-6.30568	0.11933	1.64765
13	Carbonate	17	0.40007	0.21064	5.09804	-0.12948	17	0.80251	0.12509	0.78851	-0.04709	0.61445
14	Sodium +K	17	0.52397	0.34288	5.24684	-0.27080	17	0.96312	0.09879	-2.98003	-0.11352	1.17298

GROUP=2012

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
15	SALT LOAD	17	0.91611	0.35691	0.75361	0.83104	17	0.99919	0.03624	-7.23087	1.03361	1.09955
16	Calcium	17	0.25034	0.28521	4.31660	-0.11613	17	0.95124	0.07529	-1.88273	0.04115	0.85371
17	Magnesium	17	0.20943	0.42179	3.87190	-0.15296	17	0.98820	0.05335	-5.53874	0.08579	1.29595
18	Chloride	17	0.84266	0.30494	5.56992	-0.49723	17	0.98209	0.10648	-0.88308	-0.33352	0.88865
19	Sulfate	17	0.15165	0.52418	5.49289	-0.15615	17	0.97743	0.08851	-6.13265	0.13879	1.60096
20	Carbonate	17	0.47600	0.23683	5.23939	-0.15904	17	0.84854	0.13179	0.75049	-0.04516	0.61817
21	Sodium +K	17	0.59829	0.38449	5.57181	-0.33062	17	0.97374	0.10176	-2.78402	-0.11863	1.15069

GROUP=2013

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
22	SALT LOAD	15	0.88596	0.40327	0.93593	0.79919	15	0.99938	0.03087	-7.36973	1.04341	1.11376
23	Calcium	15	0.28999	0.31995	4.48693	-0.14538	15	0.95938	0.07965	-1.92875	0.04326	0.86032
24	Magnesium	15	0.26563	0.47075	4.12982	-0.20130	15	0.99191	0.05143	-5.53828	0.08297	1.29646
25	Chloride	15	0.83084	0.35236	5.89115	-0.55522	15	0.98043	0.12473	-0.95189	-0.35401	0.91763
26	Sulfate	15	0.17276	0.59705	5.70166	-0.19399	15	0.98963	0.06959	-6.55071	0.16627	1.64300
27	Carbonate	15	0.52162	0.25848	5.43198	-0.19191	15	0.89828	0.12406	0.69536	-0.05263	0.63517
28	Sodium +K	15	0.59520	0.43897	5.86364	-0.37846	15	0.98376	0.09153	-3.01801	-0.11731	1.19100

4. STATION 09302000 (DUCH) Duchesne River near Randlett, UT

STATION 09302000 Duchesne River near Randlett, UT UPDATE 2014
SUMMARY OF QW OBSERVATIONS, BY 3-YEAR SLIDING GROUP

Obs	WATER YEAR	# OF QW OBSV.	% P70300 SUBST.	% P00060 SUBST.
1	2010	24	0.0	0.0
2	2011	24	0.0	0.0
3	2012	25	0.0	4.0
4	2013	22	0.0	4.5
5	2014	22	0.0	4.5

STATION 09302000 Duchesne River near Randlett, UT UPDATE 2014
REGRESSION STATISTICS, BY 3-YEAR SLIDING GROUPS
REGRESSION #1: VARIABLE = e**A * DISCHARGE**B
REGRESSION #2: VARIABLE = e**C * DISCHARGE**D * COND**E
VARIABLE=(mg/L), except for SALT LOAD (tons/day)
DISCHARGE=(cfs) COND=(uMHOS/cm)

GROUP=2010

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
1	SALT LOAD	24	0.92729	0.24232	2.41805	0.64737	23	0.99908	0.02695	-6.97015	1.00366	1.08730
2	Calcium	24	0.65932	0.21762	5.45805	-0.22648	23	0.94163	0.09339	-2.27285	0.06680	0.89548
3	Magnesium	24	0.68090	0.27950	5.32165	-0.30543	23	0.98892	0.05373	-5.48914	0.10732	1.24948
4	Chloride	24	0.85083	0.26502	6.12180	-0.47350	23	0.97982	0.10032	-3.35476	-0.11664	1.10043
5	Sulfate	24	0.81953	0.29598	8.00317	-0.47183	23	0.98071	0.09954	-2.87334	-0.05999	1.26064
6	Carbonate	24	0.54949	0.22841	5.93173	-0.18871	23	0.90604	0.10812	-2.09513	0.11796	0.92751
7	Sodium +K	24	0.84772	0.25810	6.93225	-0.45556	23	0.99112	0.06402	-2.77578	-0.08836	1.12563

GROUP=2011

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
8	SALT LOAD	24	0.92729	0.24232	2.41805	0.64737	23	0.99908	0.02695	-6.97015	1.00366	1.08730
9	Calcium	24	0.65932	0.21762	5.45805	-0.22648	23	0.94163	0.09339	-2.27285	0.06680	0.89548
10	Magnesium	24	0.68090	0.27950	5.32165	-0.30543	23	0.98892	0.05373	-5.48914	0.10732	1.24948
11	Chloride	24	0.85083	0.26502	6.12180	-0.47350	23	0.97982	0.10032	-3.35476	-0.11664	1.10043
12	Sulfate	24	0.81953	0.29598	8.00317	-0.47183	23	0.98071	0.09954	-2.87334	-0.05999	1.26064
13	Carbonate	24	0.54949	0.22841	5.93173	-0.18871	23	0.90604	0.10812	-2.09513	0.11796	0.92751
14	Sodium +K	24	0.84772	0.25810	6.93225	-0.45556	23	0.99112	0.06402	-2.77578	-0.08836	1.12563

GROUP=2012

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
15	SALT LOAD	25	0.96022	0.19821	2.32122	0.67101	25	0.99945	0.02387	-7.13389	1.00409	1.11130
16	Calcium	25	0.67693	0.19583	5.31006	-0.19532	25	0.92588	0.09591	-2.94768	0.09558	0.97057
17	Magnesium	25	0.79120	0.20143	5.17066	-0.27017	25	0.98906	0.04715	-4.24840	0.06164	1.10707
18	Chloride	25	0.88994	0.23104	6.04367	-0.45268	25	0.98418	0.08955	-4.22618	-0.09089	1.20707
19	Sulfate	25	0.86774	0.25977	7.95932	-0.45847	25	0.99128	0.06821	-4.10068	-0.03362	1.41747
20	Carbonate	25	0.68727	0.13665	5.66843	-0.13958	25	0.89017	0.08280	0.38100	0.04668	0.62146
21	Sodium +K	25	0.88437	0.22513	6.82198	-0.42900	25	0.99017	0.06713	-3.52224	-0.06459	1.21581

GROUP=2013

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
22	SALT LOAD	22	0.92052	0.19805	2.34201	0.66884	22	0.99913	0.02122	-7.35038	1.01619	1.13492
23	Calcium	22	0.41509	0.19606	5.19693	-0.16390	22	0.87321	0.09365	-3.34146	0.14209	0.99979
24	Magnesium	22	0.63298	0.20043	5.14980	-0.26120	22	0.98039	0.04753	-4.44570	0.08268	1.12357
25	Chloride	22	0.83521	0.21885	6.19715	-0.48892	22	0.97839	0.08132	-3.84087	-0.12918	1.17539
26	Sulfate	22	0.75539	0.25799	7.93247	-0.44990	22	0.98976	0.05416	-4.49409	-0.00456	1.45507
27	Carbonate	22	0.50113	0.13226	5.64217	-0.13155	22	0.77151	0.09184	0.85072	0.04016	0.56105
28	Sodium +K	22	0.81154	0.22344	6.95768	-0.46012	22	0.98403	0.06674	-3.56109	-0.08315	1.23168

5. STATION 09306500 (WHITE) White River near Watson, UT

STATION 09306500 White River near Watson, UT UPDATE 2014
SUMMARY OF QW OBSERVATIONS, BY 3-YEAR SLIDING GROUP

Obs	WATER YEAR	# OF QW OBSV.	% P70300 SUBST.	% P00060 SUBST.
1	2010	23	0.0	0.0
2	2011	23	0.0	0.0
3	2012	24	0.0	0.0
4	2013	21	0.0	0.0
5	2014	21	0.0	0.0

STATION 09306500 White River near Watson, UT UPDATE 2014
REGRESSION STATISTICS, BY 3-YEAR SLIDING GROUPS
REGRESSION #1: VARIABLE = e**A * DISCHARGE**B
REGRESSION #2: VARIABLE = e**C * DISCHARGE**D * COND**E
VARIABLE=(mg/L), except for SALT LOAD (tons/day)
DISCHARGE=(cfs) COND=(uMHOS/cm)

GROUP=2010

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
1	SALT LOAD	23	0.94429	0.15572	1.45052	0.77393	23	0.99498	0.04787	-7.60188	1.01580	1.17935
2	Calcium	23	0.58461	0.10935	5.10920	-0.15661	23	0.76637	0.08403	0.70089	-0.03882	0.57432
3	Magnesium	23	0.62456	0.15568	4.60898	-0.24240	23	0.92007	0.07360	-3.80815	-0.01750	1.09659
4	Chloride	23	0.74415	0.24795	5.45283	-0.51050	23	0.94071	0.12231	-7.79196	-0.15661	1.72554
5	Sulfate	23	0.59345	0.25141	7.19344	-0.36670	23	0.96367	0.07701	-7.42766	0.02397	1.90485
6	Carbonate	23	0.40020	0.10035	5.26197	-0.09896	23	0.69365	0.07349	0.98437	0.01534	0.55729
7	Sodium +K	23	0.52133	0.27688	5.76904	-0.34884	23	0.88975	0.13617	-9.03454	0.04670	1.92862

GROUP=2011

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
8	SALT LOAD	23	0.94429	0.15572	1.45052	0.77393	23	0.99498	0.04787	-7.60188	1.01580	1.17935
9	Calcium	23	0.58461	0.10935	5.10920	-0.15661	23	0.76637	0.08403	0.70089	-0.03882	0.57432
10	Magnesium	23	0.62456	0.15568	4.60898	-0.24240	23	0.92007	0.07360	-3.80815	-0.01750	1.09659
11	Chloride	23	0.74415	0.24795	5.45283	-0.51050	23	0.94071	0.12231	-7.79196	-0.15661	1.72554
12	Sulfate	23	0.59345	0.25141	7.19344	-0.36670	23	0.96367	0.07701	-7.42766	0.02397	1.90485
13	Carbonate	23	0.40020	0.10035	5.26197	-0.09896	23	0.69365	0.07349	0.98437	0.01534	0.55729
14	Sodium +K	23	0.52133	0.27688	5.76904	-0.34884	23	0.88975	0.13617	-9.03454	0.04670	1.92862

GROUP=2012

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
15	SALT LOAD	24	0.95088	0.14602	1.31237	0.80003	24	0.99872	0.02409	-6.94672	1.01728	1.07746
16	Calcium	24	0.45464	0.11840	4.99452	-0.13463	24	0.72846	0.08552	0.18608	-0.00815	0.62730
17	Magnesium	24	0.57682	0.14799	4.45968	-0.21516	24	0.92464	0.06392	-3.22968	-0.01290	1.00313
18	Chloride	24	0.78275	0.20035	5.25892	-0.47358	24	0.96259	0.08509	-5.18810	-0.19878	1.36289
19	Sulfate	24	0.59121	0.22104	7.01097	-0.33105	24	0.98230	0.04707	-5.38032	-0.00510	1.61654
20	Carbonate	24	0.28067	0.09396	5.10849	-0.07309	24	0.76914	0.05448	0.67087	0.04364	0.57892
21	Sodium +K	24	0.46812	0.25009	5.45176	-0.29219	24	0.90545	0.10793	-7.54531	0.04970	1.69556

GROUP=2013

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
22	SALT LOAD	21	0.93220	0.12670	1.15094	0.82710	21	0.99856	0.01898	-6.75544	1.01762	1.04854
23	Calcium	21	0.08706	0.09938	4.53971	-0.05402	21	0.52677	0.07351	0.18970	0.05080	0.57689
24	Magnesium	21	0.45722	0.12755	4.38998	-0.20608	21	0.88597	0.06006	-2.76004	-0.03378	0.94823
25	Chloride	21	0.60639	0.20055	5.04136	-0.43822	21	0.90501	0.10122	-5.97670	-0.17271	1.46121
26	Sulfate	21	0.39900	0.19031	6.66749	-0.27298	21	0.97542	0.03954	-5.08809	0.01031	1.55901
27	Carbonate	21	0.20094	0.07942	5.08258	-0.07011	21	0.71246	0.04895	1.07478	0.02647	0.53151
28	Sodium +K	21	0.33849	0.22867	5.41843	-0.28797	21	0.85791	0.10888	-7.36244	0.02003	1.69499

6. STATION 09315000 (GRUT) Green River at Green River, UT

STATION 09315000 Green River at Green River, UT UPDATE 2014
SUMMARY OF QW OBSERVATIONS, BY 3-YEAR SLIDING GROUP

Obs	WATER YEAR	# OF QW OBSV.	% P70300 SUBST.	% P00060 SUBST.
1	2010	26	0.0	0.0
2	2011	26	0.0	0.0
3	2012	26	0.0	0.0
4	2013	20	0.0	0.0
5	2014	20	0.0	0.0

STATION 09315000 Green River at Green River, UT UPDATE 2014
REGRESSION STATISTICS, BY 3-YEAR SLIDING GROUPS
REGRESSION #1: VARIABLE = e**A * DISCHARGE**B
REGRESSION #2: VARIABLE = e**C * DISCHARGE**D * COND**E
VARIABLE=(mg/L), except for SALT LOAD (tons/day)
DISCHARGE=(cfs) COND=(uMHOS/cm)

GROUP=2010

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
1	SALT LOAD	26	0.94161	0.18777	2.11825	0.74956	26	0.99902	0.02481	-6.81928	1.00350	1.06202
2	Calcium	26	0.54175	0.16705	5.44243	-0.18056	26	0.95599	0.05288	-2.18152	0.03606	0.90594
3	Magnesium	26	0.49352	0.22634	4.90599	-0.22210	26	0.96488	0.06088	-5.57513	0.07571	1.24545
4	Chloride	26	0.79987	0.19916	6.15847	-0.39580	26	0.98115	0.06244	-2.94016	-0.13728	1.08117
5	Sulfate	26	0.62777	0.24860	7.62181	-0.32092	26	0.99047	0.04063	-4.15721	0.01376	1.39967
6	Carbonate	26	0.51793	0.16043	5.90192	-0.16530	26	0.77867	0.11105	0.23849	-0.00439	0.67297
7	Sodium +K	26	0.78039	0.18733	6.84291	-0.35103	26	0.98756	0.04554	-1.89068	-0.10288	1.03779

GROUP=2011

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
8	SALT LOAD	26	0.94161	0.18777	2.11825	0.74956	26	0.99902	0.02481	-6.81928	1.00350	1.06202
9	Calcium	26	0.54175	0.16705	5.44243	-0.18056	26	0.95599	0.05288	-2.18152	0.03606	0.90594
10	Magnesium	26	0.49352	0.22634	4.90599	-0.22210	26	0.96488	0.06088	-5.57513	0.07571	1.24545
11	Chloride	26	0.79987	0.19916	6.15847	-0.39580	26	0.98115	0.06244	-2.94016	-0.13728	1.08117
12	Sulfate	26	0.62777	0.24860	7.62181	-0.32092	26	0.99047	0.04063	-4.15721	0.01376	1.39967
13	Carbonate	26	0.51793	0.16043	5.90192	-0.16530	26	0.77867	0.11105	0.23849	-0.00439	0.67297
14	Sodium +K	26	0.78039	0.18733	6.84291	-0.35103	26	0.98756	0.04554	-1.89068	-0.10288	1.03779

GROUP=2012

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
15	SALT LOAD	26	0.93502	0.21406	2.12875	0.74857	26	0.99939	0.02123	-7.35604	1.01704	1.12960
16	Calcium	26	0.52170	0.19195	5.47892	-0.18480	26	0.95441	0.06053	-2.64919	0.04526	0.96803
17	Magnesium	26	0.49350	0.23726	4.85527	-0.21590	26	0.96968	0.05930	-5.38639	0.07400	1.21974
18	Chloride	26	0.77359	0.23298	6.16040	-0.39699	26	0.97734	0.07529	-3.67884	-0.11849	1.17182
19	Sulfate	26	0.60792	0.28033	7.63097	-0.32178	26	0.98255	0.06040	-4.56831	0.02352	1.45289
20	Carbonate	26	0.56375	0.15703	5.90080	-0.16456	26	0.95288	0.05272	-0.70166	0.02233	0.78633
21	Sodium +K	26	0.72251	0.23443	6.81354	-0.34871	26	0.97615	0.07021	-3.16445	-0.06628	1.18834

