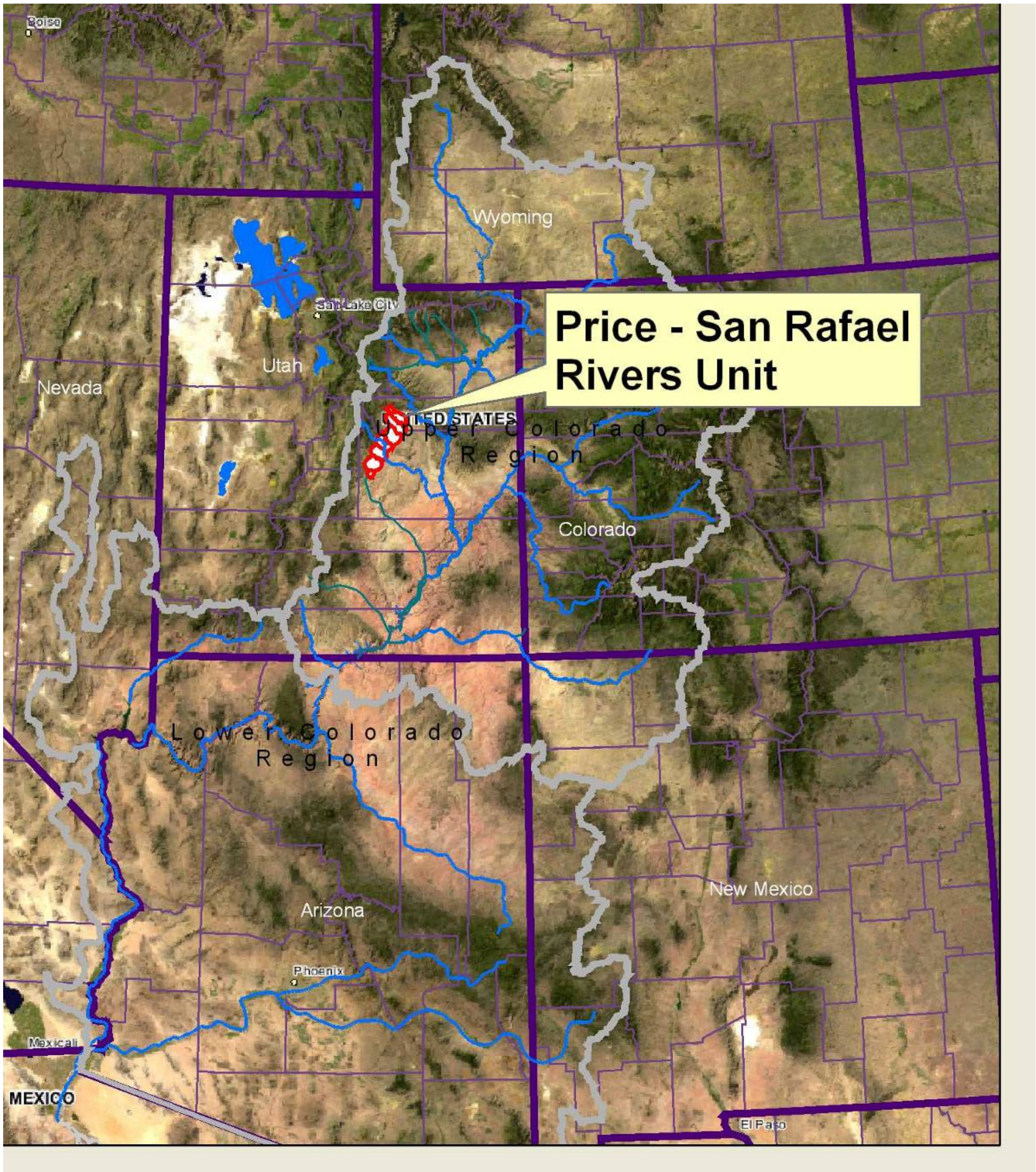
Colorado River Basin Salinity Control Program

Price – San Rafael Rivers Unit

Monitoring and Evaluation Report, FY2007



U.S. Department of Agriculture

Natural Resources Conservation Service

Executive Summary

Project Status

- NRCS and Reclamation have reviewed and concurred on pre-project agricultural salt load allocation
- On-farm salt load reduction calculation procedures have been revised to assure proportionality and concurrence with EIS projections and salt load reduction has been recalculated back through FY1997
- For FY2007, $2.39 million was obligated planning 1,244 acres to reduce salt loading by 2,500 tons at an amortized cost of $80/ton FA+TA
- For FY2007, $2.43 million was applied on 2,975 acres to reduce salt loading by 8,600 tons at an amortized cost of $33/ton FA+TA
- Since 1997, $18.33 million has been obligated planning 24,200 acres to reduce salt loading by 68,000 tons at an amortized cost of $34/ton nominal or $41/ton in 2007 dollars FA+TA
- Since 1997, $11.44 million has been applied on 17,300 acres to reduce salt loading by 50,000 tons at an amortized cost of $29/ton nominal or $33/ton in 2007 dollars FA+TA
- Of 66,000 water rights acres, 36,000 acres are projected to be improved
- Of approximately 73,000 original off-farm tons, USDA programs have applied 1,550 tons of salt load reduction for major lateral construction

Hydro-salinity

- IWM record keeping, soil moisture monitoring, and sprinkler condition surveys all indicate that salt load reduction estimates, using the latest calculation procedures, are probably conservative
- Adding soil moisture monitors to the NRCS salinity cost schedule would encourage more irrigators to take advantage of the technology
- Adding data recorders to existing soil moisture probe arrays would enable the collection and use of much more data for irrigation timing and training at a much lower cost

Wildlife Habitat and Wetlands

- Detailed cover maps are not available for inclusion in this report
- In FY2007, 112 acres of wildlife habitat projects were planned and funded
- No wildlife habitat projects were applied in FY2007

Economics

- Alfalfa production is clearly in an upward trend
- Interest in salinity control projects remains strong

Table 1, Project progress summary

Price - San Rafael Rivers Unit FY2007 Program Summary				
Practices Applied	**Units**	**FY2007**	**Cumulative**	**Target**
1. Irrigation Systems				
A. Sprinkler System	Acres	2,973	17,283	36,000
B. Improved Surface System	Acres	-	-	
C. Drip Irrigation System	Acres	2	10	
2. Irrigation Water Management	Acres	2,975	17,293	
3. Wildlife Wetland Habitat Management	Acres	-	-	
4. Wildlife Upland Habitat Management	Acres	-	32	
5. Salt Load Reduction, on-farm*	Tons/Year	8,417	48,929	147,000
5a. Salt Load Reduction, off-farm	Tons/Year	-	1,553	
6. Deep Percolation Reduction (Includes seepage) Note: deep percolation is not equal to return flow.	Acre-Ft/Yr			
7. Total Irrigation Contracts (Planned)	Number	37	588	
	Dollars, FA	2,393,232	18,331,470	
	Acres	1,244	24,151	

***Note: On-farm Salt Load Reduction has been recalculated using new procedures adopted in FY2007 by three Upper Basin States. In the process, all EQIP and BSPP contracts were reviewed and acres corrected. All cumulative numbers reflect results of this recalculation.**

NRCS Salinity Control Programs			
Program Name	**Acronym**	**Start Year**	**End Year**
Environmental Quality Incentive Program	EQIP	1997	Current
Basin States Parallel Program	BSPP	1998	Current

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Monitoring and Evaluation History and Background

The Colorado River Basin Salinity Control Program was established by the following Congressional Actions:

- The Water Quality Act of 1965 (Public Law 89-234) as amended by the Federal Water Pollution Control Act of 1972, mandated efforts to maintain water quality standards in the United States.

- Congress enacted the Colorado River Basin Salinity Control Act (PL 93-320) in June, 1974. Title I of the Act addresses the United States' commitment to Mexico and provided the means for the U.S. to comply with the provisions of Minute 242. Title II of the Act created a water quality program for salinity control in the United States. Primary responsibility was assigned to the Secretary of Interior and the Bureau of Reclamation (Reclamation). USDA was instructed to support Reclamation's program with its existing authorities.

- The Environmental Protection Agency (EPA) promulgated a regulation in December, 1974, which established a basin wide salinity control policy for the Colorado River Basin and also established a water quality standards procedure requiring basin states to adopt and submit for approval to the EPA, standards for salinity, including numeric criteria and a plan of implementation.

- In 1984, PL 98-569 amended the Salinity Control Act, authorizing the USDA Colorado River Salinity Control Program. Congress appropriated funds to provide financial assistance through Long Term Agreements administered by Agricultural Stabilization and Conservation Service (ASCS) with technical support from Soil Conservation Service (SCS). PL 98-569 also requires continuing technical assistance along with monitoring and evaluation to determine effectiveness of measures applied.

- In 1995, PL 103-354 reorganized several agencies of USDA, transforming SCS into Natural Resources Conservation Service (NRCS) and ASCS into Farm Service Agency (FSA).

- In 1996, the Federal Agricultural Improvement and Reform Act (PL 104-127) combined four existing programs, including the Colorado River Basin Salinity Control Program, into the Environmental Quality Incentives Program (EQIP).

Over the years, Monitoring and Evaluation (M&E) has evolved from a mode of labor/cost intensive detailed evaluation of a few farms and biological sites to a broader but less detailed evaluation of many farms and environmental concerns, driven by budgetary restraints and improved technology.

M&E is conducted as outlined in "The Framework Plan for Monitoring and Evaluating (M&E) the Colorado River Salinity Control Program", first issued for Uintah Basin Unit in 1980 and revised in 1991 and 2001.

Project Status

Pre-Project Salt Loading

In order to plan and track progress on the Price – San Rafael Rivers Unit (PSR) of the Colorado River Basin Salinity Control Project (CRBSCP), it is necessary to understand pre-project conditions.

Salt load at a given point in a watercourse is generally estimated by multiplying average flow by average salt concentration over a discreet period of time and summing to determine annual average salt load. Since flow rates and concentrations are highly variable, shorter measurement intervals over longer periods of record result in more acceptable estimates.

The average salt pickup for a given drainage is the watercourse salt load below the drainage, less the watercourse salt load above the drainage.

Salt pickup has many sources including natural processes, springs, wells, mines, and agricultural activity. Agricultural irrigation is a particularly large source which involves diverting water from a stream, transporting water to fields and applying water to the soil. Salt pickup occurs when seepage and leakage from canals and excess water application on fields allows water to percolate below the plant root zone where it dissolves salt from the soil and eventually returns the dissolved salt to the river system.

One of the challenges of salt load evaluation is to quantify how much salt is produced by what source, and what can be done to reduce the amount of salt returning to the river system. Since irrigation is a primary source of salt loading and completely human induced, therein exists a high potential to make meaningful change.

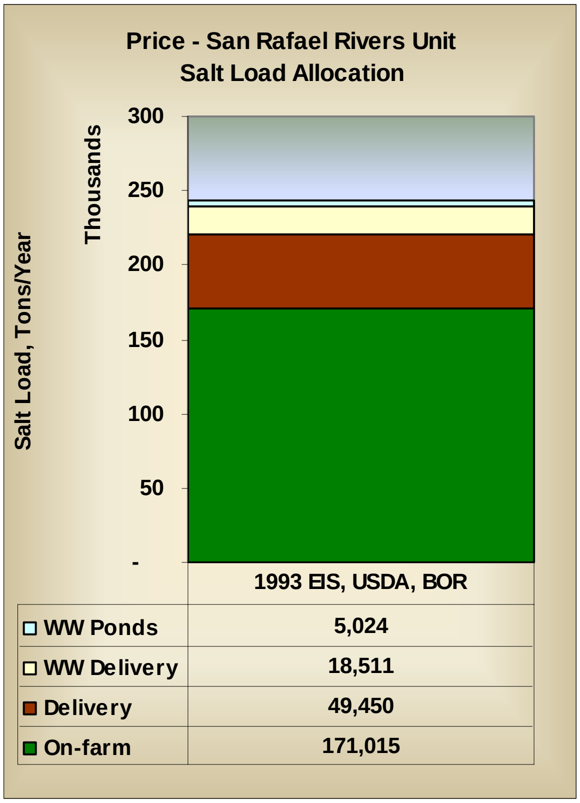
For PSR, in 1993, U.S. Department of Agriculture (USDA) Soil Conservation Service and U.S. Department of Interior Bureau of Reclamation (Reclamation) developed a joint environmental impact statement (EIS).

With the joint EIS in place, Reclamation initiated Requests for Proposals (RFP) under the Water Challenge Grant Program which resulted in several joint proposals over the years. The costs of these projects were generally justified by combining the total federal cost of on-farm and off-farm salinity control components and weighing the cost against total salt load reduction. Regardless of how the project was justified, each agency remains accountable for federal dollars expended by their agency and salt load reduction directly associated with those federal dollars.

Implementation has not always been divided along agency lines or on-farm/off-farm boundaries. Traditionally NRCS, the successor to Soil Conservation Service, has focused on on-farm projects and Reclamation has emphasized off-farm projects. (The line where on-farm and off-farm come together is blurry at times.) However, this tradition is not hard and fast and Reclamation has done some on-farm projects and NRCS has done some off-farm projects. Consequently, it is expected that Reclamation and NRCS will each allocate salt load reduction to on-farm and off-farm practices funded through their agency. This report deals only with NRCS funding and associated salt load reduction.

In 2007, Reclamation and NRCS met to review the EIS and made a consensus agreement on the probable initial salt contribution of agriculture, prior to implementing Federal Salinity Control Programs. The result of this effort is depicted in figure 1. (WW is winter-water for livestock.)

Figure 1, PSR pre-project agricultural salt load allocation.



Progress

Table 1 (page 3) is a summary of the cumulative status of all USDA salinity control activities, which began in FY1997 with the Environmental Quality Improvement Program (EQIP) and the Basin States Parallel Program (BSPP).

In FY2007, all EQIP and BSPP contracts were reviewed, acreage adjusted to correct apparent inaccuracies, and salt load reduction recalculated. Revised salt load reduction calculations are based on a formula agreed to by NRCS in Utah and Colorado designed to assure proportionality and concurrence with EIS projections (The revised calculation procedure is detailed in Appendix I). Data expressed in this report is adjusted and will not balance to previous reports, but is believed to be more representative of what has actually occurred over time.

Funding

Of a nominal $18.3 million Financial Assistance (FA) obligated, approximately $11.4 million has been applied. Table 2 summarizes FA funds planned and applied by program. Figure 2 depicts annual FA obligations. Figure 3 illustrates FA Obligated through FY2007 by Program.

Practices Planned and Applied

There are approximately 66,000 acres of land with water-rights in PSR, of which an average 45,000 acres are irrigated in a given season. Pre-project planning estimated that 36,050 acres would be treated. About a fourth of treatments would be improved flood systems.

Since 1997 588 contracts have been written with landowners to upgrade irrigation practices on 24,100 acres. As of the end of FY2007, practices are applied on about 17,300 acres. With the exception of 10 acres of drip irrigation, all of the obligated systems are sprinklers. There have been no improved flood contracts written with NRCS.

As pipelines and sprinkler systems are installed, landowners are more able to continuously irrigate land which was previously irrigated intermittently. Because of this, average annually irrigated acreage is increasing.

Figures 4 and 5 depict cumulative acres projected, acres planned, and acres applied.

Table 2, Nominal financial assistance planned and applied by program

Program	Contracts Planned	FA, $ Obligated	FA, $ Applied	Irrigation Acres Treated	$/Acre Treated	Avg Acres Treated /Contract
EQIP	499	14,336,613	9,359,673	13,718	682	27
BSPP	89	3,994,857	2,081,451	3,575	582	40
Totals	588	18,331,470	11,441,124	17,293	662	29

Figure 2, Annual FA obligated

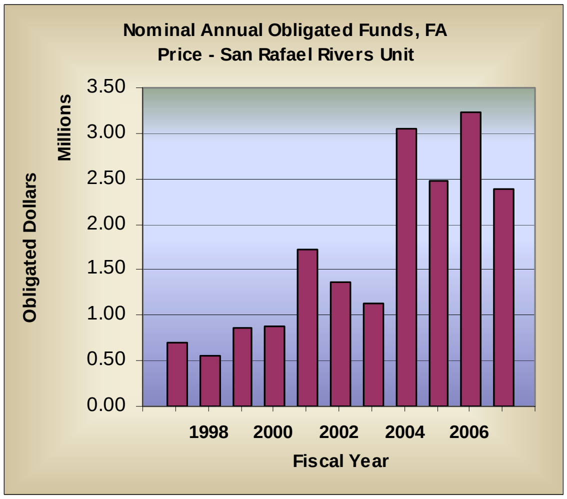


Figure 3, FA obligated by program

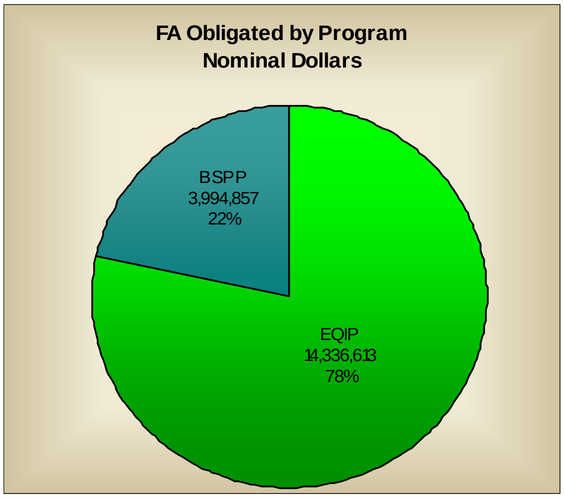


Figure 4, Projected, cumulative planned and applied improved acres

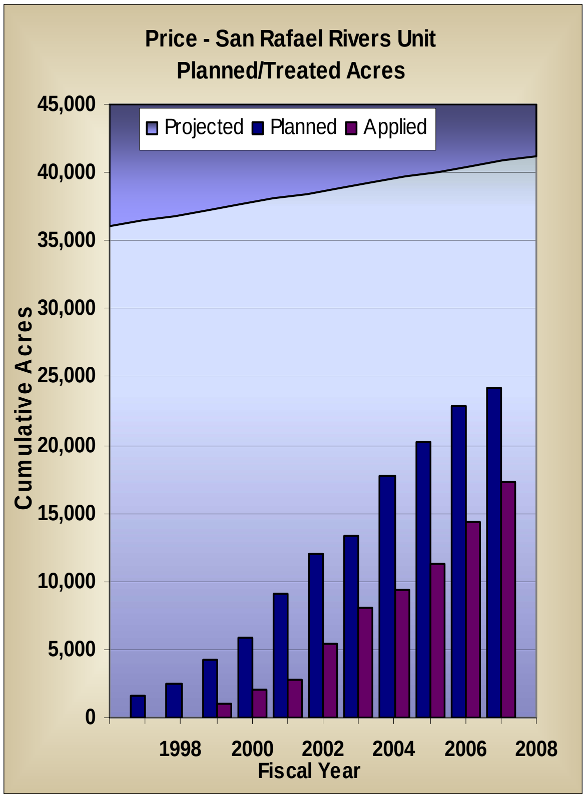
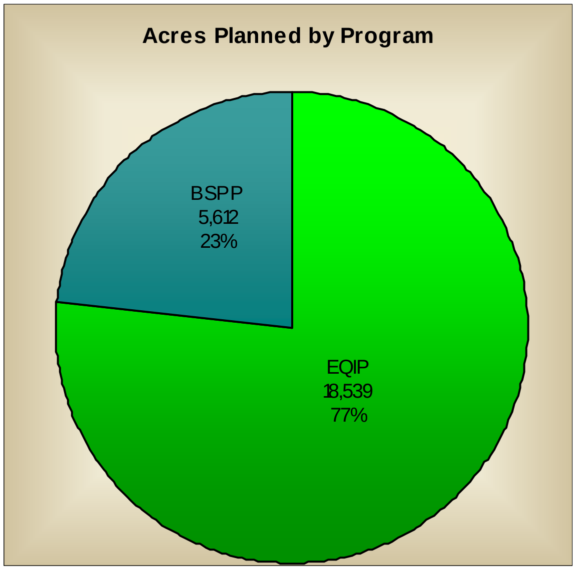


Figure 5 depicts cumulative acres planned by Program.

Figure 5, Acres planned by Program



Salt Load Reduction

Calculation of salt load reduction has been enigmatic since early in the Salinity Control Program. Little data is available to help determine actual rates of deep percolation (water percolating below the root zone) or return flow (the fraction of deep percolation that ultimately picks up salt and returns to the river system). Detailed studies are cost prohibitive so salt and water budgets are often used to estimate reasonable values.

On-Farm

For on-farm projects, total water applied to a field (irrigation and precipitation) must equal total water leaving the field (evaporation, crop-use, run-off, non-crop plant consumption, and deep percolation, a fraction of which becomes return flow), adjusted for changes in water storage in the soil. If there is a high water table, additional variables must be considered.

Since water applied by flooding is rarely measured, deep percolation is generally estimated based on mathematically modeled evapotranspiration (ET) and assumed system efficiency. However, this method assumes that optimal water volumes are available for delivery, which is rarely the case in PSR. The 1993 PSR Environmental Impact Statement (EIS) implied that less than 25% of optimal irrigation water could be delivered prior to implementation of salinity control measures.

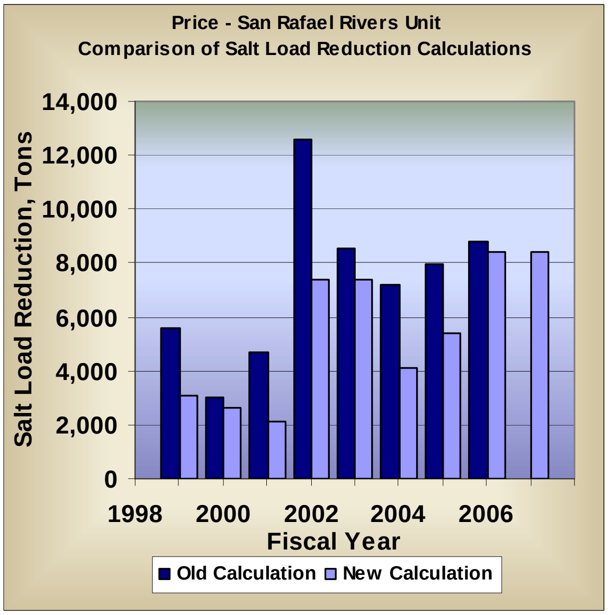
Difficulty in dealing with all potential variables has led to several different methods of estimating salt load reduction. Ideally, the calculation procedure used is expected to produce a result that is proportional and concurrent with pre-project salt loading.