GROUP=2013

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
22	SALT LOAD	20	0.80563	0.22144	2.71636	0.66828	20	0.99883	0.01764	-7.67801	1.03869	1.15375
23	Calcium	20	0.43532	0.19156	5.94456	-0.24932	20	0.92747	0.07064	-2.47535	0.05072	0.93459
24	Magnesium	20	0.39267	0.24408	5.40813	-0.29092	20	0.97591	0.05002	-5.85325	0.11037	1.24999
25	Chloride	20	0.66284	0.23851	6.87493	-0.49572	20	0.97385	0.06835	-3.91016	-0.11139	1.19712
26	Sulfate	20	0.44165	0.29757	8.13402	-0.39230	20	0.98390	0.05199	-5.67259	0.09970	1.53250
27	Carbonate	20	0.56828	0.14873	6.55535	-0.25295	20	0.94370	0.05527	0.02544	-0.02025	0.72481
28	Sodium +K	20	0.63062	0.24056	7.68919	-0.46594	20	0.96955	0.07108	-3.15999	-0.07933	1.20424

7. STATION 09328500, San Rafael River near Green River, UT

STATION 09328500 San Rafael River near Green River, UT UPDATE 2014
SUMMARY OF QW OBSERVATIONS, BY 3-YEAR SLIDING GROUP

Obs	WATER YEAR	# OF QW OBSV.	% P70300 SUBST.	% P00060 SUBST.
1	2010	26	3.8	0.0
2	2011	26	3.8	0.0
3	2012	26	0.0	0.0
4	2013	20	0.0	0.0
5	2014	20	0.0	0.0

STATION 09328500 San Rafael River near Green River, UT UPDATE 2014
REGRESSION STATISTICS, BY 3-YEAR SLIDING GROUPS
REGRESSION #1: VARIABLE = e**A * DISCHARGE**B
REGRESSION #2: VARIABLE = e**C * DISCHARGE**D * COND**E
VARIABLE=(mg/L), except for SALT LOAD (tons/day)
DISCHARGE=(cfs) COND=(uMHOS/cm)

GROUP=2010

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
1	SALT LOAD	26	0.91521	0.31389	2.94805	0.64393	26	0.99732	0.05704	-7.42052	1.00639	1.16111
2	Calcium	25	0.59706	0.35610	6.31706	-0.27023	25	0.70763	0.31015	0.10648	-0.05046	0.69350
3	Magnesium	25	0.68924	0.39353	6.00357	-0.36538	25	0.92101	0.20287	-5.31172	0.03504	1.26352
4	Chloride	25	0.70722	0.44425	5.51665	-0.43044	25	0.88936	0.27923	-6.14931	-0.01762	1.30268
5	Sulfate	25	0.72243	0.41180	8.53751	-0.41417	25	0.97409	0.12864	-4.51752	0.04781	1.45779
6	Carbonate	25	0.34566	0.31223	5.49690	-0.14148	25	0.34739	0.31883	4.96353	-0.12260	0.05956
7	Sodium +K	25	0.62684	0.51805	6.97731	-0.41859	25	0.85413	0.33117	-6.48382	0.05777	1.50314

GROUP=2011

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
8	SALT LOAD	26	0.91521	0.31389	2.94805	0.64393	26	0.99732	0.05704	-7.42052	1.00639	1.16111
9	Calcium	25	0.59706	0.35610	6.31706	-0.27023	25	0.70763	0.31015	0.10648	-0.05046	0.69350
10	Magnesium	25	0.68924	0.39353	6.00357	-0.36538	25	0.92101	0.20287	-5.31172	0.03504	1.26352
11	Chloride	25	0.70722	0.44425	5.51665	-0.43044	25	0.88936	0.27923	-6.14931	-0.01762	1.30268
12	Sulfate	25	0.72243	0.41180	8.53751	-0.41417	25	0.97409	0.12864	-4.51752	0.04781	1.45779
13	Carbonate	25	0.34566	0.31223	5.49690	-0.14148	25	0.34739	0.31883	4.96353	-0.12260	0.05956
14	Sodium +K	25	0.62684	0.51805	6.97731	-0.41859	25	0.85413	0.33117	-6.48382	0.05777	1.50314

GROUP=2012

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
15	SALT LOAD	26	0.92906	0.30209	2.81708	0.68273	26	0.99665	0.06703	-6.99319	0.99798	1.10942
16	Calcium	26	0.57713	0.30284	6.16910	-0.22095	26	0.67140	0.27270	1.41202	-0.06808	0.53797
17	Magnesium	26	0.62366	0.39892	5.80534	-0.32071	26	0.89385	0.21642	-5.43997	0.04065	1.27171
18	Chloride	26	0.64993	0.44787	5.32162	-0.38111	26	0.87342	0.27510	-6.58403	0.00147	1.34638
19	Sulfate	26	0.70535	0.37748	8.37447	-0.36473	26	0.96481	0.13326	-3.41013	0.01395	1.33269
20	Carbonate	26	0.36730	0.30981	5.52419	-0.14742	26	0.40887	0.30590	2.88223	-0.06252	0.29877
21	Sodium +K	26	0.57383	0.52339	6.81335	-0.37928	26	0.85085	0.31629	-7.22560	0.07184	1.58763

GROUP=2013

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
22	SALT LOAD	20	0.91112	0.26165	2.56526	0.77271	20	0.99445	0.06726	-6.17112	0.98415	1.01063
23	Calcium	20	0.27676	0.22169	5.92414	-0.12649	20	0.29322	0.22551	4.77094	-0.09858	0.13340
24	Magnesium	20	0.31314	0.44176	5.67251	-0.27513	20	0.90238	0.17137	-8.43656	0.06635	1.63215
25	Chloride	20	0.32479	0.48599	5.13054	-0.31090	20	0.82393	0.25537	-9.27780	0.03782	1.66677
26	Sulfate	20	0.47247	0.27243	8.01514	-0.23781	20	0.94643	0.08933	-0.88921	-0.02230	1.03006
27	Carbonate	20	0.25682	0.29133	5.54344	-0.15797	20	0.58914	0.22290	-1.17418	0.00461	0.77710
28	Sodium +K	20	0.25886	0.56721	6.61740	-0.30920	20	0.75524	0.33541	-9.38933	0.07821	1.85167

8. STATION 09071750 (GLEN) Colorado River above Glenwood Springs CO

STATION 09071750 Colorado River above Glenwood Springs, CO UPDATE 2014
SUMMARY OF QW OBSERVATIONS, BY 3-YEAR SLIDING GROUP

Obs	WATER YEAR	# OF QW OBSV.	% P70300 SUBST.	% P00060 SUBST.
1	2010	18	0.0	0.0
2	2011	18	0.0	0.0
3	2012	18	0.0	0.0
4	2013	15	0.0	0.0
5	2014	15	0.0	0.0

STATION 09071750 Colorado River above Glenwood Springs, CO UPDATE 2014
REGRESSION STATISTICS, BY 3-YEAR SLIDING GROUPS
REGRESSION #1: VARIABLE = e**A * DISCHARGE**B
REGRESSION #2: VARIABLE = e**C * DISCHARGE**D * COND**E
VARIABLE=(mg/L), except for SALT LOAD (tons/day)
DISCHARGE=(cfs) COND=(uMHOS/cm)

GROUP=2010

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
1	SALT LOAD	18	0.90628	0.11032	3.8626	0.46251	18	0.99325	0.03057	-8.25824	1.10004	1.16234
2	Calcium	18	0.83199	0.11687	6.4882	-0.35061	18	0.96362	0.05617	-5.30957	0.26992	1.13136
3	Magnesium	18	0.82083	0.13705	5.2548	-0.39547	18	0.93542	0.08498	-7.24558	0.26203	1.19874
4	Chloride	18	0.97273	0.11609	11.2073	-0.93481	18	0.98700	0.08279	1.62949	-0.43104	0.91848
5	Sulfate	18	0.84667	0.16058	8.0158	-0.50870	18	0.95558	0.08926	-7.41909	0.30315	1.48015
6	Carbonate	18	0.82800	0.09130	6.0761	-0.27005	18	0.95548	0.04797	-2.88816	0.20145	0.85964
7	Sodium +K	18	0.96007	0.11917	9.7983	-0.78777	18	0.98974	0.06240	-1.91751	-0.17155	1.12350

GROUP=2011

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
8	SALT LOAD	18	0.90628	0.11032	3.8626	0.46251	18	0.99325	0.03057	-8.25824	1.10004	1.16234
9	Calcium	18	0.83199	0.11687	6.4882	-0.35061	18	0.96362	0.05617	-5.30957	0.26992	1.13136
10	Magnesium	18	0.82083	0.13705	5.2548	-0.39547	18	0.93542	0.08498	-7.24558	0.26203	1.19874
11	Chloride	18	0.97273	0.11609	11.2073	-0.93481	18	0.98700	0.08279	1.62949	-0.43104	0.91848
12	Sulfate	18	0.84667	0.16058	8.0158	-0.50870	18	0.95558	0.08926	-7.41909	0.30315	1.48015
13	Carbonate	18	0.82800	0.09130	6.0761	-0.27005	18	0.95548	0.04797	-2.88816	0.20145	0.85964
14	Sodium +K	18	0.96007	0.11917	9.7983	-0.78777	18	0.98974	0.06240	-1.91751	-0.17155	1.12350

GROUP=2012

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
15	SALT LOAD	18	0.89141	0.11833	3.9130	0.45219	18	0.99329	0.03038	-8.30693	1.10826	1.16165
16	Calcium	18	0.84175	0.11854	6.5679	-0.36463	18	0.96272	0.05943	-4.48162	0.22861	1.05039
17	Magnesium	18	0.83085	0.12809	5.1118	-0.37861	18	0.95538	0.06795	-6.60541	0.25048	1.11385
18	Chloride	18	0.96709	0.13152	11.2863	-0.95084	18	0.98619	0.08801	0.60547	-0.37740	1.01534
19	Sulfate	18	0.83103	0.17480	8.0344	-0.51703	18	0.96270	0.08483	-8.41678	0.36622	1.56387
20	Carbonate	18	0.83717	0.08914	6.0499	-0.26957	18	0.94634	0.05285	-1.73148	0.14821	0.73971
21	Sodium +K	18	0.95700	0.12971	9.9891	-0.81606	18	0.99294	0.05428	-2.65347	-0.13730	1.20182

GROUP=2013

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
22	SALT LOAD	15	0.82628	0.14299	3.8366	0.46092	15	0.99612	0.02226	-8.15638	1.10201	1.14483
23	Calcium	15	0.74203	0.13906	6.4486	-0.34857	15	0.95297	0.06179	-4.21771	0.22160	1.01820
24	Magnesium	15	0.74660	0.14561	5.0359	-0.36942	15	0.96054	0.05981	-6.31347	0.23726	1.08340
25	Chloride	15	0.94982	0.15303	11.5048	-0.98404	15	0.97848	0.10432	1.69541	-0.45968	0.93639
26	Sulfate	15	0.69493	0.21355	7.7343	-0.47636	15	0.93961	0.09889	-8.48857	0.39084	1.54862
27	Carbonate	15	0.75635	0.09969	5.9617	-0.25961	15	0.93061	0.05538	-1.19006	0.12269	0.68270
28	Sodium +K	15	0.91747	0.16680	10.0129	-0.82198	15	0.98636	0.07057	-2.91457	-0.13094	1.23404

9. STATION 09095500 (CAMEO) Colorado River near Cameo, CO

STATION 09095500 Colorado River near Cameo, CO UPDATE 2014
SUMMARY OF QW OBSERVATIONS, BY 3-YEAR SLIDING GROUP

Obs	WATER YEAR	# OF QW OBSV.	% P70300 SUBST.	% P00060 SUBST.
1	2010	15	0.0	0.0
2	2011	15	0.0	0.0
3	2012	16	0.0	0.0
4	2013	14	0.0	0.0
5	2014	14	0.0	0.0

STATION 09095500 Colorado River near Cameo, CO UPDATE 2014
REGRESSION STATISTICS, BY 3-YEAR SLIDING GROUPS
REGRESSION #1: VARIABLE = e**A * DISCHARGE**B
REGRESSION #2: VARIABLE = e**C * DISCHARGE**D * COND**E
VARIABLE=(mg/L), except for SALT LOAD (tons/day)
DISCHARGE=(cfs) COND=(uMHOS/cm)

GROUP=2010

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
1	SALT LOAD	15	0.69355	0.20719	5.4497	0.35552	15	0.99087	0.03723	-9.7008	1.15985	1.28917
2	Calcium	15	0.53831	0.35876	7.6834	-0.44186	15	0.92347	0.15203	-16.6433	0.84963	2.06998
3	Magnesium	15	0.97066	0.07130	6.3860	-0.46775	15	0.98268	0.05702	2.9976	-0.28786	0.28832
4	Chloride	15	0.98501	0.10667	12.6991	-0.98628	15	0.98852	0.09715	8.8654	-0.78275	0.32621
5	Sulfate	15	0.67720	0.42328	10.2562	-0.69928	15	0.97094	0.13218	-19.7201	0.89214	2.55071
6	Carbonate	15	0.94935	0.05726	6.5579	-0.28275	15	0.96268	0.05116	8.7390	-0.39855	-0.18559
7	Sodium +K	15	0.98784	0.08660	11.6184	-0.89036	15	0.99166	0.07466	8.0161	-0.69911	0.30652

GROUP=2011

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
8	SALT LOAD	15	0.69355	0.20719	5.4497	0.35552	15	0.99087	0.03723	-9.7008	1.15985	1.28917
9	Calcium	15	0.53831	0.35876	7.6834	-0.44186	15	0.92347	0.15203	-16.6433	0.84963	2.06998
10	Magnesium	15	0.97066	0.07130	6.3860	-0.46775	15	0.98268	0.05702	2.9976	-0.28786	0.28832
11	Chloride	15	0.98501	0.10667	12.6991	-0.98628	15	0.98852	0.09715	8.8654	-0.78275	0.32621
12	Sulfate	15	0.67720	0.42328	10.2562	-0.69928	15	0.97094	0.13218	-19.7201	0.89214	2.55071
13	Carbonate	15	0.94935	0.05726	6.5579	-0.28275	15	0.96268	0.05116	8.7390	-0.39855	-0.18559
14	Sodium +K	15	0.98784	0.08660	11.6184	-0.89036	15	0.99166	0.07466	8.0161	-0.69911	0.30652

GROUP=2012

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
15	SALT LOAD	16	0.64393	0.22372	5.1436	0.38825	16	0.99077	0.03739	-9.8711	1.16934	1.30316
16	Calcium	16	0.46220	0.35538	7.5203	-0.42516	16	0.91268	0.14860	-14.5966	0.72540	1.91959
17	Magnesium	16	0.90305	0.11830	6.3206	-0.46592	16	0.95168	0.08667	0.6233	-0.16954	0.49448
18	Chloride	16	0.97460	0.11503	12.1166	-0.91955	16	0.98443	0.09345	7.2494	-0.66635	0.42244
19	Sulfate	16	0.57217	0.42857	9.7279	-0.63959	16	0.94659	0.15714	-17.5348	0.77866	2.36620
20	Carbonate	16	0.89816	0.07271	6.4952	-0.27866	16	0.89837	0.07538	6.7157	-0.29013	-0.01914
21	Sodium +K	16	0.96363	0.12739	11.2169	-0.84617	16	0.97903	0.10038	5.5795	-0.55290	0.48929

GROUP=2013

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
22	SALT LOAD	14	0.52482	0.24140	5.2225	0.37616	14	0.99345	0.02960	-10.4777	1.21798	1.33804
23	Calcium	14	0.34296	0.38095	7.4078	-0.40808	14	0.95987	0.09834	-16.7670	0.88814	2.06029
24	Magnesium	14	0.87588	0.12134	6.3938	-0.47791	14	0.93935	0.08859	0.7116	-0.17324	0.48427
25	Chloride	14	0.97822	0.09691	12.4139	-0.96306	14	0.98811	0.07480	8.1375	-0.73376	0.36445
26	Sulfate	14	0.42070	0.46401	9.3243	-0.58630	14	0.96446	0.12004	-20.1167	0.99229	2.50910
27	Carbonate	14	0.80594	0.07831	6.1599	-0.23661	14	0.80726	0.08151	6.5837	-0.25933	-0.03612
28	Sodium +K	14	0.95943	0.11925	11.2831	-0.85990	14	0.97852	0.09064	5.9262	-0.57267	0.45654

10. STATION 09152500 (GUNN) Gunnison River near Grand Junction, CO

STATION 09152500 Gunnison River near Grand Junction, Co UPDATE 2014
SUMMARY OF QW OBSERVATIONS, BY 3-YEAR SLIDING GROUP

Obs	WATER YEAR	# OF QW OBSV.	% P70300 SUBST.	% P00060 SUBST.
1	2010	21	0.0	0.0
2	2011	21	0.0	0.0
3	2012	25	0.0	0.0
4	2013	21	0.0	0.0
5	2014	21	0.0	0.0

STATION 09152500 Gunnison River near Grand Junction, Co UPDATE 2014
REGRESSION STATISTICS, BY 3-YEAR SLIDING GROUPS
REGRESSION #1: VARIABLE = e**A * DISCHARGE**B
REGRESSION #2: VARIABLE = e**C * DISCHARGE**D * COND**E
VARIABLE=(mg/L), except for SALT LOAD (tons/day)
DISCHARGE=(cfs) COND=(uMHOS/cm)

GROUP=2010

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
1	SALT LOAD	21	0.75515	0.18860	3.2308	0.61397	21	0.99146	0.03618	-6.67547	0.98558	1.07359
2	Calcium	21	0.41139	0.21899	7.0209	-0.33936	21	0.91791	0.08402	-3.83998	0.06805	1.17703
3	Magnesium	21	0.63531	0.17201	6.4570	-0.42085	21	0.91950	0.08303	-1.66142	-0.11631	0.87983
4	Chloride	21	0.80294	0.13262	5.6407	-0.49625	21	0.88934	0.10211	0.94576	-0.32013	0.50881
5	Sulfate	21	0.51136	0.23788	8.9302	-0.45109	21	0.98321	0.04531	-3.56743	0.01772	1.35442
6	Carbonate	21	0.68793	0.10560	6.5579	-0.29064	21	0.83715	0.07837	2.65375	-0.14418	0.42311
7	Sodium +K	21	0.64034	0.18331	7.2117	-0.45339	21	0.93655	0.07910	-1.68229	-0.11976	0.96388

GROUP=2011

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
8	SALT LOAD	21	0.75515	0.18860	3.2308	0.61397	21	0.99146	0.03618	-6.67547	0.98558	1.07359
9	Calcium	21	0.41139	0.21899	7.0209	-0.33936	21	0.91791	0.08402	-3.83998	0.06805	1.17703
10	Magnesium	21	0.63531	0.17201	6.4570	-0.42085	21	0.91950	0.08303	-1.66142	-0.11631	0.87983
11	Chloride	21	0.80294	0.13262	5.6407	-0.49625	21	0.88934	0.10211	0.94576	-0.32013	0.50881
12	Sulfate	21	0.51136	0.23788	8.9302	-0.45109	21	0.98321	0.04531	-3.56743	0.01772	1.35442
13	Carbonate	21	0.68793	0.10560	6.5579	-0.29064	21	0.83715	0.07837	2.65375	-0.14418	0.42311
14	Sodium +K	21	0.64034	0.18331	7.2117	-0.45339	21	0.93655	0.07910	-1.68229	-0.11976	0.96388

GROUP=2012

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
15	SALT LOAD	25	0.77282	0.18880	3.5705	0.57022	25	0.99299	0.03391	-6.68460	0.98410	1.07648
16	Calcium	25	0.52634	0.21939	7.3442	-0.37870	25	0.95286	0.07076	-4.14238	0.08488	1.20574
17	Magnesium	25	0.72350	0.16867	6.6487	-0.44678	25	0.94012	0.08026	-1.58840	-0.11434	0.86465
18	Chloride	25	0.87980	0.11563	5.7433	-0.51226	25	0.92582	0.09288	1.79594	-0.35295	0.41435
19	Sulfate	25	0.62645	0.23481	9.2891	-0.49793	25	0.98510	0.04795	-3.40534	0.01440	1.33253
20	Carbonate	25	0.73513	0.11613	6.7637	-0.31679	25	0.88050	0.07975	2.01700	-0.12522	0.49826
21	Sodium +K	25	0.74330	0.18009	7.5806	-0.50182	25	0.94140	0.08798	-1.14841	-0.14953	0.91629

GROUP=2013

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
22	SALT LOAD	21	0.54587	0.15494	4.7783	0.39469	21	0.98056	0.03294	-7.45124	1.02475	1.14713
23	Calcium	21	0.57480	0.21006	8.6362	-0.56748	21	0.96884	0.05842	-7.67838	0.27305	1.53032
24	Magnesium	21	0.76353	0.14573	7.7653	-0.60842	21	0.91897	0.08764	-1.76674	-0.11732	0.89411
25	Chloride	21	0.89710	0.09925	6.9134	-0.68089	21	0.91421	0.09311	3.64860	-0.51269	0.30624
26	Sulfate	21	0.74266	0.17413	10.5898	-0.68733	21	0.98212	0.04716	-2.96182	0.01085	1.27115
27	Carbonate	21	0.69600	0.11764	7.4314	-0.41358	21	0.92585	0.05969	-0.82100	0.01159	0.77408
28	Sodium +K	21	0.80890	0.14139	8.7895	-0.67588	21	0.92328	0.09204	-0.03520	-0.22123	0.82776

11. STATION 09180000 (DOLOR) Dolores River near Cisco, UT

STATION 09180000 Dolores River near Cisco, UT UPDATE 2014
SUMMARY OF QW OBSERVATIONS, BY 3-YEAR SLIDING GROUP

Obs	WATER YEAR	# OF QW OBSV.	% P70300 SUBST.	% P00060 SUBST.
1	2010	25	4.0	0.0
2	2011	25	4.0	0.0
3	2012	24	0.0	0.0
4	2013	20	0.0	0.0
5	2014	20	0.0	0.0

STATION 09180000 Dolores River near Cisco, UT UPDATE 2014
REGRESSION STATISTICS, BY 3-YEAR SLIDING GROUPS
REGRESSION #1: VARIABLE = e**A * DISCHARGE**B
REGRESSION #2: VARIABLE = e**C * DISCHARGE**D * COND**E
VARIABLE=(mg/L), except for SALT LOAD (tons/day)
DISCHARGE=(cfs) COND=(uMHOS/cm)

GROUP=2010

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
1	SALT LOAD	25	0.73201	0.33233	3.09468	0.53432	25	0.99325	0.05394	-6.11243	0.97097	0.97772
2	Calcium	24	0.64619	0.25565	6.21452	-0.32936	24	0.78208	0.20536	1.55242	-0.11050	0.49871
3	Magnesium	24	0.75260	0.26548	5.56640	-0.44141	24	0.91647	0.15789	-0.79126	-0.14295	0.68009
4	Chloride	24	0.55728	0.66788	8.66663	-0.71434	24	0.86376	0.37922	-7.68448	0.05326	1.74911
5	Sulfate	24	0.69339	0.37441	8.17155	-0.53675	24	0.80949	0.30207	1.39229	-0.21850	0.72519
6	Carbonate	24	0.73592	0.12646	5.50512	-0.20126	24	0.82850	0.10431	3.30185	-0.09782	0.23569
7	Sodium +K	24	0.59210	0.51962	7.79399	-0.59682	24	0.92585	0.22675	-6.03636	0.05245	1.47946

GROUP=2011

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
8	SALT LOAD	25	0.73201	0.33233	3.09468	0.53432	25	0.99325	0.05394	-6.11243	0.97097	0.97772
9	Calcium	24	0.64619	0.25565	6.21452	-0.32936	24	0.78208	0.20536	1.55242	-0.11050	0.49871
10	Magnesium	24	0.75260	0.26548	5.56640	-0.44141	24	0.91647	0.15789	-0.79126	-0.14295	0.68009
11	Chloride	24	0.55728	0.66788	8.66663	-0.71434	24	0.86376	0.37922	-7.68448	0.05326	1.74911
12	Sulfate	24	0.69339	0.37441	8.17155	-0.53675	24	0.80949	0.30207	1.39229	-0.21850	0.72519
13	Carbonate	24	0.73592	0.12646	5.50512	-0.20126	24	0.82850	0.10431	3.30185	-0.09782	0.23569
14	Sodium +K	24	0.59210	0.51962	7.79399	-0.59682	24	0.92585	0.22675	-6.03636	0.05245	1.47946

GROUP=2012

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
15	SALT LOAD	24	0.78785	0.25997	2.86985	0.55173	24	0.98901	0.06057	-6.11259	0.97802	0.97324
16	Calcium	24	0.60790	0.23158	6.09818	-0.31755	24	0.71575	0.20181	1.78844	-0.11302	0.46695
17	Magnesium	24	0.68757	0.27198	5.50471	-0.44434	24	0.88211	0.17100	-2.11070	-0.08293	0.82512
18	Chloride	24	0.58465	0.58403	8.72886	-0.76309	24	0.87295	0.33060	-8.53670	0.05630	1.87070
19	Sulfate	24	0.70051	0.29956	7.94080	-0.50455	24	0.78219	0.26148	2.38974	-0.24111	0.60145
20	Carbonate	24	0.53764	0.15376	5.37385	-0.18261	24	0.81349	0.09996	1.15948	0.01740	0.45662
21	Sodium +K	24	0.60491	0.45283	7.72671	-0.61707	24	0.94180	0.17789	-7.11081	0.08709	1.60763

GROUP=2013

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
22	SALT LOAD	20	0.65787	0.29430	3.12049	0.49551	20	0.98516	0.06308	-6.19589	0.98908	0.97749
23	Calcium	20	0.61345	0.25381	6.45519	-0.38823	20	0.76579	0.20329	1.29825	-0.11503	0.54107
24	Magnesium	20	0.65042	0.32049	5.93625	-0.53080	20	0.89332	0.18218	-2.71037	-0.07272	0.90721
25	Chloride	20	0.52827	0.57742	8.51457	-0.74194	20	0.85983	0.32388	-7.15338	0.08811	1.64390
26	Sulfate	20	0.67933	0.34174	8.43313	-0.60395	20	0.81129	0.26976	1.33786	-0.22806	0.74444
27	Carbonate	20	0.48179	0.18386	5.54119	-0.21525	20	0.84638	0.10301	0.54992	0.04918	0.52369
28	Sodium +K	20	0.55229	0.46980	7.73818	-0.63357	20	0.94836	0.16418	-6.56362	0.12411	1.50056

12. STATION 09180500 (CISCO) Colorado River near Cisco, UT

STATION 09180500 Colorado River near Cisco, UT UPDATE 2014
SUMMARY OF QW OBSERVATIONS, BY 3-YEAR SLIDING GROUP

Obs	WATER YEAR	# OF QW OBSV.	% P70300 SUBST.	% P00060 SUBST.
1	2010	25	0.0	0.0
2	2011	25	0.0	0.0
3	2012	25	0.0	0.0
4	2013	19	0.0	0.0
5	2014	19	0.0	0.0

STATION 09180500 Colorado River near Cisco, UT UPDATE 2014
REGRESSION STATISTICS, BY 3-YEAR SLIDING GROUPS
REGRESSION #1: VARIABLE = e**A * DISCHARGE**B
REGRESSION #2: VARIABLE = e**C * DISCHARGE**D * COND**E
VARIABLE=(mg/L), except for SALT LOAD (tons/day)
DISCHARGE=(cfs) COND=(uMHOS/cm)

GROUP=2010

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
1	SALT LOAD	25	0.76320	0.16459	5.6954	0.38446	25	0.98595	0.04100	-8.07891	1.05423	1.18027
2	Calcium	25	0.72294	0.25883	9.0757	-0.54400	25	0.89945	0.15943	-8.75107	0.32283	1.52751
3	Magnesium	25	0.92605	0.12556	8.0980	-0.57814	25	0.98222	0.06295	-1.34469	-0.11899	0.80911
4	Chloride	25	0.93496	0.17399	11.6219	-0.85832	25	0.93736	0.17458	8.73367	-0.71788	0.24748
5	Sulfate	25	0.82341	0.26111	11.6341	-0.73361	25	0.96770	0.11418	-8.73233	0.25671	1.74513
6	Carbonate	25	0.87257	0.07652	6.6515	-0.26052	25	0.91998	0.06200	2.62423	-0.06469	0.34508
7	Sodium +K	25	0.95684	0.12357	10.7727	-0.75704	25	0.96373	0.11583	6.51202	-0.54986	0.36508

GROUP=2011

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
8	SALT LOAD	25	0.76320	0.16459	5.6954	0.38446	25	0.98595	0.04100	-8.07891	1.05423	1.18027
9	Calcium	25	0.72294	0.25883	9.0757	-0.54400	25	0.89945	0.15943	-8.75107	0.32283	1.52751
10	Magnesium	25	0.92605	0.12556	8.0980	-0.57814	25	0.98222	0.06295	-1.34469	-0.11899	0.80911
11	Chloride	25	0.93496	0.17399	11.6219	-0.85832	25	0.93736	0.17458	8.73367	-0.71788	0.24748
12	Sulfate	25	0.82341	0.26111	11.6341	-0.73361	25	0.96770	0.11418	-8.73233	0.25671	1.74513
13	Carbonate	25	0.87257	0.07652	6.6515	-0.26052	25	0.91998	0.06200	2.62423	-0.06469	0.34508
14	Sodium +K	25	0.95684	0.12357	10.7727	-0.75704	25	0.96373	0.11583	6.51202	-0.54986	0.36508

GROUP=2012

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
15	SALT LOAD	25	0.74794	0.19699	5.2429	0.43488	25	0.99141	0.03719	-8.48088	1.07151	1.21825
16	Calcium	25	0.63223	0.29033	8.5649	-0.48785	25	0.91726	0.14080	-9.55332	0.35263	1.60834
17	Magnesium	25	0.87198	0.15713	7.6153	-0.52556	25	0.97670	0.06854	-2.45887	-0.05823	0.89428
18	Chloride	25	0.94724	0.15236	11.3184	-0.82735	25	0.95329	0.14658	7.66188	-0.65774	0.32458
19	Sulfate	25	0.75144	0.29849	11.0342	-0.66514	25	0.97001	0.10601	-8.80721	0.25528	1.76130
20	Carbonate	25	0.78836	0.09531	6.4243	-0.23574	25	0.89225	0.06953	1.69115	-0.01617	0.42016
21	Sodium +K	25	0.92962	0.15468	10.4240	-0.72048	25	0.95658	0.12423	3.63778	-0.40567	0.60241

GROUP=2013

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
22	SALT LOAD	19	0.35911	0.23195	5.6016	0.38948	19	0.97722	0.04508	-8.26805	1.07847	1.18115
23	Calcium	19	0.32437	0.32751	8.7398	-0.50903	19	0.86743	0.14954	-9.13816	0.37908	1.52250
24	Magnesium	19	0.64514	0.18494	7.8795	-0.55936	19	0.95835	0.06531	-2.69962	-0.03383	0.90093
25	Chloride	19	0.81703	0.16392	10.8857	-0.77697	19	0.86667	0.14423	5.68740	-0.51874	0.44269
26	Sulfate	19	0.46857	0.33683	11.3865	-0.70946	19	0.93505	0.12138	-7.82766	0.24503	1.63629
27	Carbonate	19	0.59044	0.11345	6.9829	-0.30556	19	0.81407	0.07880	1.87854	-0.05199	0.43469
28	Sodium +K	19	0.74576	0.16989	9.8547	-0.65268	19	0.88921	0.11560	2.08457	-0.26669	0.66171

13. STATION 09355500 (ARCH) San Juan River near Archuleta, NM

STATION 09355500 San Juan River near Archuleta, NM UPDATE 2014
SUMMARY OF QW OBSERVATIONS, BY 3-YEAR SLIDING GROUP

Obs	WATER YEAR	# OF QW OBSV.	% P70300 SUBST.	% P00060 SUBST.
1	2010	11	18.2	0.0
2	2011	11	18.2	0.0
3	2012	11	18.2	9.1
4	2013	8	12.5	12.5