Procedures used in the past attempted to determine deep percolation by assessing irrigation assets and operator skills to estimate efficiency and deep percolation or by utilizing an empirical equation that may fit the data set from which it is derived, but is not necessarily realistic for other areas.

In 2007, NRCS personnel in Utah and Colorado agreed to use a new procedure that starts with pre-project tons/acre, as documented and agreed to by NRCS and Reclamation. Salt load reduction is then allocated on the basis of acres treated and change in practice. For example, if 40 acres are upgraded from unimproved flood to a wheel line sprinkler system, irrigation salt load would be reduced by 84%. As illustrated in figure 1, pre-project, PSR was producing 171,000 tons/acre-year from an average annually irrigated 44,000 acres. However, by installing improved irrigation systems delivered water is sufficient to irrigate a larger share of water-right acres. When fully treated, an average of 52,000 acres is expected to be irrigated annually. Hence, the effective initial salt load is 171,000 tons/year ÷ 52,000 acres = 3.29 tons/acre-year. The salt load reduction for a hypothetical 40 acres would be 3.29 tons/acre–year x 40 acres x 0.84 = 111 tons/year. Development of this procedure is outlined in Appendix 1. The Water and Salt Savings Worksheet for Ranking, which utilizes this procedure, is in Appendix II.

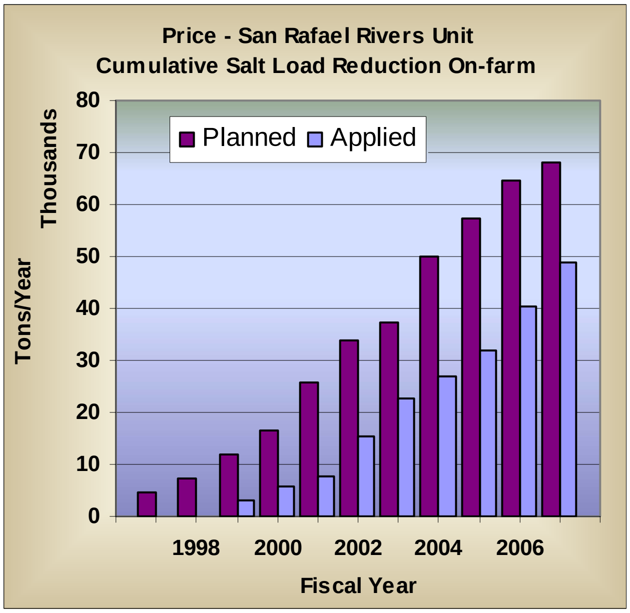
Salt load reductions for all salinity control contracts (1997-2007) have been recalculated and numbers reported have been adjusted. A comparison of old salt load calculations with calculations using the new procedure is depicted in figure 6.

Figure 6, Comparison of annual salt load reduction calculations, applied practices



Cumulative salt load reduction is depicted in figure 7.

Figure 7, Cumulative salt load reduction for PSR using revised procedure.



Off-farm

Deep percolation from ditches and canals is due to seepage (uniform percolation of water through soil layers) and leakage (water losses through fissures, cracks, or other channels, known or unknown). Seepage and leakage can be estimated by measuring channel flow changes, doing pit studies, or other technical studies. Seepage is often estimated using equations that account for wetted perimeter, permeability and canal length. For small channels (<10 cfs) seepage (deep percolation) has historically been estimated by multiplying channel length by a predetermined loss factor expressed in tons/mile, derived from wetted perimeter-permeability evaluations, set out by Hedlund (1994).

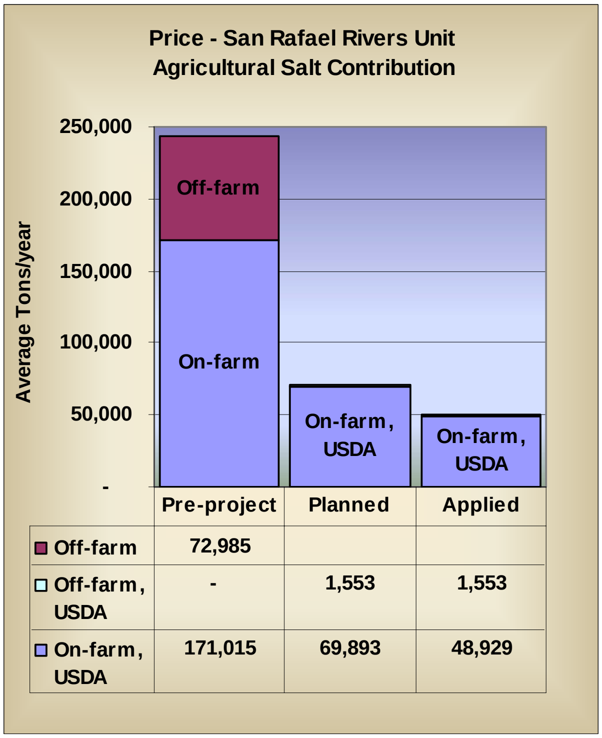
Once water has seeped/leaked from the channel, it must still be determined how much is used by vegetation, and how much returns to the river system. Traditionally, 50% of deep percolation from canal seepage has been allocated to return flow. The actual ratio cannot be measured and is probably highly variable.

Maps in the EIS clearly indicate that in 1993, major canals and laterals were considered off-farm and smaller laterals and delivery systems were determined to be on-farm and to be treated as part of the on-farm irrigation system for economics and salt load reduction calculations.

In FY2007, Reclamation and NRCS agreed to the on-farm/off-farm salt load allocation presented in figure 1 (page 7). Reclamation is presently evaluating the off-farm allocation. When completed, NRCS' off-farm tons/mile-year factor may need additional adjustment.

Figure 8 summarizes the status of USDA salt load reduction as of the end of FY2007.

Figure 8, USDA tons planned/treated compared to original agricultural salt load

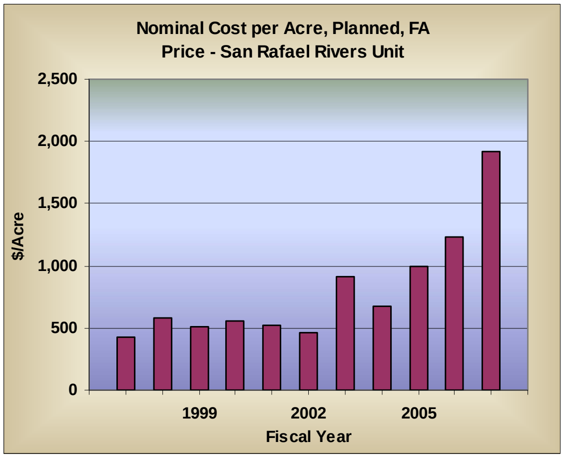


Cost per Ton

Figure 9 depicts the average cost/acre of planned on-farm systems, by year.

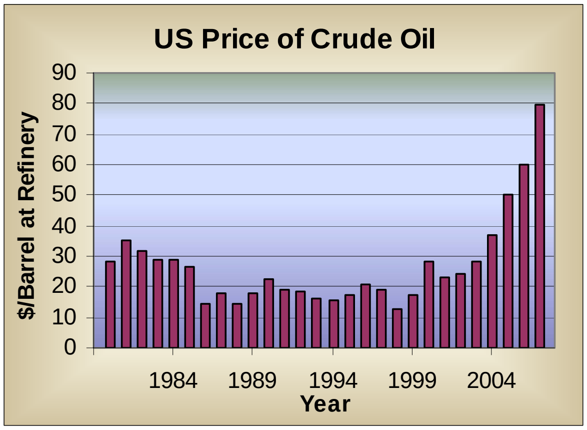
Note the average cost of installation has tripled in the last six years. The quality of projects is relatively constant and does not seem to be a major factor in increasing costs.

Figure 9, Cost per acre for planned practices



Why is cost/acre increasing? Since 1998, the United States average price of crude oil has increased six fold, from about $13/barrel to about $80/barrel. (See figure 10.) The cost of plastic pipe and fuel are directly related to the cost of crude oil. In addition, higher crude oil prices have launched a new energy boom in the Price – San Rafael Rivers Basin, driving up labor and equipment costs.

Figure 10, US price of crude oil, by year



When adjusted salt load reduction calculations are applied, amortized cost per ton increases proportionally to cost/acre.

In FY2007 the amortized cost for planned salt load reduction is $80/ton FA+TA, calculated as follows: $2.39 million in FA was obligated on 1,244 planned acres. About $1.60 million in Technical Assistance (TA) was also required.

The total $3.99 million amortized at 4.875% over 25 years = $279,500/year. The planned salt load reduction is 3,500 tons (1,244 acres x 3.29 tons/acre x 0.86). Hence, the average cost of planned practices = $279,500/year ÷ 3,500 tons/year = $80/Ton-year (FA+TA).

Calculated similarly, practices applied in FY2007 cost $34/ton-year, based on applying $2.43 million in FA and $1.62 million in TA on 3,000 acres, reducing salt load by 8,400 tons.

Table 3 calculates annual cost/ton for obligated (planned) practices, nominal and in 2007 dollars.

Table 4 calculates annual cost/ton for applied practices.

Figure 11 depicts nominal annual cost/ton of planned and applied practices.

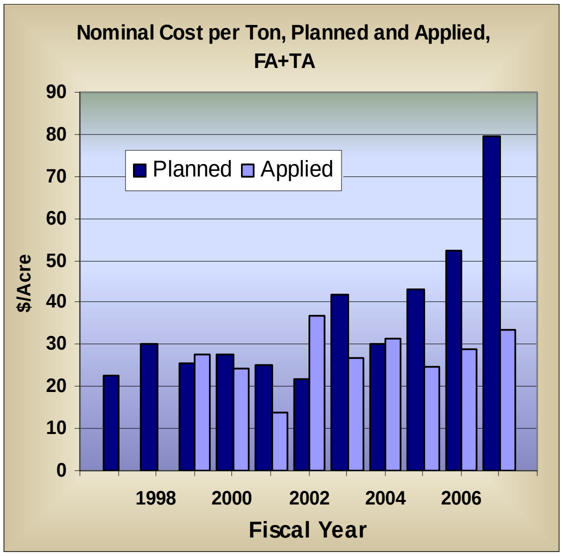
Table 3, Calculated cost/ton, nominal and 2007 dollars, for planned practices

FY	Nominal FA Obligated	Nominal FA Obligated +67% TA	Federal Water Project Interest Rate	Amortized FA+TA	PPI	Amortized FA+TA 2007 Dollars	Obligated Salt Load Reduction, Tons/Year	Nominal $/Ton	$/Ton 2007 Dollars
1996		-	7.625%	-	210.9	-			
1997	692,191	1,153,652	7.375%	102,363	216.4	139,664	4,553	22	31
1998	549,364	915,607	7.125%	79,455	210.9	111,238	2,643	30	42
1999	862,317	1,437,195	6.875%	121,941	210.9	170,717	4,812	25	35
2000	875,959	1,459,932	6.625%	121,075	220.1	162,442	4,409	27	37
2001	1,718,908	2,864,846	6.375%	232,155	225.6	303,877	9,314	25	33
2002	1,359,897	2,266,496	6.125%	179,412	227.4	232,946	8,214	22	28
2003	1,135,541	1,892,568	5.875%	146,296	234.7	184,012	3,509	42	52
2004	3,044,481	5,074,135	5.625%	382,901	243.9	463,511	12,716	30	36
2005	2,477,342	4,128,903	5.375%	304,063	262.2	342,336	7,049	43	49
2006	3,222,238	5,370,397	5.125%	385,831	271.4	419,721	7,396	52	57
2007	2,393,232	3,988,720	4.875%	279,474	295.3	279,474	3,509	80	80
Totals	18,331,470	30,552,450		2,334,964		2,809,940	68,125	34	41