STATION 09355500 San Juan River near Archuleta, NM UPDATE 2014
REGRESSION STATISTICS, BY 3-YEAR SLIDING GROUPS
REGRESSION #1: VARIABLE = e**A * DISCHARGE**B
REGRESSION #2: VARIABLE = e**C * DISCHARGE**D * COND**E
VARIABLE=(mg/L), except for SALT LOAD (tons/day)
DISCHARGE=(cfs) COND=(uMHOS/cm)

GROUP=2010

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
1	SALT LOAD	11	0.99838	0.03964	-0.82861	0.98791	11	0.99943	0.024975	-7.57890	1.01077	1.19937
2	Calcium	9	0.01478	0.03985	3.37951	-0.00470	9	0.30387	0.036177	-1.36735	0.00824	0.84804
3	Magnesium	9	0.13612	0.03464	1.59656	0.01325	9	0.38033	0.031693	-2.45451	0.02430	0.72373
4	Chloride	9	0.11845	0.05237	1.12096	-0.01850	9	0.57739	0.039166	-7.18936	0.00416	1.48466
5	Sulfate	9	0.34936	0.04856	3.85504	-0.03429	9	0.63152	0.039474	-3.17819	-0.01512	1.25650
6	Carbonate	9	0.00341	0.02452	3.88664	-0.00138	9	0.35082	0.021377	0.70247	0.00730	0.56886
7	Sodium +K	9	0.09811	0.05423	2.56832	0.01724	9	0.27226	0.052615	-2.67240	0.03152	0.93627

GROUP=2011

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
8	SALT LOAD	11	0.99838	0.03964	-0.82861	0.98791	11	0.99943	0.024975	-7.57890	1.01077	1.19937
9	Calcium	9	0.01478	0.03985	3.37951	-0.00470	9	0.30387	0.036177	-1.36735	0.00824	0.84804
10	Magnesium	9	0.13612	0.03464	1.59656	0.01325	9	0.38033	0.031693	-2.45451	0.02430	0.72373
11	Chloride	9	0.11845	0.05237	1.12096	-0.01850	9	0.57739	0.039166	-7.18936	0.00416	1.48466
12	Sulfate	9	0.34936	0.04856	3.85504	-0.03429	9	0.63152	0.039474	-3.17819	-0.01512	1.25650
13	Carbonate	9	0.00341	0.02452	3.88664	-0.00138	9	0.35082	0.021377	0.70247	0.00730	0.56886
14	Sodium +K	9	0.09811	0.05423	2.56832	0.01724	9	0.27226	0.052615	-2.67240	0.03152	0.93627

GROUP=2012

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
15	SALT LOAD	11	0.99689	0.05646	-0.66235	0.96753	11	0.99938	0.026826	-6.65145	1.00296	1.04049
16	Calcium	9	0.22128	0.05915	3.57276	-0.02826	9	0.75805	0.035613	-1.83905	0.00744	0.93500
17	Magnesium	9	0.08834	0.04068	1.79889	-0.01135	9	0.83946	0.018441	-2.27058	0.01549	0.70308
18	Chloride	9	0.38393	0.07008	1.36465	-0.04957	9	0.88699	0.032419	-5.61347	-0.00355	1.20561
19	Sulfate	9	0.43227	0.10861	4.26193	-0.08493	9	0.92955	0.041326	-6.93940	-0.01105	1.93525
20	Carbonate	9	0.16482	0.03535	3.98779	-0.01407	9	0.60731	0.026185	1.15196	0.00463	0.48995
21	Sodium +K	9	0.20648	0.10130	3.07983	-0.04630	9	0.72960	0.063871	-5.98378	0.01347	1.56592

GROUP=2013

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
22	SALT LOAD	8	0.99523	0.06709	-0.48319	0.94146	8	0.99936	0.027033	-7.36332	1.01001	1.16019
23	Calcium	7	0.51668	0.05165	3.72623	-0.04877	7	0.97396	0.013404	-2.46011	0.01981	1.03326
24	Magnesium	7	0.45254	0.04060	1.94714	-0.03371	7	0.98309	0.007978	-2.97453	0.02085	0.82204
25	Chloride	7	0.71228	0.06263	1.64154	-0.08999	7	0.92325	0.036162	-4.96185	-0.01678	1.10292
26	Sulfate	7	0.64785	0.11750	4.68876	-0.14555	7	0.94958	0.049708	-8.70456	0.00293	2.23700
27	Carbonate	7	0.52423	0.04058	4.15466	-0.03890	7	0.82100	0.027831	0.20782	0.00485	0.65922
28	Sodium +K	7	0.43870	0.09307	3.30101	-0.07515	7	0.75559	0.068666	-5.31035	0.02032	1.43830

14. STATION 09379500 (BLUFF) San Juan River near Bluff, UT

STATION 09379500 San Juan River near Bluff, UT UPDATE 2014
SUMMARY OF QW OBSERVATIONS, BY 3-YEAR SLIDING GROUP

Obs	WATER YEAR	# OF QW OBSV.	% P70300 SUBST.	% P00060 SUBST.
1	2010	25	0.0	0.0
2	2011	25	0.0	0.0
3	2012	26	0.0	0.0
4	2013	19	0.0	0.0
5	2014	19	0.0	0.0

STATION 09379500 San Juan River near Bluff, UT UPDATE 2014
REGRESSION STATISTICS, BY 3-YEAR SLIDING GROUPS
REGRESSION #1: VARIABLE = e**A * DISCHARGE**B
REGRESSION #2: VARIABLE = e**C * DISCHARGE**D * COND**E
VARIABLE=(mg/L), except for SALT LOAD (tons/day)
DISCHARGE=(cfs) COND=(uMHOS/cm)

GROUP=2010

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
1	SALT LOAD	25	0.65567	0.24495	1.29613	0.83311	25	0.99458	0.03141	-7.18479	0.98945	1.14038
2	Calcium	25	0.00587	0.24648	4.57240	-0.04666	25	0.75066	0.12622	-2.87289	0.09059	1.00112
3	Magnesium	25	0.14421	0.30007	4.81187	-0.30360	25	0.36601	0.26408	-0.51931	-0.20532	0.71685
4	Chloride	25	0.32570	0.20565	5.05855	-0.35227	25	0.81375	0.11051	-1.04730	-0.23971	0.82102
5	Sulfate	25	0.04261	0.31306	6.41440	-0.16278	25	0.97758	0.04898	-4.38230	0.03625	1.45177
6	Carbonate	25	0.50799	0.12573	6.43751	-0.31489	25	0.75582	0.09057	3.32328	-0.25748	0.41875
7	Sodium +K	25	0.10224	0.33965	5.79613	-0.28250	25	0.65905	0.21401	-3.53868	-0.11041	1.25520

GROUP=2011

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
8	SALT LOAD	25	0.65567	0.24495	1.29613	0.83311	25	0.99458	0.03141	-7.18479	0.98945	1.14038
9	Calcium	25	0.00587	0.24648	4.57240	-0.04666	25	0.75066	0.12622	-2.87289	0.09059	1.00112
10	Magnesium	25	0.14421	0.30007	4.81187	-0.30360	25	0.36601	0.26408	-0.51931	-0.20532	0.71685
11	Chloride	25	0.32570	0.20565	5.05855	-0.35227	25	0.81375	0.11051	-1.04730	-0.23971	0.82102
12	Sulfate	25	0.04261	0.31306	6.41440	-0.16278	25	0.97758	0.04898	-4.38230	0.03625	1.45177
13	Carbonate	25	0.50799	0.12573	6.43751	-0.31489	25	0.75582	0.09057	3.32328	-0.25748	0.41875
14	Sodium +K	25	0.10224	0.33965	5.79613	-0.28250	25	0.65905	0.21401	-3.53868	-0.11041	1.25520

GROUP=2012

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
15	SALT LOAD	26	0.92782	0.21995	-1.33160	1.23257	26	0.99859	0.03135	-7.50197	1.00002	1.17769
16	Calcium	26	0.28700	0.28373	2.39650	0.28137	26	0.72328	0.18056	-3.89147	0.04439	1.20013
17	Magnesium	26	0.00209	0.42362	2.92739	-0.03028	26	0.26527	0.37131	-3.23600	-0.26256	1.17635
18	Chloride	26	0.34586	0.18292	4.10121	-0.20790	26	0.59710	0.14665	0.88947	-0.32895	0.61300
19	Sulfate	26	0.33696	0.27531	3.33471	0.30677	26	0.97890	0.05016	-4.33984	0.01753	1.46478
20	Carbonate	26	0.42385	0.11745	5.37351	-0.15746	26	0.42883	0.11946	5.06425	-0.16911	0.05903
21	Sodium +K	26	0.17776	0.27256	2.65689	0.19809	26	0.53318	0.20979	-2.42002	0.00675	0.96899

GROUP=2013

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
22	SALT LOAD	19	0.93217	0.24894	-1.26969	1.23026	19	0.99892	0.03232	-7.46200	1.00502	1.16558
23	Calcium	19	0.26739	0.34540	2.45697	0.27817	19	0.74558	0.20981	-4.54003	0.02366	1.31704
24	Magnesium	19	0.00110	0.48241	2.85655	-0.02135	19	0.33683	0.40517	-4.15602	-0.27643	1.31997
25	Chloride	19	0.37866	0.21669	4.24912	-0.22549	19	0.64599	0.16859	0.68533	-0.35512	0.67081
26	Sulfate	19	0.36238	0.30635	3.37953	0.30786	19	0.98430	0.04955	-4.20666	0.03192	1.42795
27	Carbonate	19	0.48172	0.13358	5.47356	-0.17167	19	0.49191	0.13633	5.00391	-0.18875	0.08840
28	Sodium +K	19	0.20837	0.27143	2.82272	0.18563	19	0.51080	0.21994	-1.38382	0.03262	0.79180

15. STATION 09380000 (LEES) Colorado River at Lees Ferry, AZ

STATION 09380000 Colorado River at Lees Ferry, AZ UPDATE 2014
SUMMARY OF QW OBSERVATIONS, BY 3-YEAR SLIDING GROUP

Obs	WATER YEAR	# OF QW OBSV.	% P70300 SUBST.	% P00060 SUBST.
1	2010	13	0.0	0.0
2	2011	13	0.0	0.0
3	2012	22	0.0	0.0
4	2013	27	0.0	0.0
5	2014	27	0.0	0.0

STATION 09380000 Colorado River at Lees Ferry, AZ UPDATE 2014
REGRESSION STATISTICS, BY 3-YEAR SLIDING GROUPS
REGRESSION #1: VARIABLE = e**A * DISCHARGE**B
REGRESSION #2: VARIABLE = e**C * DISCHARGE**D * COND**E
VARIABLE=(mg/L), except for SALT LOAD (tons/day)
DISCHARGE=(cfs) COND=(uMHOS/cm)

GROUP=2010

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
1	SALT LOAD	13	0.93679	0.08677	-0.00704	1.01421	13	0.99723	0.019035	-6.28397	0.99733	0.98615
2	Calcium	13	0.00111	0.07689	4.19316	-0.00777	13	0.65935	0.047093	-0.42438	-0.02019	0.72544
3	Magnesium	13	0.01265	0.05507	3.17120	-0.01892	13	0.77142	0.027789	-0.40001	-0.02853	0.56106
4	Chloride	13	0.00894	0.17282	3.18667	0.04984	13	0.94827	0.041409	-9.26008	0.01636	1.95546
5	Sulfate	13	0.02106	0.10499	4.65077	0.04675	13	0.96926	0.019514	-2.99345	0.02619	1.20096
6	Carbonate	13	0.16475	0.03535	4.83442	-0.04766	13	0.80274	0.018015	2.54915	-0.05381	0.35903
7	Sodium +K	13	0.00404	0.11766	3.81575	0.02276	13	0.90738	0.037631	-4.47395	0.00046	1.30236

GROUP=2011

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
8	SALT LOAD	13	0.93679	0.08677	-0.00704	1.01421	13	0.99723	0.019035	-6.28397	0.99733	0.98615
9	Calcium	13	0.00111	0.07689	4.19316	-0.00777	13	0.65935	0.047093	-0.42438	-0.02019	0.72544
10	Magnesium	13	0.01265	0.05507	3.17120	-0.01892	13	0.77142	0.027789	-0.40001	-0.02853	0.56106
11	Chloride	13	0.00894	0.17282	3.18667	0.04984	13	0.94827	0.041409	-9.26008	0.01636	1.95546
12	Sulfate	13	0.02106	0.10499	4.65077	0.04675	13	0.96926	0.019514	-2.99345	0.02619	1.20096
13	Carbonate	13	0.16475	0.03535	4.83442	-0.04766	13	0.80274	0.018015	2.54915	-0.05381	0.35903
14	Sodium +K	13	0.00404	0.11766	3.81575	0.02276	13	0.90738	0.037631	-4.47395	0.00046	1.30236

GROUP=2012

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
15	SALT LOAD	22	0.93635	0.10328	0.55635	0.96015	22	0.99785	0.019495	-6.90662	1.00348	1.07543
16	Calcium	22	0.01022	0.06836	4.30645	-0.01684	22	0.86680	0.025730	-0.36874	0.01030	0.67371
17	Magnesium	22	0.05108	0.07919	3.45474	-0.04453	22	0.87742	0.029200	-1.97766	-0.01299	0.78282
18	Chloride	22	0.02235	0.19865	4.40606	-0.07280	22	0.96763	0.037084	-9.95377	0.01056	2.06929
19	Sulfate	22	0.01713	0.12197	5.51607	-0.03903	22	0.96936	0.022095	-3.30940	0.01221	1.27178
20	Carbonate	22	0.12023	0.04826	4.82209	-0.04324	22	0.77524	0.025026	1.76099	-0.02547	0.44111
21	Sodium +K	22	0.00081	0.12324	4.14818	-0.00850	22	0.88258	0.043345	-4.36273	0.04091	1.22645

GROUP=2013

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
22	SALT LOAD	27	0.85698	0.13101	1.26132	0.89143	27	0.99831	0.014524	-7.30450	1.02047	1.11251
23	Calcium	27	0.07372	0.09327	4.87881	-0.07314	27	0.93408	0.025394	-1.03331	0.01592	0.76785
24	Magnesium	27	0.09893	0.09539	3.90599	-0.08786	27	0.95739	0.021172	-2.21814	0.00439	0.79539
25	Chloride	27	0.10427	0.22755	5.83295	-0.21581	27	0.97853	0.035958	-8.95312	0.00693	1.92038
26	Sulfate	27	0.07901	0.15294	6.38597	-0.12451	27	0.98286	0.021295	-3.57937	0.02561	1.29428
27	Carbonate	27	0.10821	0.05356	4.92613	-0.05186	27	0.91182	0.017189	1.58220	-0.00148	0.43430
28	Sodium +K	27	0.06516	0.16534	5.28532	-0.12134	27	0.93476	0.044580	-5.20322	0.03667	1.36223

16. STATION 09402500 (GRCAN) Colorado River Near Grand Canyon, AZ - NO REGRESSION STATS

No QW since late 1980's. Alternate method from Mueller calculates GRCAN load from Lees Ferry load and the flow difference between GRCAN and LEES. See no.15 STATION 09380000 (LEES) Colorado River at Lees Ferry, AZ

COLORADO RIVER NEAR GRAND CANYON-09402500- MONTHLY Q, LOAD, TDS DATA, JAN 2011-DECEMBER 2013

Obs	YEAR	MONTH	WMONTH	GCQ	GCLOAD	MTDS
16	2011	1	Jan	1,036,542	652,526	463
17	2011	2	Feb	1,009,377	662,880	483
18	2011	3	Mar	1,088,747	763,988	516
19	2011	4	Apr	1,006,243	732,415	535
20	2011	5	May	1,211,860	835,867	507
21	2011	6	Jun	1,415,469	939,378	488
22	2011	7	Jul	1,533,417	1,000,189	480
23	2011	8	Aug	1,537,255	965,285	462
24	2011	9	Sep	998,567	627,824	462
25	2011	10	Oct	1,014,408	622,860	452
26	2011	11	Nov	1,127,689	655,382	427
27	2011	12	Dec	1,257,872	652,818	382
28	2012	1	Jan	886,142	508,891	422
29	2012	2	Feb	673,226	449,683	491
30	2012	3	Mar	629,120	471,203	551
31	2012	4	Apr	628,225	458,955	537
32	2012	5	May	624,780	428,571	504
33	2012	6	Jun	735,191	488,483	489
34	2012	7	Jul	918,543	586,686	470
35	2012	8	Aug	878,874	563,738	472
36	2012	9	Sep	525,878	363,102	508
37	2012	10	Oct	524,754	347,336	487
38	2012	11	Nov	764,523	494,583	476
39	2012	12	Dec	822,664	519,035	464
40	2013	1	Jan	838,669	531,746	466
41	2013	2	Feb	634,136	443,985	515
42	2013	3	Mar	652,681	483,170	544
43	2013	4	Apr	575,938	458,212	585
44	2013	5	May	630,471	489,271	571
45	2013	6	Jun	831,642	610,947	540
46	2013	7	Jul	924,327	656,202	522
47	2013	8	Aug	882,252	623,741	520
48	2013	9	Sep	686,242	517,262	554
49	2013	10	Oct	502,480	387,771	568
50	2013	11	Nov	722,946	555,964	566
51	2013	12	Dec	620,157	470,795	558

17. STATION 09415000 (VIRGIN) Virgin River at Littlefield, AZ

STATION 09415000 Virgin River at Littlefield, AZ UPDATE 2014
SUMMARY OF QW OBSERVATIONS, BY 3-YEAR SLIDING GROUP

Obs	WATER YEAR	# OF QW OBSV.	% P70300 SUBST.	% P00060 SUBST.
1	2010	10	0.0	0.0
2	2011	10	0.0	0.0
3	2012	12	0.0	0.0
4	2013	10	0.0	0.0
5	2014	10	0.0	0.0

STATION 09415000 Virgin River at Littlefield, AZ UPDATE 2014
REGRESSION STATISTICS, BY 3-YEAR SLIDING GROUPS
REGRESSION #1: VARIABLE = e**A * DISCHARGE**B
REGRESSION #2: VARIABLE = e**C * DISCHARGE**D * COND**E
VARIABLE=(mg/L), except for SALT LOAD (tons/day)
DISCHARGE=(cfs) COND=(uMHOS/cm)

GROUP=2010

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
1	SALT LOAD	10	0.91167	0.08503	3.69869	0.58475	10	0.99950	0.00686	-6.9362	0.99171	1.08882
2	Calcium	10	0.82043	0.08436	7.44489	-0.38600	10	0.90672	0.06500	0.1099	-0.10531	0.75097
3	Magnesium	10	0.88742	0.05538	6.03912	-0.33285	10	0.94814	0.04018	0.9376	-0.13763	0.52231
4	Chloride	10	0.79838	0.12318	8.39955	-0.52472	10	0.96302	0.05640	-5.5626	0.00957	1.42947
5	Sulfate	10	0.90493	0.07602	9.17721	-0.50208	10	0.99278	0.02240	0.0105	-0.15130	0.93850
6	Carbonate	10	0.01918	0.17422	4.73029	0.05216	10	0.46825	0.13713	-10.0565	0.61800	1.51389
7	Sodium +K	10	0.72445	0.11641	7.61629	-0.40406	10	0.98796	0.02601	-6.6630	0.14237	1.46193

GROUP=2011

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
8	SALT LOAD	10	0.91167	0.08503	3.69869	0.58475	10	0.99950	0.00686	-6.9362	0.99171	1.08882
9	Calcium	10	0.82043	0.08436	7.44489	-0.38600	10	0.90672	0.06500	0.1099	-0.10531	0.75097
10	Magnesium	10	0.88742	0.05538	6.03912	-0.33285	10	0.94814	0.04018	0.9376	-0.13763	0.52231
11	Chloride	10	0.79838	0.12318	8.39955	-0.52472	10	0.96302	0.05640	-5.5626	0.00957	1.42947
12	Sulfate	10	0.90493	0.07602	9.17721	-0.50208	10	0.99278	0.02240	0.0105	-0.15130	0.93850
13	Carbonate	10	0.01918	0.17422	4.73029	0.05216	10	0.46825	0.13713	-10.0565	0.61800	1.51389
14	Sodium +K	10	0.72445	0.11641	7.61629	-0.40406	10	0.98796	0.02601	-6.6630	0.14237	1.46193

GROUP=2012

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
15	SALT LOAD	12	0.91701	0.09530	3.33673	0.65739	12	0.99902	0.01093	-7.0746	1.00178	1.09998
16	Calcium	12	0.78618	0.09242	7.37308	-0.36775	12	0.88896	0.07021	0.3310	-0.13481	0.74401
17	Magnesium	12	0.88655	0.05408	5.94772	-0.31373	12	0.95979	0.03394	1.1722	-0.15576	0.50455
18	Chloride	12	0.58306	0.15120	7.62157	-0.37103	12	0.92736	0.06653	-7.4782	0.12845	1.59533
19	Sulfate	12	0.84808	0.09050	8.89159	-0.44369	12	0.99181	0.02216	-0.7820	-0.12371	1.02204
20	Carbonate	12	0.03859	0.14234	4.70108	0.05918	12	0.36366	0.12207	-4.3947	0.36005	0.96099
21	Sodium +K	12	0.42752	0.14048	6.83400	-0.25192	12	0.91856	0.05585	-7.4644	0.22105	1.51066

GROUP=2013

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
22	SALT LOAD	10	0.95597	0.06530	2.92979	0.74233	10	0.99752	0.01658	-6.4482	0.99102	1.02775
23	Calcium	10	0.87613	0.05508	7.35621	-0.35740	10	0.97812	0.02475	-0.0334	-0.16144	0.80984
24	Magnesium	10	0.90432	0.04138	5.93555	-0.31042	10	0.97189	0.02398	0.7939	-0.17407	0.56348
25	Chloride	10	0.35990	0.09663	6.67153	-0.17678	10	0.89883	0.04107	-6.4380	0.17087	1.43670
26	Sulfate	10	0.81232	0.07400	8.55658	-0.37562	10	0.97961	0.02608	-1.7730	-0.10170	1.13203
27	Carbonate	10	0.33832	0.05083	4.61224	0.08868	10	0.33976	0.05428	4.2617	0.09798	0.03842
28	Sodium +K	10	0.14400	0.08798	6.03935	-0.08804	10	0.81399	0.04385	-5.4693	0.21715	1.26125

18. STATION 09421500 (HOOVER) Colorado River below Hoover Dam, AZ-NV

STATION 09421500 Colorado River below Hoover Dam, AZ UPDATE 2014
SUMMARY OF QW OBSERVATIONS, BY 3-YEAR SLIDING GROUP

Obs	WATER YEAR	# OF QW OBSV.	% P70300 SUBST.	% P00060 SUBST.
1	2010	33	0.0	0.0
2	2011	33	0.0	0.0
3	2012	33	0.0	0.0
4	2013	28	0.0	0.0
5	2014	28	0.0	0.0

STATION 09421500 Colorado River below Hoover Dam, AZ UPDATE 2014
REGRESSION STATISTICS, BY 3-YEAR SLIDING GROUPS
REGRESSION #1: VARIABLE = e**A * DISCHARGE**B
REGRESSION #2: VARIABLE = e**C * DISCHARGE**D * COND**E
VARIABLE=(mg/L), except for SALT LOAD (tons/day)
DISCHARGE=(cfs) COND=(uMHOS/cm)

GROUP=2010

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
1	SALT LOAD	33	0.99477	0.036527	0.51365	0.99202	33	0.99743	0.026007	-4.83370	0.99074	0.78408
2	Calcium	33	0.00261	0.050173	4.35525	-0.00505	33	0.06174	0.049467	1.84961	-0.00565	0.36740
3	Magnesium	33	0.00132	0.059810	3.24967	-0.00428	33	0.05244	0.059222	0.47404	-0.00495	0.40699
4	Chloride	33	0.00445	0.056333	4.42705	-0.00742	33	0.48911	0.041022	-3.63479	-0.00936	1.18210
5	Sulfate	33	0.00457	0.046893	5.44468	-0.00626	33	0.46571	0.034923	-1.10172	-0.00783	0.95989
6	Carbonate	33	0.00005	0.020899	4.41052	-0.00028	33	0.03425	0.020878	5.20324	-0.00009	-0.11624
7	Sodium +K	33	0.02789	0.068173	4.70594	-0.02274	33	0.48181	0.050596	-4.84897	-0.02503	1.40102

GROUP=2011

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
8	SALT LOAD	33	0.99477	0.036527	0.51365	0.99202	33	0.99743	0.026007	-4.83370	0.99074	0.78408
9	Calcium	33	0.00261	0.050173	4.35525	-0.00505	33	0.06174	0.049467	1.84961	-0.00565	0.36740
10	Magnesium	33	0.00132	0.059810	3.24967	-0.00428	33	0.05244	0.059222	0.47404	-0.00495	0.40699
11	Chloride	33	0.00445	0.056333	4.42705	-0.00742	33	0.48911	0.041022	-3.63479	-0.00936	1.18210
12	Sulfate	33	0.00457	0.046893	5.44468	-0.00626	33	0.46571	0.034923	-1.10172	-0.00783	0.95989
13	Carbonate	33	0.00005	0.020899	4.41052	-0.00028	33	0.03425	0.020878	5.20324	-0.00009	-0.11624
14	Sodium +K	33	0.02789	0.068173	4.70594	-0.02274	33	0.48181	0.050596	-4.84897	-0.02503	1.40102

GROUP=2012

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
15	SALT LOAD	33	0.99630	0.040401	0.46218	0.99525	33	0.99845	0.026615	-5.70943	0.99281	0.90924
16	Calcium	33	0.00000	0.046355	4.30377	-0.00008	33	0.09342	0.044867	1.46190	-0.00121	0.41868
17	Magnesium	33	0.00268	0.052747	3.24656	-0.00410	33	0.33104	0.043914	-2.82425	-0.00650	0.89439
18	Chloride	33	0.00642	0.064496	4.39770	-0.00778	33	0.62447	0.040306	-5.80536	-0.01181	1.50318
19	Sulfate	33	0.00025	0.053286	5.37028	-0.00126	33	0.48820	0.038756	-2.09677	-0.00421	1.10009
20	Carbonate	33	0.01256	0.025378	4.44787	-0.00429	33	0.01287	0.025794	4.35881	-0.00433	0.01312
21	Sodium +K	33	0.01683	0.070100	4.58337	-0.01376	33	0.40185	0.055581	-4.21563	-0.01724	1.29632

GROUP=2013

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
22	SALT LOAD	28	0.99830	0.029853	0.43532	0.99629	28	0.99864	0.027215	-3.44201	0.99450	0.57265
23	Calcium	28	0.01200	0.038581	4.34898	-0.00586	28	0.01206	0.039344	4.26689	-0.00590	0.01213
24	Magnesium	28	0.00482	0.047307	3.22913	-0.00454	28	0.01685	0.047952	1.72228	-0.00523	0.22255
25	Chloride	28	0.00413	0.045481	4.33530	-0.00404	28	0.37137	0.036850	-3.66758	-0.00773	1.18196
26	Sulfate	28	0.00088	0.037116	5.32415	0.00152	28	0.17818	0.034329	0.79363	-0.00058	0.66912
27	Carbonate	28	0.03604	0.025974	4.47461	-0.00692	28	0.04046	0.026428	3.96473	-0.00715	0.07530
28	Sodium +K	28	0.00975	0.064329	4.50939	-0.00879	28	0.11920	0.061871	-1.68770	-0.01166	0.91526

19. STATION 09427520 (PARKER) Colorado River below Parker Dam, AZ-CA

STATION 09427520 Colorado River below Parker Dam, AZ UPDATE 2014
SUMMARY OF QW OBSERVATIONS, BY 3-YEAR SLIDING GROUP

Obs	WATER YEAR	# OF QW OBSV.	% P70300 SUBST.	% P00060 SUBST.
1	2010	88	0.0	0.0
2	2011	88	0.0	0.0
3	2012	96	0.0	0.0
4	2013	90	0.0	0.0
5	2014	90	0.0	0.0

STATION 09427520 Colorado River below Parker Dam, AZ UPDATE 2014
REGRESSION STATISTICS, BY 3-YEAR SLIDING GROUPS
REGRESSION #1: VARIABLE = e**A * DISCHARGE**B
REGRESSION #2: VARIABLE = e**C * DISCHARGE**D * COND**E
VARIABLE=(mg/L), except for SALT LOAD (tons/day)
DISCHARGE=(cfs) COND=(uMHOS/cm)

GROUP=2010

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
1	SALT LOAD	88	0.99135	0.037009	0.53468	0.99148	88	0.99562	0.026502	-6.24631	1.00584	0.96909
2	Calcium	88	0.04327	0.047797	4.05924	0.02543	88	0.07659	0.047233	1.73181	0.03036	0.33262
3	Magnesium	88	0.10423	0.065531	3.74044	-0.05593	88	0.31776	0.057525	-4.60735	-0.03825	1.19300
4	Chloride	88	0.00686	0.065623	4.53644	-0.01364	88	0.32532	0.054405	-5.15912	0.00689	1.38561
5	Sulfate	88	0.00496	0.051685	5.49372	-0.00913	88	0.36013	0.041690	-2.56290	0.00793	1.15139
6	Carbonate	88	0.06225	0.029503	4.22371	0.01902	88	0.07676	0.029445	5.18140	0.01699	-0.13687
7	Sodium +K	88	0.05851	0.063943	4.89743	-0.03989	88	0.45032	0.049145	-5.86510	-0.01709	1.53810

GROUP=2011

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
8	SALT LOAD	88	0.99135	0.037009	0.53468	0.99148	88	0.99562	0.026502	-6.24631	1.00584	0.96909
9	Calcium	88	0.04327	0.047797	4.05924	0.02543	88	0.07659	0.047233	1.73181	0.03036	0.33262
10	Magnesium	88	0.10423	0.065531	3.74044	-0.05593	88	0.31776	0.057525	-4.60735	-0.03825	1.19300
11	Chloride	88	0.00686	0.065623	4.53644	-0.01364	88	0.32532	0.054405	-5.15912	0.00689	1.38561
12	Sulfate	88	0.00496	0.051685	5.49372	-0.00913	88	0.36013	0.041690	-2.56290	0.00793	1.15139
13	Carbonate	88	0.06225	0.029503	4.22371	0.01902	88	0.07676	0.029445	5.18140	0.01699	-0.13687
14	Sodium +K	88	0.05851	0.063943	4.89743	-0.03989	88	0.45032	0.049145	-5.86510	-0.01709	1.53810

GROUP=2012

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
15	SALT LOAD	96	0.99428	0.027426	0.51925	0.99092	96	0.99574	0.023798	-3.21758	0.99757	0.53778
16	Calcium	96	0.00538	0.044856	4.20876	0.00904	96	0.01061	0.044978	3.33186	0.01060	0.12620
17	Magnesium	96	0.07085	0.049858	3.57241	-0.03773	96	0.10656	0.049152	0.93527	-0.03303	0.37952
18	Chloride	96	0.00676	0.061383	4.50725	-0.01388	96	0.36466	0.049356	-5.43362	0.00381	1.43063
19	Sulfate	96	0.01798	0.036114	5.50321	-0.01339	96	0.10482	0.034665	2.60591	-0.00824	0.41696
20	Carbonate	96	0.11842	0.026078	4.16056	0.02619	96	0.21969	0.024666	1.77602	0.03043	0.34317
21	Sodium +K	96	0.08570	0.043938	4.83417	-0.03686	96	0.22039	0.040790	0.28449	-0.02877	0.65476

GROUP=2013

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
22	SALT LOAD	90	0.99635	0.026470	0.54868	0.98662	90	0.99657	0.025811	-1.74425	0.98949	0.33204
23	Calcium	90	0.00197	0.037137	4.32353	-0.00372	90	0.03887	0.036652	1.79666	-0.00055	0.36592
24	Magnesium	90	0.02652	0.058896	3.41259	-0.02192	90	0.02754	0.059202	4.08871	-0.02276	-0.09791
25	Chloride	90	0.03637	0.050000	4.55562	-0.02190	90	0.13464	0.047653	-1.09438	-0.01482	0.81818
26	Sulfate	90	0.10300	0.035225	5.61735	-0.02691	90	0.10812	0.035325	4.67549	-0.02573	0.13639
27	Carbonate	90	0.19515	0.025362	4.14175	0.02816	90	0.27516	0.024206	1.31224	0.03170	0.40974
28	Sodium +K	90	0.04354	0.046491	4.68633	-0.02236	90	0.05203	0.046549	3.13664	-0.02042	0.22441

20. STATION 09429490 (IMPER) Colorado River above Imperial Dam, AZ-CA

STATION 09429490 Colorado River above Imperial Dam, AZ UPDATE 2014
SUMMARY OF QW OBSERVATIONS, BY 3-YEAR SLIDING GROUP