Table 4, Calculated cost/ton, nominal and 2007 dollars, for applied practices

FY	Nominal FA Applied	Nominal FA Applied +67% TA	Federal Water Project Interest Rate	Amortized FA+TA	PPI	Amortized FA+TA 2007 Dollars	Salt Load Reduction, Tons/Year	Nominal $/Ton	$/Ton 2007 Dollars
1996	-	-	7.625%	-	210.9	-	-	-	-
1997	-	-	7.375%	-	216.4	-	-	-	-
1998	-	-	7.125%	-	210.9	-	-	-	-
1999	598,612	997,687	6.875%	84,650	210.9	118,510	3,070	28	39
2000	464,291	773,818	6.625%	64,174	220.1	86,100	2,651	24	32
2001	218,264	363,773	6.375%	29,479	225.6	38,586	2,111	14	18
2002	2,063,945	3,439,909	6.125%	272,297	227.4	353,547	7,405	37	48
2003	1,542,280	2,570,467	5.875%	198,697	234.7	249,924	7,410	27	34
2004	1,016,295	1,693,825	5.625%	127,818	243.9	154,727	4,088	31	38
2005	1,072,550	1,787,583	5.375%	131,642	262.2	148,212	5,370	25	28
2006	2,037,288	3,395,480	5.125%	243,945	271.4	265,372	8,406	29	32
2007	2,427,599	4,045,998	4.875%	283,488	295.3	283,488	8,417	34	34
Totals	11,441,124	19,068,541		1,436,190		1,698,467	48,929	29	35

Figure 11, Nominal amortized cost/ton, planned and applied practices



Hydro Salinity

Before implementation of salinity control measures, PSR agricultural operations contributed an estimated 244,000 tons of salt per year into the Colorado River (on-farm and off-farm), from 44,000 acres of annually irrigated land. Salt loading of 171,000 Tons/year was allocated to on-farm activities and 73,000 tons to off-farm canals, large laterals, and winter water systems, see figure 1 (page 7).

Three assumptions guide the calculation of salt load reduction from irrigation improvements:

1. Salt concentration of subsurface return flow from irrigation is relatively constant, regardless of the amount of canal seepage or on-farm deep percolation (Hedlund, 1994)
2. The supply of mineral salts in the soil is essentially infinite and salinity of out-flowing water is dependent only on solubility of salts in the soil. Therefore, salt loading is directly proportional to the volume of subsurface return flow (Hedlund, 1994)
3. Water that percolates below the root zone of the crop and is not consumed by plants or evaporation will eventually find its way into the river system. Salt loading into the river is reduced by reducing deep percolation. (Hedlund, 1994)

Deep percolation and salt load reductions are achieved by reducing or eliminating canal/ditch seepage/leakage and by improving the efficiency of irrigation, reducing on-farm deep percolation. It is estimated that upgrading an uncontrolled flood irrigation system to a well designed and operated sprinkler system will reduce deep percolation and salt load by 84-91%. (See appendix I.)

NRCS salinity control programs focus on helping cooperators improve irrigation systems, better manage water use, and sharply reduce deep percolation/salt loading.

Salinity Monitoring Methods

The 1991, "*...Framework Plan for Monitoring and Evaluating (M&E) the Colorado River Salinity Control Program*" as utilized in the Uintah Basin and adopted by the EIS for the Price – San Rafael Rivers Unit, focused on:

- Intensive instrumentation and analysis on several irrigated farms, requiring expensive equipment and frequent field visits to ensure and validate collected data
- Detailed water budgets to determine/verify deep percolation reductions
- Multi-level soil moisture measured weekly, with a neutron probe
- Detailed sprinkler evaluations, using catch cans, ran annually on selected farms
- Crop yields physically measured and analyzed

As a result of labor intensive testing in the Uintah Basin Unit, it was confirmed that irrigation systems installed and operated as originally designed, produced the desired result of improved irrigation efficiencies and sharply reduced deep percolation rates, concurrent with reduced farm labor and improved yields.

Due to budget restraints, field intensive M&E efforts were never fully implemented in PSR. A new "*Framework Plan for Monitoring and Evaluating (M&E) the Colorado River Salinity Control Program*" was adopted in 2001. Having established that properly installed and operated practices yield predictable and favorable results, the 2001 Framework Plan addresses hydro-salinity by:

- Utilizing random cooperator surveys to collect and evaluate cooperator understanding, and impressions concerning contracts and equipment
- Formal and informal Irrigation Water Management (IWM) training and encouragement
- Equipment spot checks and operational evaluations
- Agricultural statistics collected by government agencies

In PSR, virtually all salinity program irrigation improvements are sprinkler systems. Wheel lines out number center pivots by about two to one, on an acreage basis, presumably due to smaller average field size. The average contract size is 45 acres. The median size is 22 acres and two-thirds of contracts are less than 40 acres.

Cooperator questionnaires, interviews, and training sessions

In FY2002 and FY2003, 164 cooperators, selected randomly, were surveyed. No additional surveys were done in FY2004 through FY2007.

A quick review of cooperator surveys reveals the following:

- Ninety-four percent of respondents are actively farming their land
- Ninety-six percent say their system is as designed or better
- Seventy-five percent measure their water
- Forty percent monitor soil moisture for irrigation timing
- Seventy-one percent have had some IWM training
- Seventy-four percent think their share of the cost will pay out from reductions in labor and gains in production
- Ninety-five percent think the salinity program is beneficial to the area and region
- Thirty-three percent think their project has had a positive effect on wildlife. 18% think their project has had a negative effect on wildlife

Appendix III is a summary of cooperator responses to past NRCS surveys.

Irrigation Water Management (IWM)

The goal of IWM is to assure that irrigated crops get the right amount of water at the right place at the right time, which will accomplish the goal of minimizing deep percolation and salt loading in the river. Proper IWM is achieved by careful equipment design, cooperator education, and maintenance resulting in implementation of effective water management techniques.

In general, sprinkler systems designed by NRCS are capable of irrigating the most water-consumptive projected crop in the hottest part of the year. When growing crops with lower water needs, or at other times in the growing season, these systems are capable of over-irrigating to some extent.

Over irrigating in early spring and late fall is mitigated by water storage aspects of the soil. Crops generally use water before irrigation begins and after irrigation ends, leaving the soil moisture profile somewhat depleted. Filling the soil with water requires additional water, over and above crop needs, in the spring.

Preventing over-irrigation is a contractual obligation of the cooperator. To help cooperators fulfill this obligation they must be educated and coached in the proper use and maintenance of their irrigation systems.

IWM training is enhanced by creating financial incentives for IWM, providing initial IWM training sessions, periodic water conferences, and developing IWM tools that simplify record keeping and help cooperators properly time irrigation cycles.

Incentive IWM payments have resulted in a much greater awareness of record keeping and soil/water relationships.

Water management seminars and conventions are sponsored by various state, local, and commercial groups, encouraging everyone to manage and conserve water. NRCS is a willing and eager participant in these partnership educational endeavors.

In addition, personal guidance is available to cooperators, on request, at the local field office.

Intensive and continuous IWM training is essential to successful long term salt load reduction.

To help cooperators with irrigation timing, an essential part of IWM, NRCS demonstrates two simple, low-cost approaches:

1. Irrigation record keeping, wherein the cooperator keeps track of water put on the field and compares the volume used to the volume required by the crop

2. Soil moisture monitoring, where the cooperator determines when to irrigate, based on the available water content (AWC) of his soil

Irrigation Record Keeping

NRCS has developed and provided the, "IWM Self Certification Spreadsheet" which allows cooperators to graphically compare actual irrigation with projected average crop water requirements and/or with modeled crop evapotranspiration. Evapotranspiration is calculated from weather data collected by NRCS and other public agencies, using crop simulation techniques developed by Utah State University. The final output of the spreadsheet is a graph comparing water applied with water required on a seasonal basis. See figures 12 and 13.

Figure 12 is the input form, on which the irrigator enters data into the blue shaded cells. The spreadsheet then calculates the remaining data.

In the first plot in figure 13, if the red actual application line is below and to the right of the blue consumptive use line, the crop is under irrigated. If the red actual use line is above the blue consumptive use line, the field is over-irrigated and excessive deep percolation has occurred. (A small amount of deep percolation is designed into all irrigation systems to compensate for distribution anomalies and to leach accumulated salt from the root zone.)

The second plot of figure 13 is AWC. When AWC is 100% of capacity, additional water application results in deep percolation. Red bars descending below the x axis indicate deep percolation.

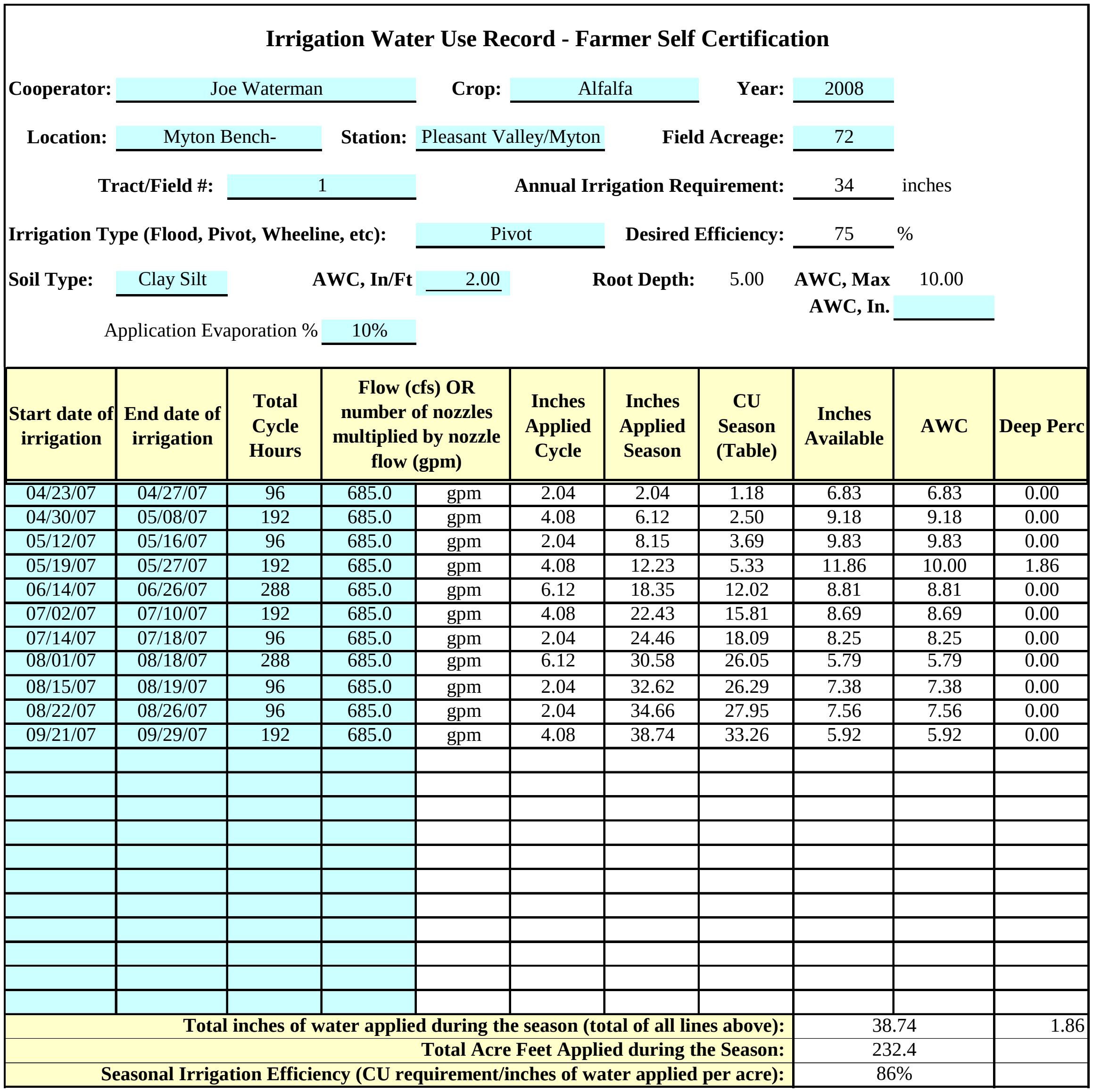
In order to receive incentive payment for IWM, each irrigator must log irrigation data and present the logs to the field office, where data is entered into the spreadsheet and the results are discussed. The graphs are printed for the farmer's reference. In general, cooperators respond positively to this training and work hard to irrigate more efficiently.

Irrigation records and subsequent training are very important to cooperator understanding and should be an integral part of any IWM certification effort.

From past IWM certification records, it appears that 95% of systems do not deep percolate excessively. New sprinkler owners are much more likely to under-irrigate than to over-irrigate. Typically, the price for under-irrigation is reduced yield, not dead crops. Without careful record keeping, the farmer may never recognize his error.

Due to the prevalence of under-irrigation, it can be assumed that, based on irrigation record keeping, salt load reduction projections are probably conservative.

Figure 12, Sample IWM Self Certification Spreadsheet – Data Entry Page



Irrigation Water Use Record - Farmer Self Certification

Cooperator: Joe Waterman **Crop:** Alfalfa **Year:** 2008

Location: Myton Bench- **Station:** Pleasant Valley/Myton **Field Acreage:** 72

Tract/Field #: 1 **Annual Irrigation Requirement:** 34 inches

Irrigation Type (Flood, Pivot, Wheeline, etc): Pivot **Desired Efficiency:** 75 %

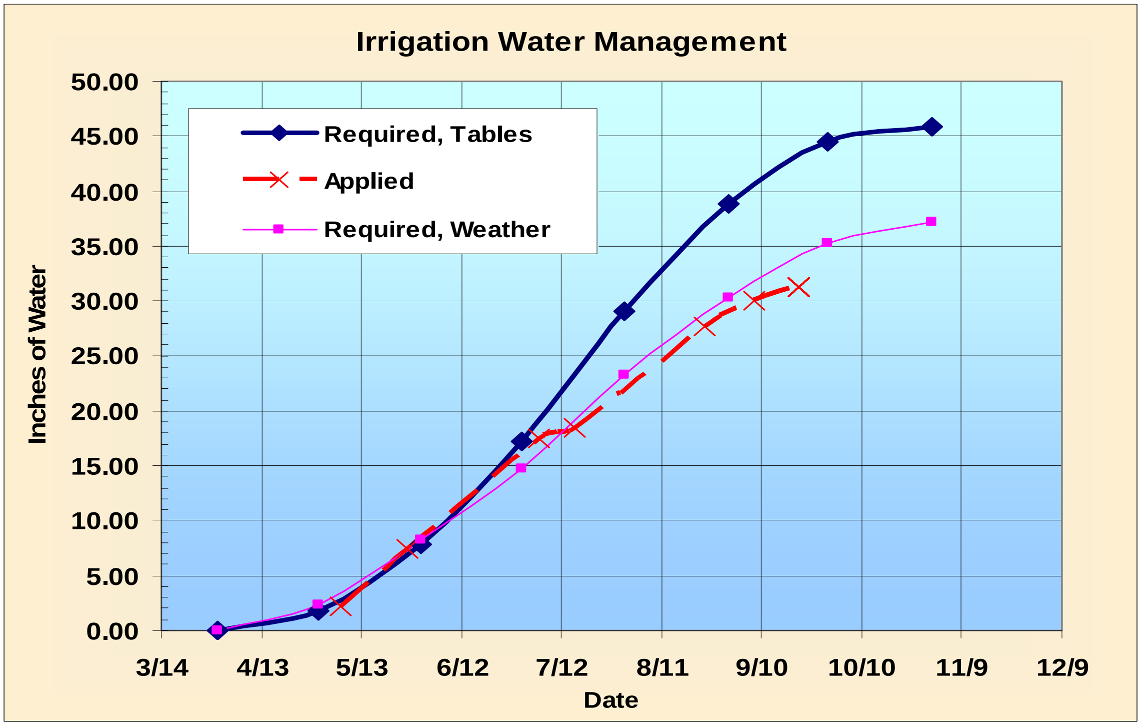
Soil Type: Clay Silt **AWC, In/Ft** 2.00 **Root Depth:** 5.00 **AWC, Max AWC, In.** 10.00

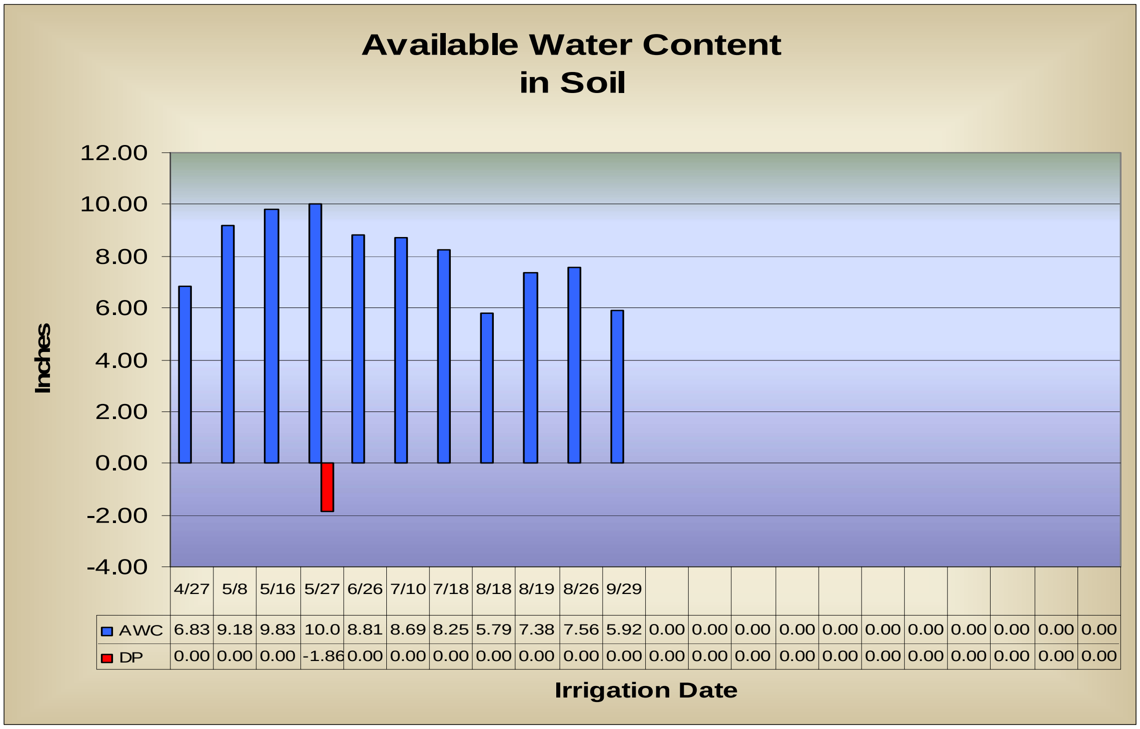
Application Evaporation % 10%

Start date of irrigation	End date of irrigation	Total Cycle Hours	Flow (cfs) OR number of nozzles multiplied by nozzle flow (gpm)		Inches Applied Cycle	Inches Applied Season	CU Season (Table)	Inches Available	AWC	Deep Perc
04/23/07	04/27/07	96	685.0	gpm	2.04	2.04	1.18	6.83	6.83	0.00
04/30/07	05/08/07	192	685.0	gpm	4.08	6.12	2.50	9.18	9.18	0.00
05/12/07	05/16/07	96	685.0	gpm	2.04	8.15	3.69	9.83	9.83	0.00
05/19/07	05/27/07	192	685.0	gpm	4.08	12.23	5.33	11.86	10.00	1.86
06/14/07	06/26/07	288	685.0	gpm	6.12	18.35	12.02	8.81	8.81	0.00
07/02/07	07/10/07	192	685.0	gpm	4.08	22.43	15.81	8.69	8.69	0.00
07/14/07	07/18/07	96	685.0	gpm	2.04	24.46	18.09	8.25	8.25	0.00
08/01/07	08/18/07	288	685.0	gpm	6.12	30.58	26.05	5.79	5.79	0.00
08/15/07	08/19/07	96	685.0	gpm	2.04	32.62	26.29	7.38	7.38	0.00
08/22/07	08/26/07	96	685.0	gpm	2.04	34.66	27.95	7.56	7.56	0.00
09/21/07	09/29/07	192	685.0	gpm	4.08	38.74	33.26	5.92	5.92	0.00
Total inches of water applied during the season (total of all lines above):								38.74		1.86
Total Acre Feet Applied during the Season:								232.4		
Seasonal Irrigation Efficiency (CU requirement/inches of water applied per acre):								86%		

Figure 13, Sample graphs from the IWM Self Certification Spreadsheet.

The blue line is a long-term average water requirement, based on location and crop. The red line is the actual water applied. Where data is available, the purple line is modeled from actual data collected at a nearby weather station, using a USU evapotranspiration model.





	4/27	5/8	5/16	5/27	6/26	7/10	7/18	8/18	8/19	8/26	9/29											
🟦 AWC	6.83	9.18	9.83	10.0	8.81	8.69	8.25	5.79	7.38	7.56	5.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
🟥 DP	0.00	0.00	0.00	-1.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Soil Moisture Monitoring

A time-tested method for timing irrigation involves augering a hole and determining the water content of soil in the root zone to decide when to apply the next irrigation. This may well be the best method available for irrigation timing, both simple and inexpensive. However, it seems to be among the first practices abandoned when ordinary people are forced to allocate a limited amount of time.

NRCS is demonstrating and guiding cooperators in the use of another tool for timing irrigation - modern soil moisture monitoring systems utilizing electronic probes and data recorders. Such systems can now be installed for about $600, giving the cooperator information on the water content of his soil at multiple depths and locations without time-consuming augering.

In a typical case, electronic probes are installed at three or more different depths, such as 12”, 24” and 48”. Using a simple data recorder, indicated soil pore pressure (implied soil moisture content) is read and recorded multiple times per day. With some recorders, soil pore pressure is presented graphically on an LCD display in the field, making it a simple matter to estimate when the next irrigation will be required (see figure 14).

Since soil will not drain water unless it is saturated, it is assumed that deep percolation is not occurring if the deepest probe reading is less than -2 centibars. In PSR, six installed data recorders indicate that deep percolation occurs less than 3% of the time on monitored fields.

PSR also has several fields with probes but no data recorder. When they were installed, the Soil Conservation District intended to read all of the probes manually, on a weekly basis, and plot the results. Unfortunately, personnel changes have thwarted this effort. Installing data recorders at each of these fields would be a much less expensive and more reliable way to monitor soil moisture. It would be prudent to negotiate a grant to make this update.