Obs	WATER YEAR	# OF QW OBSV.	% P70300 SUBST.	% P00060 SUBST.
1	2010	83	0.0	0.0
2	2011	83	0.0	0.0
3	2012	80	0.0	0.0
4	2013	69	0.0	0.0
5	2014	69	0.0	0.0

STATION 09429490 Colorado River above Imperial Dam, AZ UPDATE 2014
REGRESSION STATISTICS, BY 3-YEAR SLIDING GROUPS
REGRESSION #1: VARIABLE = e**A * DISCHARGE**B
REGRESSION #2: VARIABLE = e**C * DISCHARGE**D * COND**E
VARIABLE=(mg/L), except for SALT LOAD (tons/day)
DISCHARGE=(cfs) COND=(uMHOS/cm)

GROUP=2010

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
1	SALT LOAD	83	0.97037	0.039604	2.28118	0.81453	83	0.99468	0.016886	-7.77873	1.02775	1.16164
2	Calcium	83	0.25100	0.053067	5.38900	-0.11040	83	0.44218	0.046082	-2.12972	0.04895	0.86820
3	Magnesium	83	0.33384	0.060009	4.72249	-0.15267	83	0.58429	0.047700	-5.59614	0.06603	1.19152
4	Chloride	83	0.61045	0.055375	6.86562	-0.24913	83	0.83894	0.035827	-5.02775	0.00295	1.37335
5	Sulfate	83	0.57224	0.043945	7.20811	-0.18267	83	0.83535	0.027433	-2.45706	0.02218	1.11606
6	Carbonate	83	0.52188	0.035634	5.70451	-0.13380	83	0.78187	0.024219	-1.66452	0.02238	0.85092
7	Sodium +K	83	0.55810	0.059446	6.89525	-0.24010	83	0.77703	0.042489	-4.83874	0.00860	1.35495

GROUP=2011

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
8	SALT LOAD	83	0.97037	0.039604	2.28118	0.81453	83	0.99468	0.016886	-7.77873	1.02775	1.16164
9	Calcium	83	0.25100	0.053067	5.38900	-0.11040	83	0.44218	0.046082	-2.12972	0.04895	0.86820
10	Magnesium	83	0.33384	0.060009	4.72249	-0.15267	83	0.58429	0.047700	-5.59614	0.06603	1.19152
11	Chloride	83	0.61045	0.055375	6.86562	-0.24913	83	0.83894	0.035827	-5.02775	0.00295	1.37335
12	Sulfate	83	0.57224	0.043945	7.20811	-0.18267	83	0.83535	0.027433	-2.45706	0.02218	1.11606
13	Carbonate	83	0.52188	0.035634	5.70451	-0.13380	83	0.78187	0.024219	-1.66452	0.02238	0.85092
14	Sodium +K	83	0.55810	0.059446	6.89525	-0.24010	83	0.77703	0.042489	-4.83874	0.00860	1.35495

GROUP=2012

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
15	SALT LOAD	80	0.97540	0.033215	2.11056	0.83244	80	0.99469	0.015528	-6.66907	1.00220	1.03635
16	Calcium	80	0.22601	0.045066	5.27686	-0.09694	80	0.39350	0.040151	-0.98075	0.02406	0.73865
17	Magnesium	80	0.39795	0.043334	4.60951	-0.14024	80	0.68857	0.031368	-4.37724	0.03353	1.06079
18	Chloride	80	0.62728	0.044740	6.69556	-0.23104	80	0.87046	0.026547	-4.09123	-0.02246	1.27327
19	Sulfate	80	0.56464	0.036437	7.03570	-0.16517	80	0.80954	0.024256	-1.12150	-0.00745	0.96287
20	Carbonate	80	0.43449	0.034838	5.59351	-0.12155	80	0.69675	0.025677	-1.48806	0.01538	0.83591
21	Sodium +K	80	0.49728	0.052289	6.57144	-0.20701	80	0.76392	0.036064	-4.79525	0.01278	1.34172

GROUP=2013

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
22	SALT LOAD	69	0.98281	0.027512	2.34901	0.80552	69	0.99745	0.010666	-5.88913	0.97874	0.95547
23	Calcium	69	0.55062	0.031278	5.61692	-0.13408	69	0.69409	0.026001	-0.11659	-0.01352	0.66498
24	Magnesium	69	0.60828	0.035540	4.88572	-0.17150	69	0.78917	0.026270	-2.94937	-0.00676	0.90872
25	Chloride	69	0.79047	0.035305	7.00230	-0.26555	69	0.96585	0.014360	-3.47638	-0.04522	1.21533
26	Sulfate	69	0.75487	0.028524	7.28668	-0.19383	69	0.90528	0.017865	0.03828	-0.04142	0.84068
27	Carbonate	69	0.44439	0.037976	5.68603	-0.13152	69	0.63897	0.030844	-1.60478	0.02178	0.84560
28	Sodium +K	69	0.65016	0.044411	6.80446	-0.23445	69	0.83577	0.030658	-3.68993	-0.01379	1.21715