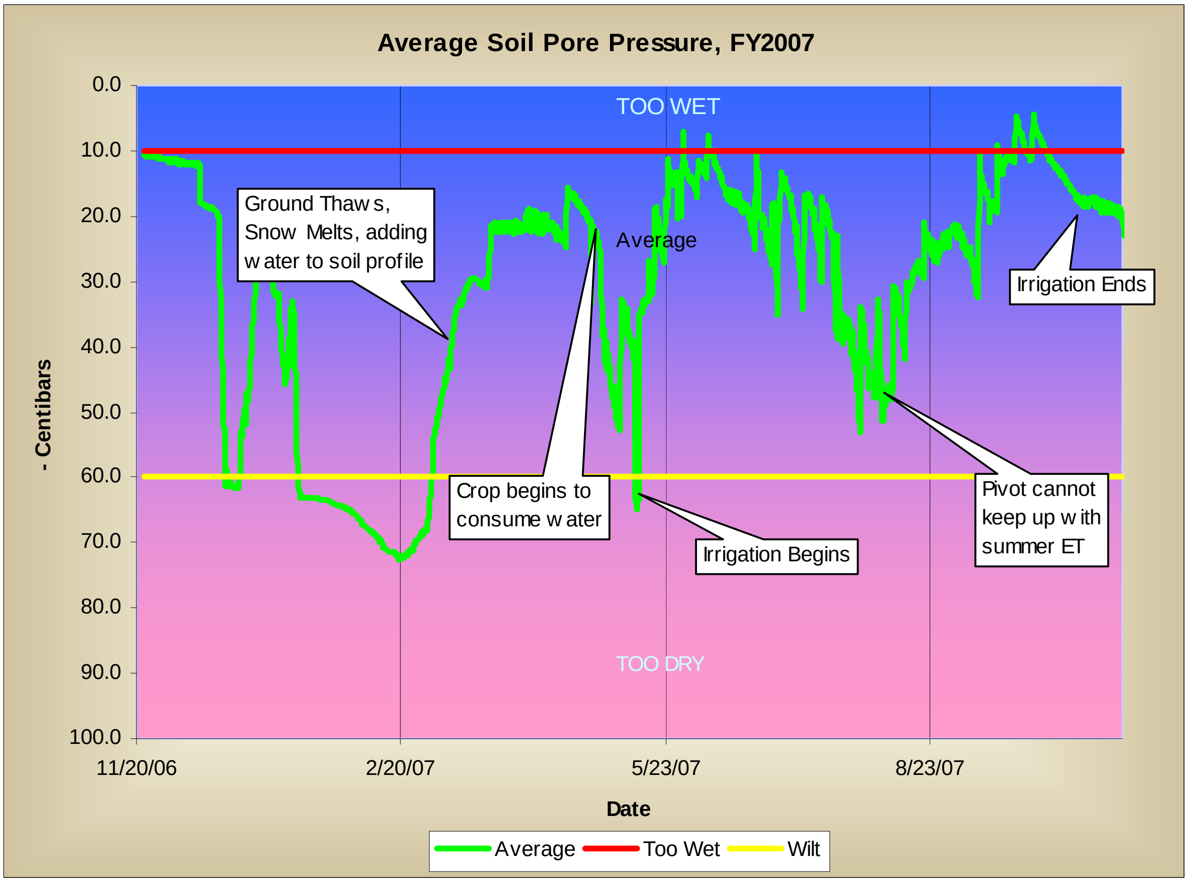
Figure 14, Soil moisture data recorder with graphing

In addition, adding soil moisture monitors to the NRCS cost schedule as an eligible IWM (449) practice would encourage more new irrigators to take advantage of this useful technology.

Figure 19 is an Excel graph of data downloaded from a soil moisture data recorder.

Figure 15, Soil moisture data downloaded from recorder and graphed in Excel.

This rich loam soil absorbs moisture readily and has good water storage characteristics. In winter, the soil freezes and sensor readings become irrelevant. As the soil thaws and the snow melts, soil moisture rises. Alfalfa starts to grow, pulling stored moisture from the soil. Irrigation begins, quickly filling the soil profile with water. As summer heat increases, center pivot irrigation is unable to keep up with evapotranspiration (ET$_C$) of the crop. When weather starts to cool, the soil profile begins to fill until irrigation ends in fall.



Equipment Spot Checks and Evaluations

Catch-can Testing

In FY2007, no catch-can tests were ran, due to limitations described in the FY2005 M&E report. As reported in the FY2005 M&E Report, the most useful aspects of catch-can testing on wheel lines were observations made before the test was ran. With sprinkler systems running, an assessment of leaks and malfunctioning heads can be made very quickly, often without leaving the vehicle.

Operating Sprinkler Condition Inventory

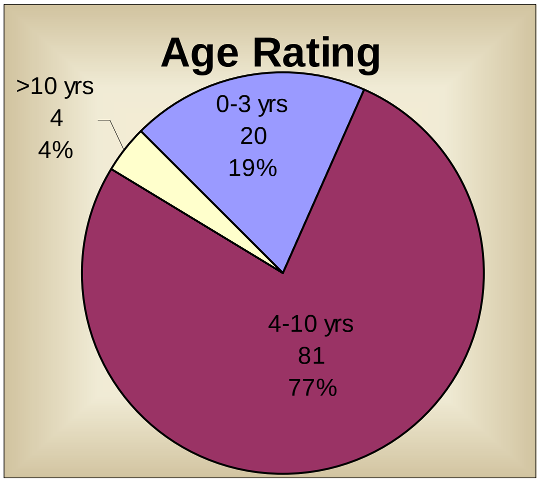
Based on the premise that 50-100 operating sprinkler systems can be observed by one person in a day, an inventory was devised to collect as much data as possible during the FY2006 irrigation season. No additional observations were made in FY2007. One hundred and seventeen systems were logged, of which 106 were operating wheel lines or hand lines.

Sprinklers were logged using a laptop computer running ArcGIS 8.3, connected to a simple field mapping GPS (Garmin GPSMap 76). Using the National Agricultural Imaging Program (NAIP) 1 meter true color image as a background, each observed sprinkler lateral was sketched into a shapefile and attributes recorded. The following rules were used for annotation:

1. Age was estimated visually and rated: 1 = 0-3 yrs, 2 = 4-10 yrs, 3 = >10 yrs
2. Condition was rated visually: 1 = no repairs needed, 2 = repairs needed, 3 = not useable without major repairs
3. Leaks from hoses, drains, heads, and other sources were estimated visually and the total gallons per minute (GPM) leakage estimated for the system
4. Sprinkler length was calculated from the shapefile
5. Acres were estimated by assuming a 660' long field (approximately 11 sets/irrigation cycle)
6. Net irrigation requirement was estimated to be 8 GPM/acre
7. The leak % represents GPM from leaks ÷ GPM for the system
8. Only wheel lines in operation were considered--idle systems were not a target of this study

Figures 16 through 21 depict results of the sprinkler inventory.

Figure 16, Rated age of sprinkler systems, based on field estimate.



Compared to systems in the Uintah Basin, PSR systems are relatively new and leaks less common. Most needed repairs can be avoided with consistent, high quality maintenance.

Figure 17, Rated condition of sprinkler systems, based on field estimate.

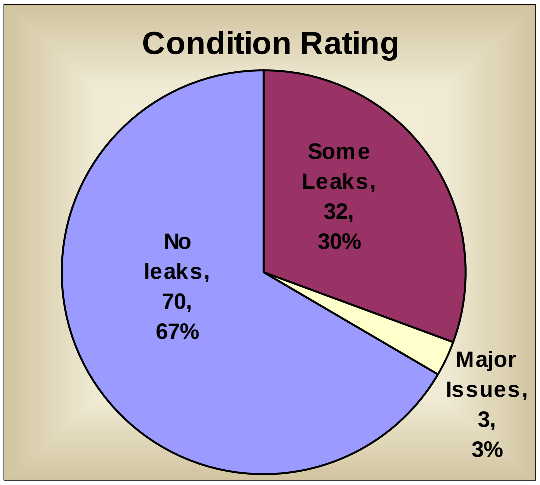


Figure 18, Wheel line condition rating

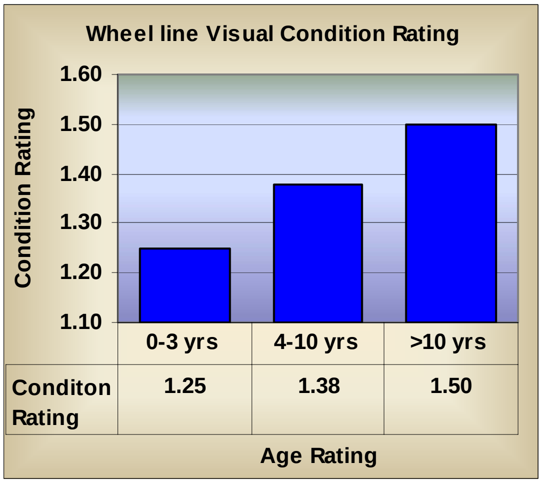


Figure 19, Drain leaks are the most common type of leak – and the most prolific – and easily repaired

Figure 20, End caps also frequently leak

Figure 21, Hose leaks are rare but prolific and expensive to repair

Wildlife Habitat and Wetlands

Background

The Final Environmental Impact Statement (EIS) for the Price/San Rafael Rivers Unit was completed in December, 1993. The EIS discusses at length anticipated impacts the application of the preferred plan will have on the landscape. The EIS states "The replacement of wetland/wildlife habitat with like habitat is a goal of USDA in all of it's programs; however, the primary goal of the CRBSCP - to reduce salinity in the Colorado River - is not compatible with the preservation and/or replacement of wetlands supported by over irrigation." This persistent quandary caused much discussion of the necessity of wetland replacement. In the beginning Soil Conservation Service (SCS) met with Utah Division of Wildlife Resources (UDWR), U.S. Bureau of Reclamation (BOR), U.S. Environmental Protection Agency (EPA), and U.S. Fish and Wildlife Service (USFWS), to discuss alternatives to wetland vegetation replacement. The EIS also states "…physical limitations severely restrict of placement of wetlands in close proximity to irrigated areas". Lined ponds with no outlets, ponds in sandstone members of the Mancos Shale Formation, and many other alternatives were discussed in the EIS.

Guidelines in the 1991 "The Framework Plan for Monitoring and Evaluating (M&E) the Colorado River Salinity Control Program" were adopted and placed in the EIS for the Price San/San Rafael Rivers Salinity Unit. In accordance with this framework plan, wildlife habitat monitoring would be performed along 18 selected transects throughout the area. Color aerial photography would be taken every three years to monitor changes in the extents of wetlands as a result of project implementation of the CRSC Program. These photographs would be scanned and wetlands digitized and compared to prior year baseline maps. Changes over time would create inferences for the basin as a whole. To supplement aerial photographs, Wildlife Habitat Evaluations from individual plans or contracts would be analyzed to determine accumulated changes in wildlife habitat, both upland and wetland.

Due to a decrease in funding for technical assistance, wildlife habitat monitoring efforts were reduced in 1997 and discontinued in 1999. Two new employees, a biologist and a civil engineer, were hired in September 2002 as the new Monitoring and Evaluation (M&E) team.