APPENDIX D

20 Station Flow and Salt over Time

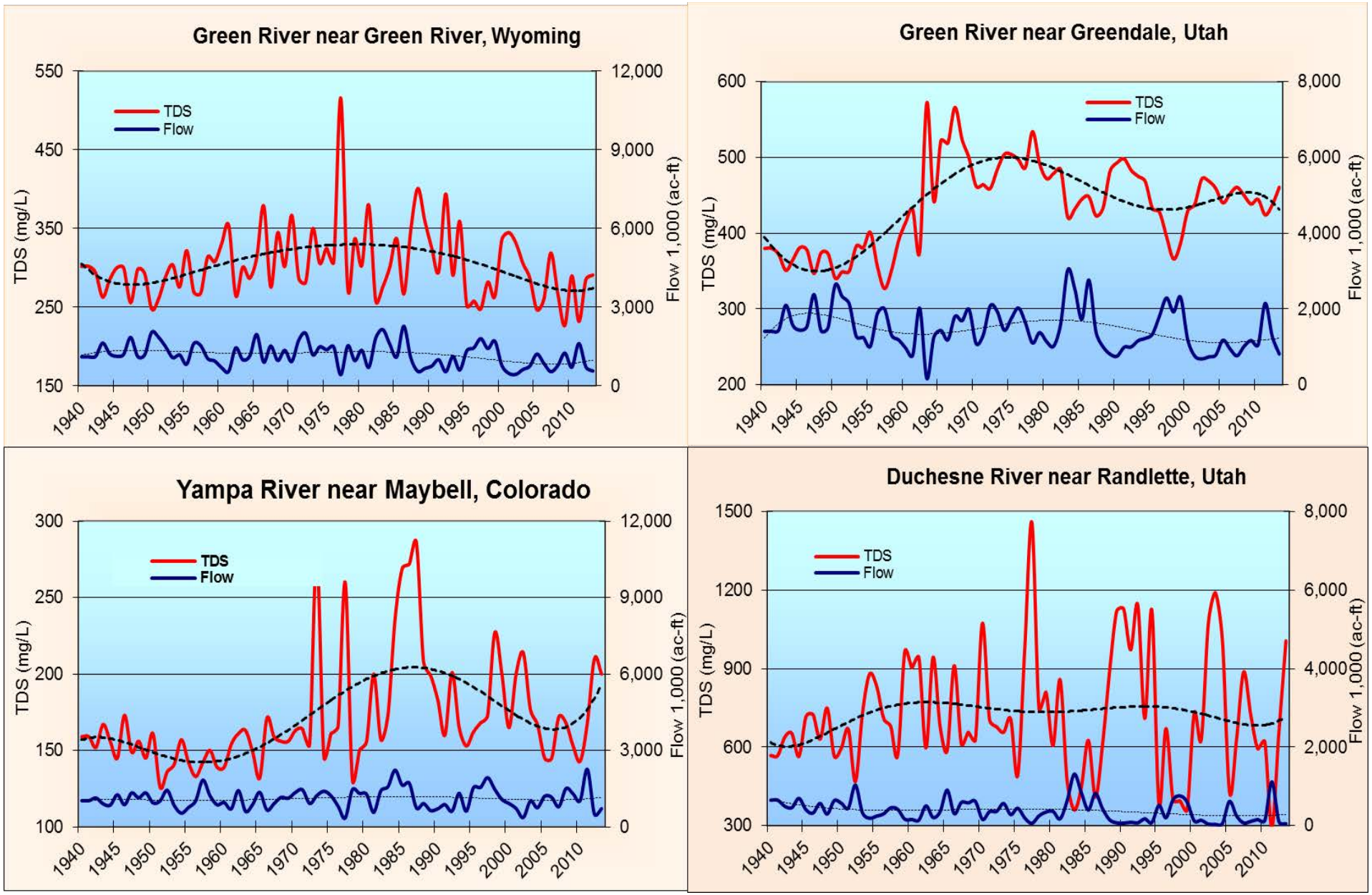


Figure D1 – Flow and TDS over Time for Sites 1-4

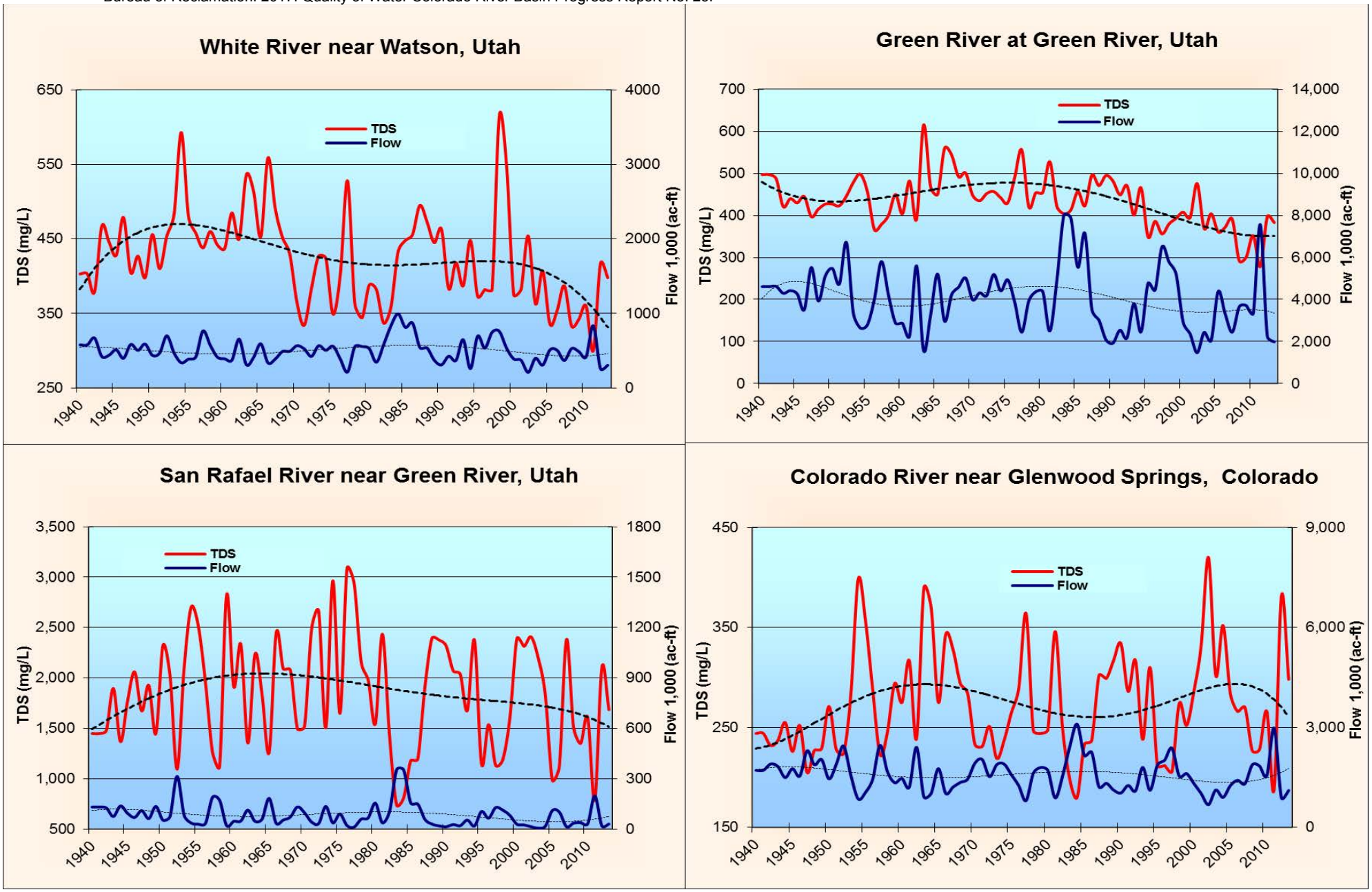


Figure D2 – Flow and TDS over Time for Sites 5 - 8

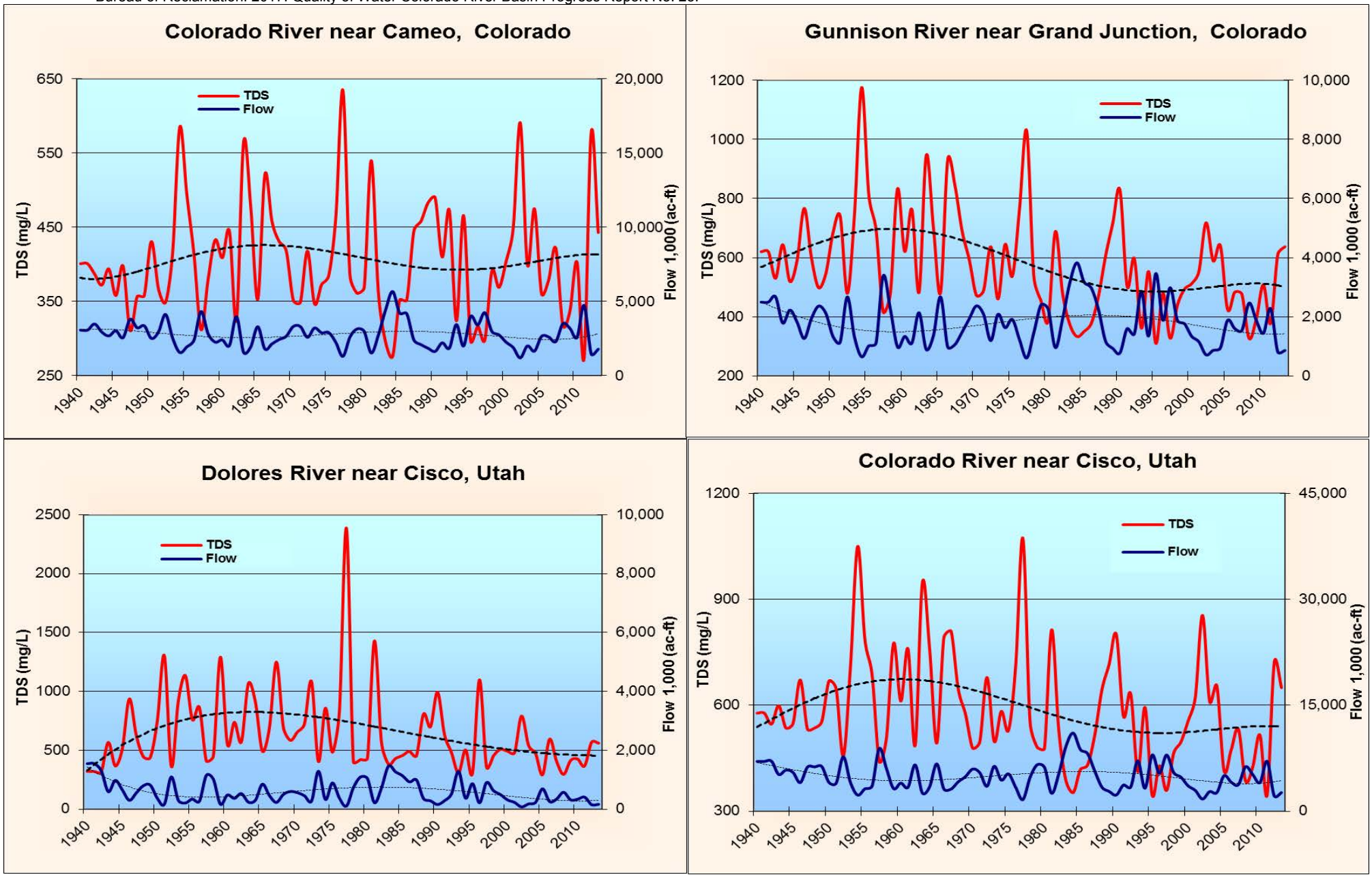


Figure D3 – Flow and TDS over Time for Sites 9 - 12

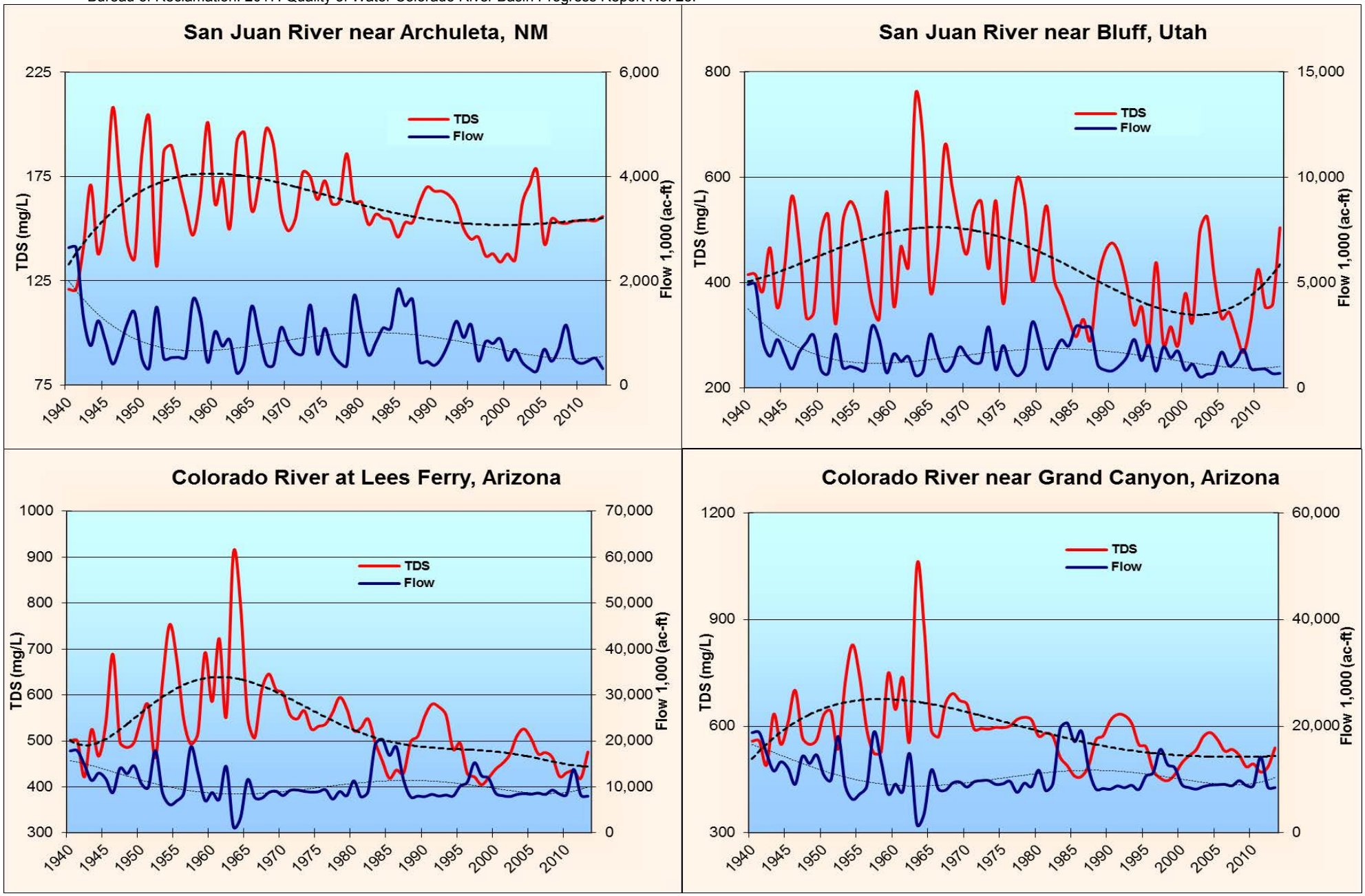


Figure D4 – Flow and TDS over Time for Sites 13 - 16

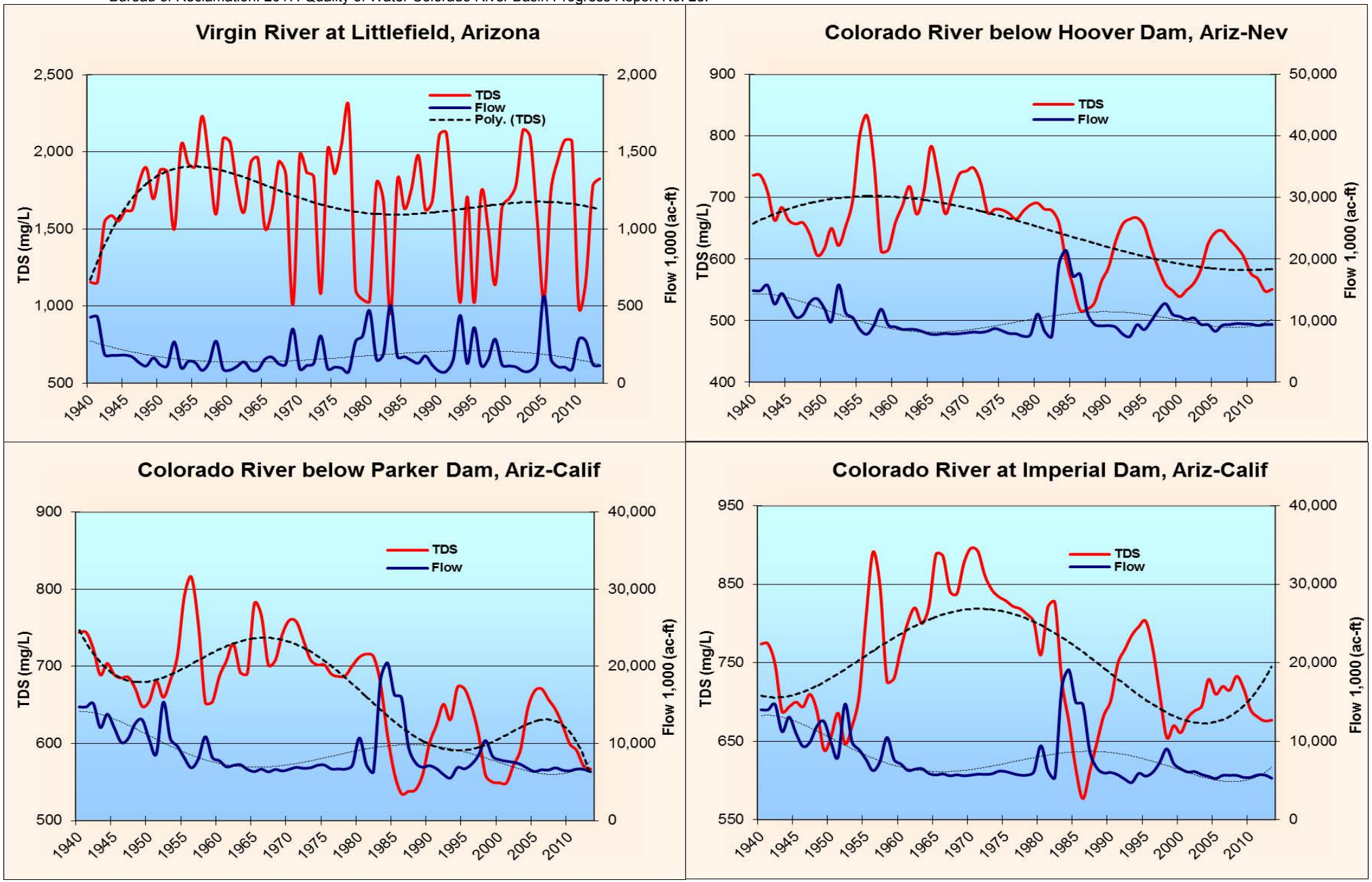


Figure D5 – Flow and TDS over Time for Sites 17 - 20

Timing and patterns of basin infilling as documented in Lake Powell during a drought

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ABSTRACT

Between 1999 and 2005, drought in the western United States led to a >44 m fall in the level of Lake Powell (Arizona-Utah), the nation's second-largest reservoir. River discharges to the reservoir were halved, yet the rivers still incised the tops of deltas left exposed along the rim of the reservoir by the lake-level fall. Erosion of the deltas enriched the rivers in sediment such that upon entering the reservoir they discharged plunging subaqueous gravity flows, one of which was imaged acoustically. Repeat bathymetric surveys of the reservoir show that the gravity flows overtopped rockfalls and formed small subaqueous fans, locally raising sediment accumulation rates 10–100-fold. The timing of deep-basin deposition differed regionally across the reservoir with respect to lake-level change. Total mass of sediment transferred from the lake perimeter to its bottom equates to ~22 yr of river input.

INTRODUCTION

The timing, location, and nature of deposition in a basin are largely dictated by base (i.e., water) level, basin-floor subsidence, and sediment supply (Posamentier et al., 1988). The impacts of base-level change and subsidence on basin infilling have been explored extensively through modeling (Paola, 2000), experiments (e.g., Heller et al., 2001), and analyses of basin stratigraphy (e.g., Van Wagoner et al., 1990). These same methods have also been used to evaluate the effects of sediment supply (e.g., Perlmutter and Matthews, 1989), but to a much lesser extent and with fewer conclusive and generally applicable results. This is because of uncertainties over (1) how sediment flux to a basin varies with respect to base-level change (e.g., are changes in the two in or out of phase?), and (2) the source of the sediments, from inside or outside the basin (Pratson et al., 2007).

Here we present new insights on these issues gained through repeat bathymetric surveys of Lake Powell (Arizona-Utah) (Fig. 1A) during a fall and rise in reservoir level between 1999 and 2005 (Fig. 1B). Lake Powell proved exceptional for this purpose because its physiography, time of operation, and water and sediment input are so well constrained. Water outflow occurs through penstocks (i.e., pipes) embedded in the Glen Canyon Dam >80 m above the adjacent reservoir floor (Fig. 2A), so essentially all sediments that enter the reservoir are trapped within it. This trapping began when the dam was completed 11 April 1963. Pre-reservoir topography was accurately surveyed beforehand (United States, 1963) and lake level has been recorded since (Fig. 1B). Input to the reservoir is gauged and dominated by the Colorado and San Juan Rivers, which supply ~95% of the water and ~90% of the sediment (Potter and Drake, 1989). Deltas have been rapidly growing beyond the mouths of both rivers (Fig. 2A), with maximum sediment accumulation rates through 1986 being measured in meters per year (Ferrari, 1988). The narrowness of the lake (generally ≤1.5 km wide) (Fig. 1A) prevents significant lateral sediment movement, so the deltas are essentially two-dimensional.

BACKGROUND AND METHODS

Between fall 1999 and fall 2004, average river inflow to Lake Powell was approximately halved by a drought in the southwestern U.S. (Fig. 1B). As withdrawals from the reservoir exceeded the inflow, lake level fell >44 m (Fig. 1B). Inflow then returned to its historical norm in spring 2005, raising lake level >9 m by early summer (Fig. 1B).

Within this period, three bathymetric surveys of Lake Powell were carried out. The surveys were conducted early (April 2001) and late (May 2004) during the fall in lake level, and (June 2005) when lake level had risen >9 m from its lowest point two months prior (Figs. 1B and 2A). Note that all the surveys were done as snowmelt from the Colorado watershed was arriving at Lake Powell and inflow was at its yearly maximum (Fig. 1B).

The surveys were of varying extent and used different high-resolution mapping systems capable of detecting lake bottom to within <3 cm. In 2001, the main axis of the Colorado arm was surveyed using a Garmin 240B single-beam 50/200 kHz fathometer integrated with a P-CODE global positioning system (GPS) receiver. In 2004, the main axes of both the Colorado and San Juan arms were surveyed with an EdgeTech 512i 0.5–12 kHz Chirp (compressed high-intensity radar pulse) sonar and a GPS receiver. In 2005, a Kongsberg EM3002 300 kHz multibeam sonar system, coupled with short-baseline differential GPS, was used to completely map the Colorado, San Juan, and Escalante arms of the reservoir. A 500 kHz SonTek acoustic Doppler profiler, with GPS, was used to profile the topsets of the Colorado and San Juan deltas, where water depths were too shallow to take the EM3002 (i.e., <10 m).

The EM3002 automatically applied sound speed corrections to the soundings and translated them into georeferenced depths. For the other surveys, depths were computed by multiplying the bottom echo traveltimes with an average water sound speed for each survey. The average sound speeds were derived from control points with known elevations located throughout the reservoir. Finally, depth measurements from all the surveys were converted into elevations using the appropriate daily reservoir levels posted by the U.S. Bureau of Reclamation (USBR).

The surveys were placed within the longer-term context of reservoir infilling by coregistering them in the geographic information system (GIS) with the few previous surveys of Lake Powell: (1) a detailed topographic survey made by the USBR before the Glen Canyon Dam was built (United States, 1963); (2) a bathymetric profile up the axes of the Colorado and San Juan arms compiled in 1976 by Potter and Drake (1989); and (3) a series of cross-lake bathymetric profiles measured by the USBR every few kilometers up each waterway of the reservoir in 1986 (Ferrari, 1988).

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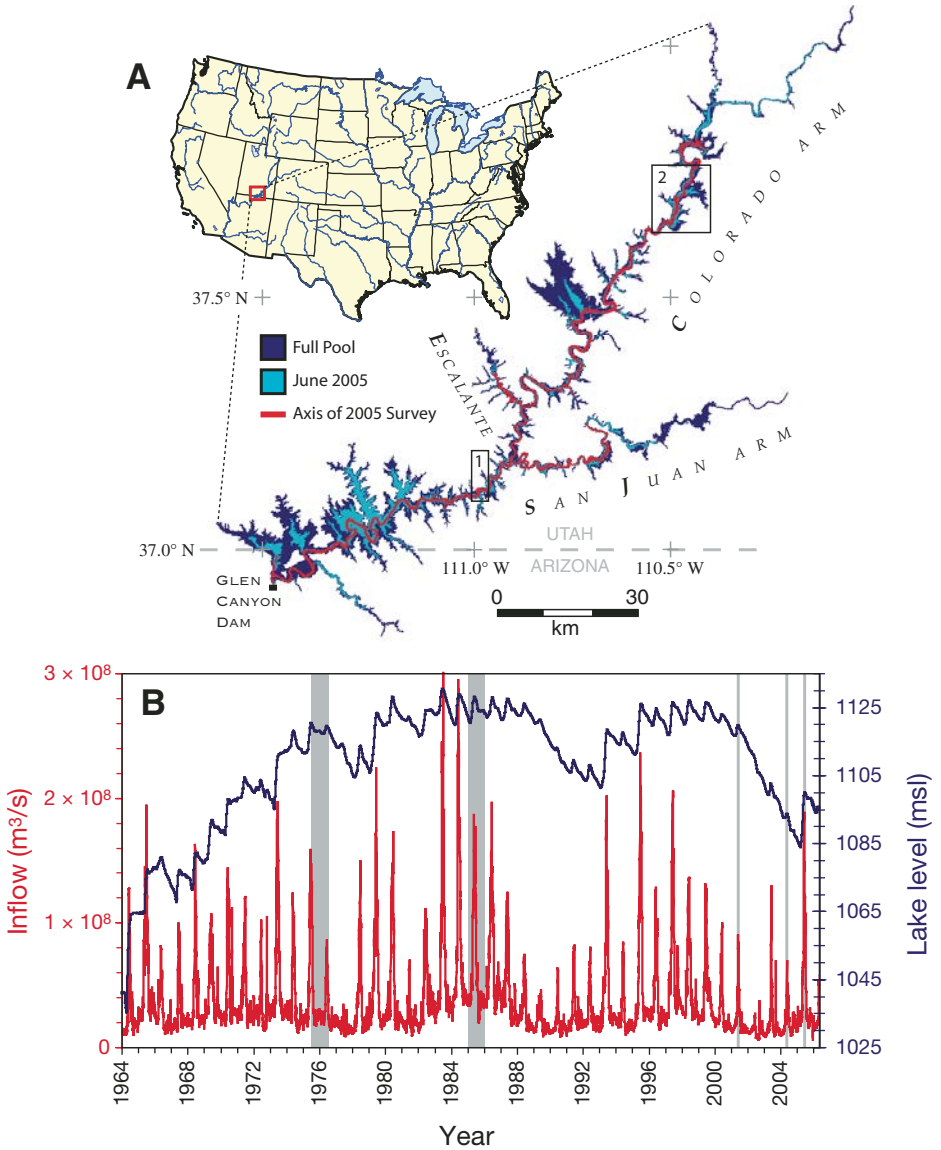

Figure 1. A: Map of Lake Powell. Full pool is maximum reservoir level (1141 m). Regions 1 and 2 correspond to Figures 3A and 3B, respectively. B: Inflow to Powell and lake level (msl—meters above sea level) since closure of Glen Canyon Dam (http://www.usbr.gov/uc/crsp/GetSiteInfo). Gray bars indicate when reservoir was surveyed.