In 2001 "The Framework Plan for Monitoring and Evaluating (M&E) the Colorado River Salinity Control Program" was revised and M&E evolved from a labor/cost intensive, detailed evaluation of a few biological sites, to a broader, less detailed evaluation of large areas and many resource concerns. This change was primarily driven by budget restraints and improved technology. Methodology adopted in 2002 was to utilize remotely sensed images (Landsat), analyze them with commercial geospatial imagery software, classify, map, and measure vegetation extents, quantify losses or gains of wetlands and wildlife habitat. It was also anticipated that with the use of Landsat images NRCS could extrapolate results from current images back in time to images acquired prior to implementation of the Colorado River Salinity Control Program. Thus NRCS could compare wetland/wildlife habitat extents from pre-Colorado River Basin Salinity Control Program to the current date.

In FY2005 it was determined by the M&E Team that use of Landsat images alone was not sufficient to accurately monitor and track small narrow wetland extents within Salinity Units. Classification of 30-meter Landsat images is an excellent tool for quantifying and assessing land cover classes on large scale projects where there are large tracts of similar vegetation. The M&E team has found it difficult to accurately interpret subtle differences in vegetation types at smaller scales such as presented by small, narrow wetlands found in arid Salinity Units. Landsat images help locate areas of potential wetland and wildlife habitat areas; once located, detailed mapping of actual extents of features is required to accurately identify and define real losses or gains of wetland/wildlife habitat. This can be accomplished with the help of current year, high resolution, aerial photograph interpretation and on-site visits. A photographic history would also be useful in documenting changes in vegetation type. Remote sensing alone will not achieve desired results sought by NRCS to report concurrency and proportionality of wildlife habitat replacement.

In FY2005 the M&E team decided to redirect its methodology to include more precise measurements of actual habitat extents by incorporating detailed mapping, establishment of permanent photo points, and smaller-scale case studies. This approach is more labor intensive. The M&E Team believes that additional manpower may be needed to assist in gathering data needed to create accurate land cover maps to achieve the most accurate and reliable result possible.

At the end of FY2007 no additional workforce had been acquired to assist the M&E team in data gathering. Photo points have been established and will be displayed when relevant information can be extrapolated from photos. Case studies are on-going and will be reported in future versions of this document.

Basin Wide Wildlife Habitat Monitoring

Detailed cover maps are not available for inclusion in this report. Permanent photo points, at representative locations throughout the area, of wetlands, wildlife habitat, agricultural areas, and areas where pipelines have recently been built have been selected and a protocol established to compare across the years. The initial years will be baseline data as there will be no comparison photos. Photographs will be taken near the same date annually, and compared approximately every five years in a visual display in M&E Reports. Historical photos are still being sought for comparison.

Wildlife Habitat Contract Monitoring

Three Environmental Quality Incentive Program (EQIP) Wildlife Only projects were planned and funded in the Price/San Rafael Basins in FY2007 for a total of 112 acres. There were no Basin States Parallel Program (BSPP) or Wildlife Habitat Incentives Program (WHIP) projects planned or funded in FY2007 (Table 5).

Funds from FY2005 Basin States Parallel Project (BSPP) Request for Proposals (RFP) for accelerated habitat replacement have not been awarded. A total of $250,000 in the BSPP RFP program is still available for wildlife habitat replacement projects.

There were no wildlife habitat projects, from any fund, applied in FY2007 (Table 6).

Table 5, Wildlife Practices Planned in FY2007

Acres of Wildlife Habitat Creation or Enhancement Planned and Funded by Program and County							
Price/San Rafael Rivers Basins, FY2006							
	EQIP		WHIP		BSPP		Total (acres)
Management Type	**Wetland (*644)**	**Upland (*645)**	**Wetland (*644)**	**Upland (*645)**	**Wetland (*644)**	**Upland (*645)**	
Carbon County	0	112	0	0	0	0	112
Emery County	0	0	0	0	0	0	0
2007 Basin Totals	**0**	**112**	**0**	**0**	**0**	**0**	**112**

* Practice 644 is Wetland Wildlife Habitat Management; practice 645 is Upland Wildlife Habitat Management.

Voluntary Habitat Replacement

NRCS continues to encourage replacement of wildlife habitat on a voluntary basis. Federal and State funding programs are in place to promote wildlife habitat replacement. This information is advertised annually in local newspapers, in Local Workgroup meetings, and Conservation District meetings throughout the Salinity Area. The Utah NRCS Homepage also has information and deadlines relating to Farm Bill programs.

Table 6. Wildlife Practices Applied in FY2006.

Acres of Wildlife Habitat Creation or Enhancement Applied by Program and County							
Price / San Rafael Rivers Basins, FY2006							
	EQIP		WHIP		BSPP		Total (acres)
Management Type	**Wetland (*644)**	**Upland (*645)**	**Wetland (*644)**	**Upland (*645)**	**Wetland (*644)**	**Upland (*645)**	
Carbon County	0	0	0	0	0	0	0
Emery County	0	0	0	0	0	32	32
2007 Basin Totals	**0**	**0**	**0**	**0**	**0**	**32**	**32**

* Practice 644 is Wetland Wildlife Habitat Management; practice 645 is Upland Wildlife Habitat Management

Voluntary habitat replacement is moving slowly in the Price /San Rafael basins as it did in the early years of the Uintah Basin Project. NRCS has reason to believe that as the project matures habitat replacement will increase in popularity and high quality applications will become more numerous.

Economics

Cooperator Economics

Production Information

While alfalfa yields have not improved markedly since inception of salinity control measures, total production of alfalfa is trending up. Figure 22 reflects total alfalfa production and yield over a 20 year period. The green line is a linear regression on production. Yield may be more closely related to precipitation than anything else. Figure 23 depicts historical mountain precipitation.

Figure 22, PSR alfalfa production

Source data is tabulated in Appendix VI

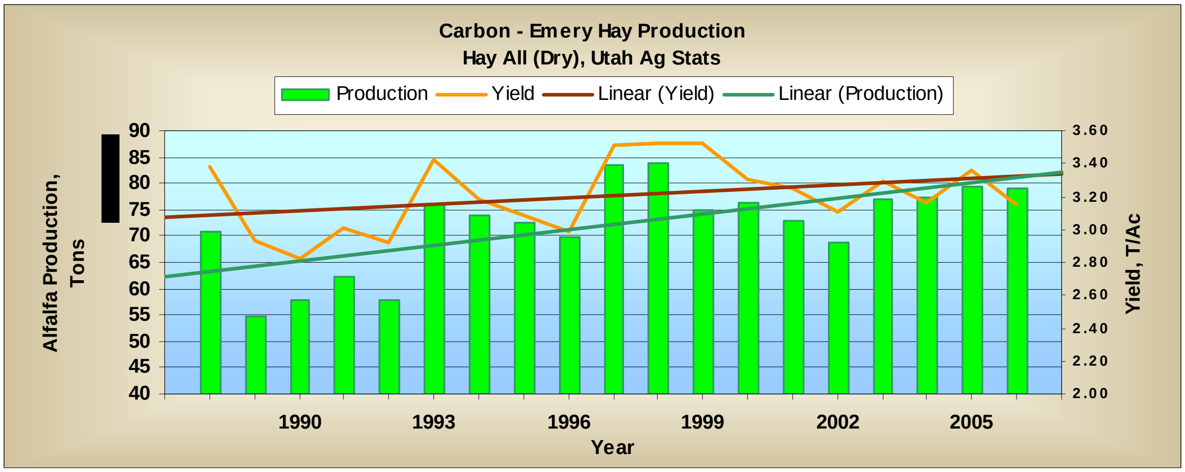
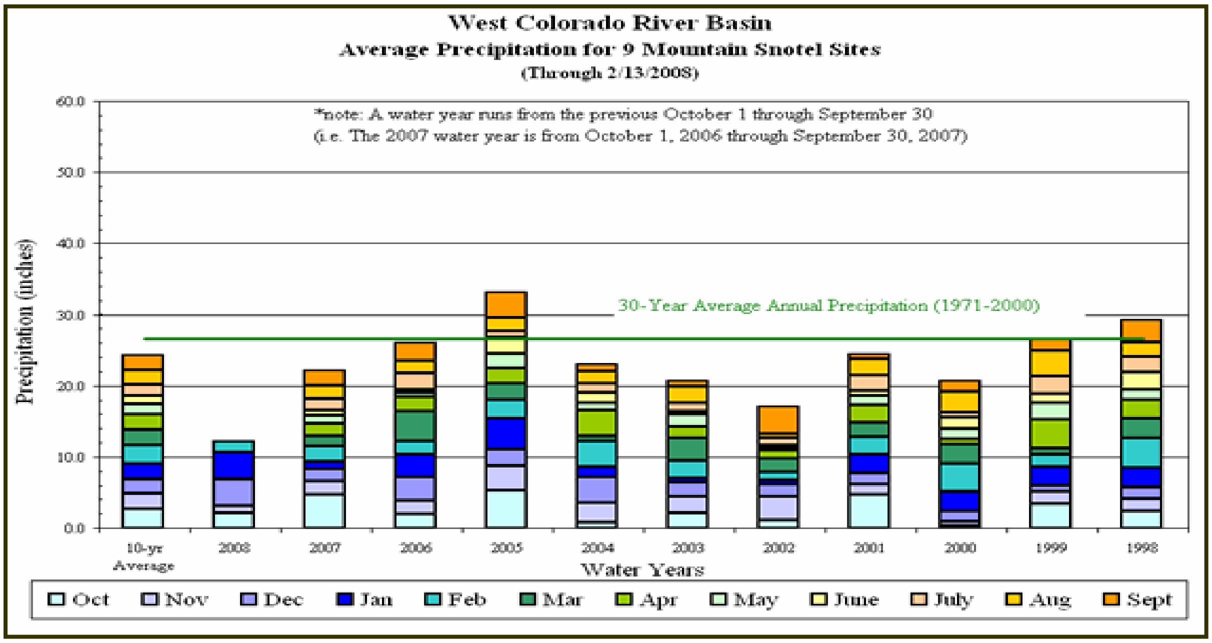


Figure 23, PSR Mountain Precipitation from Utah Division of Water Resources



Labor Information

From National Agricultural Statistics Service (NASS) data, labor benefits are elusive as both *Hired Farm Labor* and *Total Farm Production Expenses* have increased steadily over the 1987, 1992, 1997, and 2002 Agricultural Censuses. (The 2007 Agricultural Census is due out in fall, 2008).

While numerical data seems negative, anecdotal information is positive.

Since the majority of farmers do not hire outside labor, it is assumed that most cooperators are satisfied with their own personal labor savings. The 2002 Agricultural Census reports that 50% of area farmers work at off-farm jobs more than 200 days/year. The local labor market is hot, due to booming energy prices and a rapidly expanding petroleum business. It seems logical that landowners will be spending even more time in off-farm employment.

Public Economics

Ninety-five percent of survey respondents believe that salinity control programs have a positive economic affect on the area and region.

Positive public perceptions of the Salinity Control Program include:

- Reduced salinity in the Colorado River
- Increased flows in streams and rivers
- Economic lift to the entire community from employment and broadened tax base
- Local availability of expertise, information, and materials for public conservation
- Aesthetically pleasing, green fields, denser, for longer periods of time
- Improved safety and control of water resources, with a reduction in open streams

Negative public perceptions of the Salinity Control Program include:

- “Greening” of desert landscape
- Conversion of artificial wetlands to upland habitat and other shifts in wildlife habitat
- Changes in Water Related Land Use (WRLU)

Water Related Land Use (WRLU)

The State of Utah Division of Water Resources tracks land use on a regular basis. Figure 24 is a graphical presentation of land use changes in PSR from past WRLU reports. The goal of the WRLU report is to account for all agricultural lands in the State along with immediately adjacent lands.