RESULTS

The earlier bathymetric surveys of Lake Powell (Fig. 2A) show that prior to the 1999–2004 drought, sedimentation was greatest on the foresets of deltas building out from the Colorado and San Juan Rivers, with accumulation rates at these sites reaching 2–3 m/yr (Ferrari, 1988). As lake level fell during the drought, deposition shifted to the deeper part of the reservoir (Figs. 2A–2C). However, the location and extent of this deposition varied basinward of the two rivers, the differences persisting through the subsequent lake-level rise.

In the Colorado arm of the reservoir, the delta foreset continued to prograde and steepen even as lake level fell and the delta top was incised by the Colorado River (Fig. 2A). During the lake-level fall between 2001 and 2004, mean accumulation rates remained highest on the delta foreset, but sediments were deposited >70 km basinward at an average rate of 0.75 m/yr (Fig. 2B). A significant fraction of this deposition became ponded behind three large rockfalls that cross the reservoir floor (RF1–3, Fig. 2A). These were created decades before by failures of the sandstone cliffs that border much of the lake (Potter and Drake, 1989). The sediment ponding was greatest behind the rockfalls closest to the delta (RF1 and RF2; Fig. 2A, and 1 in Fig. 3A), but sediments were also carried over these obstacles to at least as far as a third rockfall near where the Colorado and San Juan arms meet (RF3, Fig. 2A). The bathymetric changes show that sediment accumulation then waned in the deep part of the lake during lake-level rise, and deposition shifted back up onto the delta foreset, where the maximum accumulation rate jumped to >13 m/yr (Fig. 2B).

In the San Juan arm of the lake, a different pattern of deposition ensued. The delta here prograded no more than 1 km during the fall and subsequent rise in lake level with little if any steepening (Fig. 2A). Sediments tended to bypass the entire delta and deposit beyond its foreset all the way to the Glen Canyon Dam, ~165 km beyond the inflow (Figs. 2A and 2C). Sedimentation in this deep, lowermost stretch of Lake Powell did not increase significantly until well into the drought. The ^{210}Pb measurements from a core collected in the lower lake in 2001 (Figs. 2A and 2C) indicate that for more than 10 yr sediment accumulation rates at the site were 0.01 m/yr. This rate agrees with an average rate of 0.04 m/yr determined ~1 km away by differencing soundings from the 1986 and 2001 bathymetric surveys. However, by the 2004 survey, mean sediment accumulation rates in the lower part of the lake increased almost two orders of magnitude, to meters per year (Fig. 2C). Furthermore, small subaqueous fans had formed at the mouths of at least two side canyons, Antelope (SF3) and Forbidden (SF1) (Fig. 2A). The Forbidden fan was imaged in the 2004 and 2005 surveys (1 in Fig. 3B). It was not present during the earlier 1986 survey and was not mapped in 2001, but the 2004 Chirp subbottom profile reveals a reflection at an equivalent depth to the lake floor in 2001 that can be traced under the fan (3 in Fig. 3B). This suggests that the fan formed during the 3 yr period when lake level fell. Fan formation may have then ceased; 1.5 m of sediment ponded behind the up-lake levee of the fan as sediment continued to come down the main axis of the lake (3 in Fig. 3B). Unlike in the Colorado arm, deep-water deposition below the San Juan arm did not decline during the subsequent lake-level rise. Instead, accumulation rates through the 2005 survey remained as high as during the period of lake-level fall (Fig. 2C).

The deep-water deposits were laid down by subaqueous gravity flows. Such events are not restricted to periods of low lake level. Turbid, bottom-hugging density currents commonly emanate from the Colorado and San Juan Rivers (http://www.gcmrc.gov/products/water_quality/; Johnson and Merritt, 1979). These hyperpycnal flows were probably frequent between 1995 and 2000 when lake-level was high, for suspended-sediment concentrations averaged ≥0.5 g/L at the Green River, Cisco, and Bluff, Utah, gauging stations 100–150 km upriver of the reservoir (http://co.water.usgs.gov/sediment/seddatabase.cfm). However, the jumps in deep-reservoir sediment accumulation rates (Figs. 2B

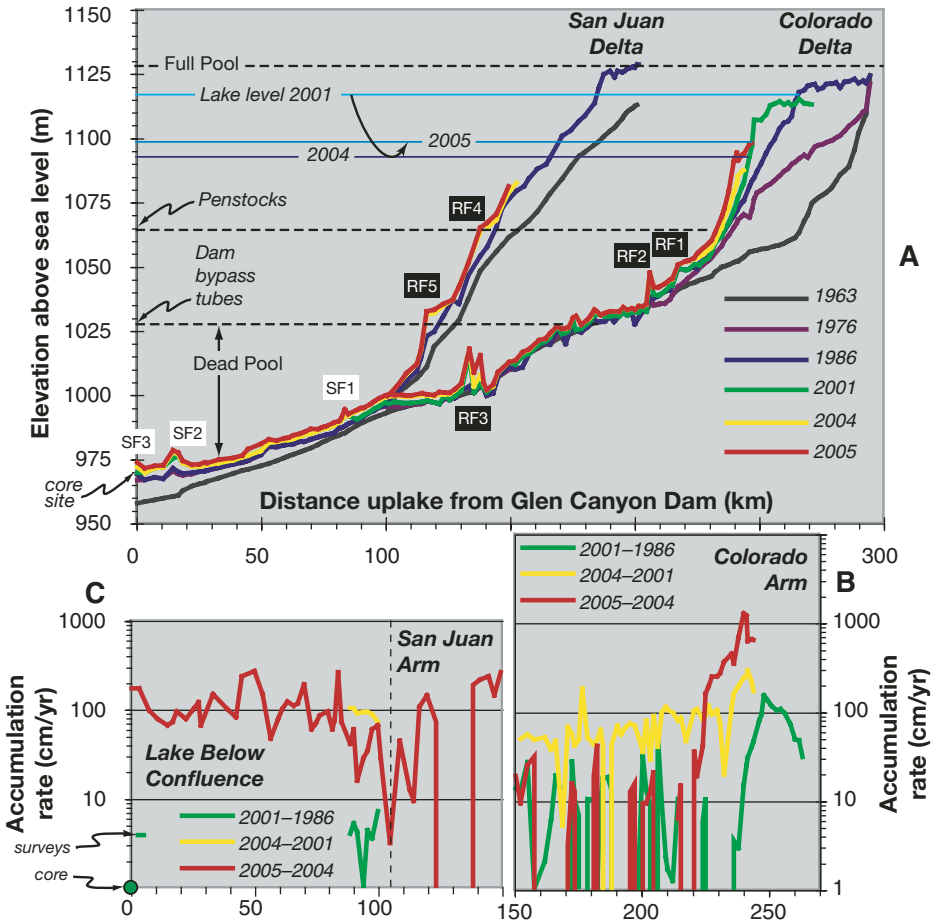

Figure 2. A: Successive bathymetric profiles along main axes of Powell. RF—rock fall; SF—subaqueous fan. Profiles portrayed at same irregular several-kilometer sample spacing as 1986 survey (Ferrari, 1988). Note that RF3 separates floor of Colorado arm from that of San Juan arm to Glen Canyon Dam. B, C: Sediment accumulation rates from differencing surveys indicated and dividing by elapsed time. Except for soundings adjacent to dam, 2001 survey stops ~80 km up reservoir of dam. Dead pool is unusable water, defined by elevation of tubes for bypassing water around dam.

and 2C) clearly point to increased deposition by subaqueous gravity flows during the drought.

At least one of these subaqueous gravity flows was imaged in the 2005 survey (Fig. 3A). Adjacent multibeam bathymetry swaths collected over five days captured the progress of the flow as it moved down the Colorado Delta foreset (2 in Fig. 3A). The type of flow is unclear. It could have been a viscous debris flow or just the bedload component of a slow-moving turbidity current. In either case, its sediment concentration was great enough to produce a distinct acoustic reflection delineating the front of the flow as an abrupt 20–40 cm rise above the reservoir floor (3 in Fig. 3A). Differences in the position of the front over time (2 in Fig. 3A) indicate that the flow was progressing down the 0.1° incline at 6 m/h.

DISCUSSION

As in natural basins, water and sediment supply to Lake Powell are coupled through the tie between regional climate and hydrology (Scholz, 2001). Because of this coupling, our observations of change in Lake Powell offer new insights on sediment supply to basins during climate-driven base-level change.

The first of these insights is that subaqueous gravity-flow dynamics may affect the timing and distribution of basin sedimentation during base-level change. In Lake Powell, a far greater fraction of incoming sediment bypassed the San Juan Delta foreset than the Colorado, and the bypassing was not limited to falling base level, but continued into the lake-level rise, although why this occurred is unclear. Until recently, the San Juan Delta foreset had always been steeper than the Colorado, but by spring 2005 the latter had achieved the same 0.1° dip (Fig. 2A, and 1 in Fig. 3A). While the mean water discharge from the San Juan River is little more than 15% that of the Colorado, sediment discharge from the two rivers is roughly equivalent (Potter and Drake, 1989). The higher concentration of suspended sediment in the San Juan River could imbue gravity flows with greater excess density to move beyond the delta foreset. Whatever the reason, the timing and extent of deep-basin sedimentation in Lake Powell were not simply a function of lake level or its rate of change, as sequence stratigraphic concepts postulate (Posamentier et al., 1988). The character and dynamics of the subaqueous gravity flows involved were also factors.

The second insight is that base-level falls that expose unconsolidated strata can lead to increased hyperpycnal flows in a basin even when river inflow is reduced. Whereas hyperpycnal flows are common in lakes (Fan and Morris, 1992), long-term recordings of coastal river discharges have suggested that such flows require floods to initiate where rivers empty into the ocean (e.g., Dadson et al., 2005; Johnson et al., 2001; Mulder and Syvitski, 1995). Like all rivers, sediment discharge in the Colorado and San Juan Rivers is directly proportional to water discharge, which declines during droughts (Committee to Review the Glen Canyon Environmental Studies, 1991). Consequently, the halving of water discharge to Lake Powell during the 1999–2004 drought should have also reduced sediment discharge to the lake and presumably hyperpycnal flows. However, our observations indicate that such flows increased over this period. The primary sediment sources for these flows were the local unconsolidated delta topsets exposed by the lake-level fall. Although diminished, river-mouth water discharges incised these strata with relative ease, becoming rich in suspended sediment and thus negatively buoyant as they crossed into the reservoir. It seems feasible that marine hyperpycnal flows could be similarly generated at river mouths during sea-level lowstands if exposed basin strata are easily eroded, even when river water discharges are lower than those needed for the phenomena to occur today.

Finally, the vast majority of sediments moved deep into a basin over the course of low base level may actually come from erosion of strata within the basin exposed by the base-level fall, and not from an up-river source. In Lake Powell, the drought triggered the redistribution of ~1 km^3 of sediments from along the lake perimeter to below the elevation of tubes that can bypass water around the Glen Canyon Dam, i.e., the "dead pool" level (Fig. 2A). Assuming that the average porosity and grain density of the strata in Lake Powell are 60% and 2500 kg/m^3, respectively, the volume of sediments moved below the dead pool level equates to a mass of 1000×10^6 Mt. Combined, the Colorado and San Juan rivers annually deliver ~41×10^6 Mt of sediment into Lake Powell, which represents 90% of the total sediment load to the lake (Potter and Drake, 1989). This suggests that possibly as much as 22 yr of river sediment input to Lake

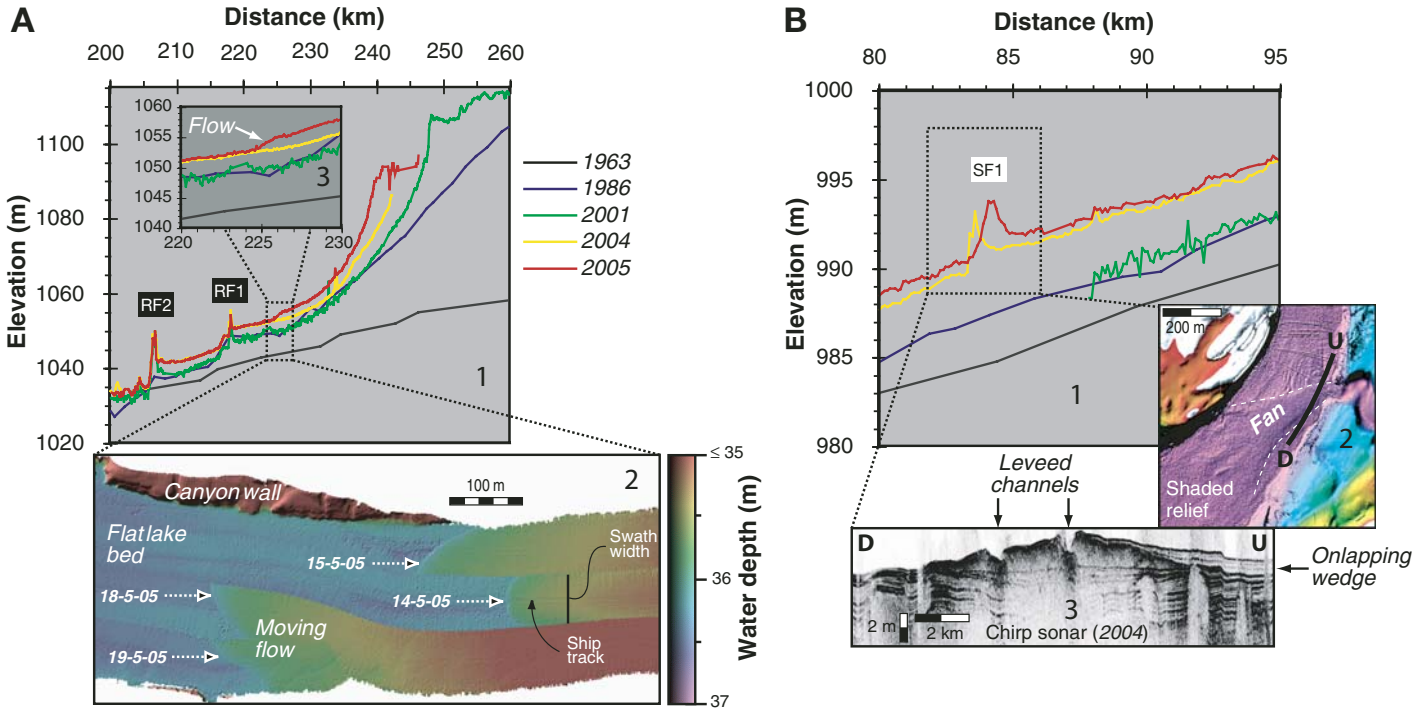

Figure 3. A: 1—Colorado Delta profile (100 m horizontal sample spacing); note filling behind RF1 (RF—rockfall) and 2 between 2001 and 2004. 2—Moving subaqueous gravity flow evident in shaded relief imagery. Arrows point to locations of flow front on successive dates (day, month, year). 3—Flow is evident in 2005 bathymetric profile of Colorado Delta, rising 3 m above surrounding reservoir floor. B: 1–2—Subaqueous fan (dashed outline) emanating from Forbidden Canyon into Lake Powell. SF—subaqueous fan. Fan formed by 2004. 3—Chirp (compressed high intensity radar pulse) sonar profile, collected in 2004.

Powell was remobilized to the deepest parts of the lake in ~20% of the time. While the speed and scale of this redistribution are undoubtedly tied to the rate and magnitude of the base-level fall in Lake Powell as well as to the erodability of the exposed strata, our estimates suggest that deep-water sediments deposited in many basins during low base level could be overwhelmingly derived from erosion of shallow-water strata in the basin exposed by the fall.

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