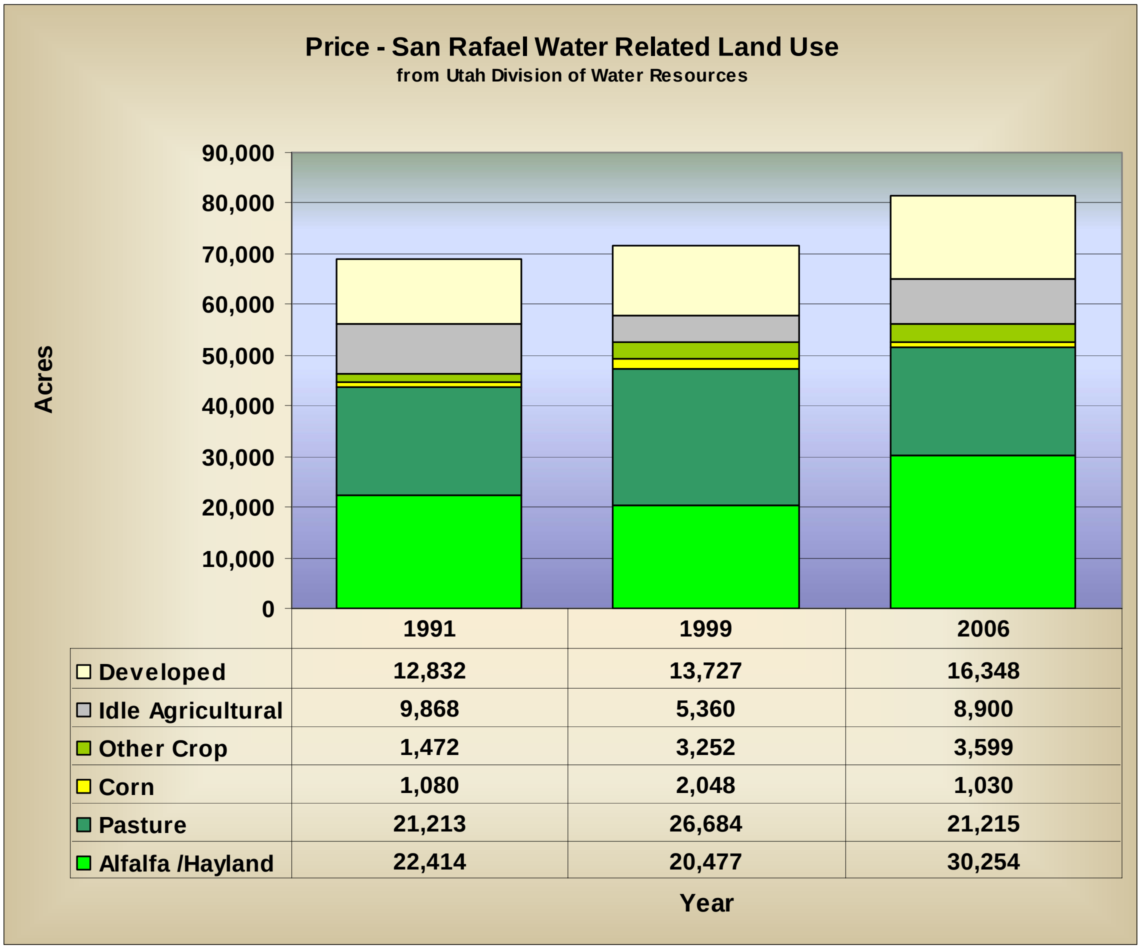
Summary

Local land owners are willing and able to participate in salinity control programs. At present funding levels, ample opportunities exist to install improved irrigation systems and reduce salt loading to the Colorado River system. Participants are apparently satisfied with results and generally positive about salinity control programs.

Irrigation installation costs are escalating. Increased world energy prices have resulted in much higher costs for pipe, transportation, labor, and equipment. In addition, the local economy is in a boom, and upward pressure on labor and equipment prices is mounting.

With labor, material, and equipment prices rising, it is expected that the cost/ton of salinity control measures will also increase. In addition, recent refinements in methods used to calculate salt load reduction are expected to reflect higher calculated cost/ton. However, the FY2007 average cost of $80/ton does not approach the cost of downstream damages from excess salt. Colorado River Basin Salinity Control Programs are successful and cost effective in reducing salt load in the Colorado River.

Figure 24, Water Related Land Use



	1991	1999	2006
☐ Developed	12,832	13,727	16,348
⬜ Idle Agricultural	9,868	5,360	8,900
🟩 Other Crop	1,472	3,252	3,599
🟨 Corn	1,080	2,048	1,030
🟩 Pasture	21,213	26,684	21,215
🟩 Alfalfa /Hayland	22,414	20,477	30,254

APPENDICES

COLORADO RIVER BASIN
SALINITY CONTROL PROGRAM

CALCULATING SALT LOAD REDUCTION

MODIFICATION OF PROCEDURE
JULY 30, 2007

Prepared by
Natural Resources Conservation Service

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NRCS
Natural Resources Conservation Service
United States Department of Agriculture

Executive Summary

The Salinity Worksheet for Ranking has been modified to simplify use, assure proportionality with the EIS/EA and to make calculations uniform in Utah and Colorado by making the following changes:

- Inputs for net irrigation requirement and seasonal irrigation factor have been eliminated.
- Minimum initial efficiency has been increased to 32%.
- Salt Load Factors have been developed that express a percentage of original salt load for a given irrigation efficiency.
- The original salt load has been determined for each salinity area from the EIS/EA or reasonable proxy data where EIS data is inconclusive.
- The salt load reduction calculation is greatly simplified. The salt load reduction is calculated by multiplying the original salt load by a factor related to the initial and final irrigation practice.
- As an example, a 20 acre flooded field has an irrigation efficiency of 32% and a salt load factor of 100%. The salinity area has an original salt load of 2.0 Tons/acre/year. It is proposed to install wheel lines with an efficiency of 65% and a salt load factor of 16%. The change in salt load is (100%-16%) x (2.0 tons/acre/year) x (20 acres) = 34 tons/year.
- Since the difference in salt load factor is always less than 100%, the cumulative tons/acre/year due to on-farm irrigation will never be exceeded, relative to the EIS/EA.
- The original salt load, SL_0 is unique to each salinity area. All salinity areas in Colorado and Utah will use the same salt load factors, SLF_e. The derived cost/ton will have the same computational basis for all salinity areas.

SALT LOAD CALCULATION

Salt loading from on-farm irrigation is the result of excess irrigation water percolating through the soil, dissolving salt, carrying it to the river.

On-farm salt load is reduced by improving irrigation efficiency, reducing the amount of excess water that deep percolates, dissolves salt from the soil, and returns to the river. Improving irrigation practices for salinity control in the Colorado River Basin began in the late 1970s and continues today.

There are or have been salinity control programs in four states, Arizona, Colorado, Utah, and Wyoming. In order to evaluate the effectiveness of treatment, it is desirable to have an evaluation procedure that is broadly applicable and that can be used for all CRSCP installations, allowing reasonable comparisons across State and Salinity Area Boundaries.

Since the inception of the CRBSCP, several different procedures have been used to estimate salt load for salinity control practices. Most procedures involved the input of numerous variables, based on the judgment of the technician doing the analysis. The expectation was that values derived from the procedures would be similar and reasonable, and would, over time, be proportional to salt load reductions anticipated by the EIS/EA upon which program economics were based, approved, and publicly accepted.

Reality is that dozens of variables affect salt pickup and transport and the confidence of any calculation cannot be determined. The potential cost of measuring each variable to develop discreet solutions is not viable. In addition, human nature is such that field staff evaluating salt load frequently move toward a worst case solution, maximizing calculated salt load reduction. While various procedures have worked well for ranking projects within specific salinity areas, the level of detail and variability in actual field computations compromised their usefulness for comparing with projects in other salinity areas and/or states.

Since discreet solutions to the salt load reduction problem are financially daunting, it makes sense to start with publicly accepted values from the EIS/EA, or a reasonable proxy for them. Using EIS/EA derived basin wide ton/acre values as a starting point and reducing ranking complexity makes this problem an accounting issue, rather than a technical issue.

By dividing the EIS anticipated salt load due to on-farm practices in tons/year, by the average irrigated acres, a maximum initial value for tons/year/acre is derived.

$$SL_0 = \frac{Tons_0}{Acres_0}$$

Where

SL_0 = The Salt Load before any treatment

$Tons_0$ = Total ton/year contributed by on-farm practices from the EIS/EA

$Acres_0$ = The average number of irrigated acres, pre-project

To determine salt load at any given efficiency, SL_e, SL_0 is multiplied by a salt load factor, SLF_e appropriate for that efficiency.

Where

SLe = the salt load at a given efficiency

SLFe = a salt load factor that is a function of efficiency

The Salt Load Factor (SLF_e) is derived using the following formula:

$$SLF_e = \frac{\left(\frac{1}{eff} - 1\right)^{1.33} \times 0.25}{\left(\frac{1}{eff_0} - 1\right)^{1.33} \times 0.25} = \left(\frac{\left(\frac{1}{eff} - 1\right)}{\left(\frac{1}{eff_0} - 1\right)}\right)^{1.33}$$

Where

eff_0 = the average efficiency of the salinity area, prior to any treatment under CRSCP.

eff = Irrigation efficiency at the time of evaluation

Values for SLF_e may be obtained from the table in figure 1.

By multiplying SL_0, by SLF_e and the number of treated acres in the project, the total tons attributed the subject acres are derived for specific irrigation efficiency.

$$SL_e = \mathrm{SL}_0 \times \mathrm{A} \times SLF_e$$

Where

A = Area in acres

Knowing the on-farm salt load before and after practice installation, a simple difference is the Salt Load Reduction, SLR, for the project.

$$SLR = SL_1 - SL_2 = (SLF_1 - SLF_2) \times SL_0 \times A$$

Where

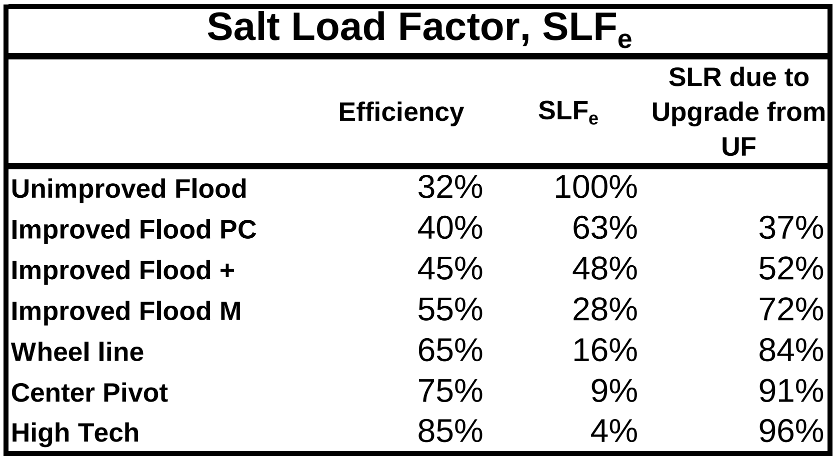
SL_1 = the beginning salt load

SL_2 = the final salt load

SLF_1 = the beginning salt load factor

SLF_2 = the final salt load factor

Natural Resources Conservation Service (NRCS) for Colorado and Utah have agreed to use an initial irrigation efficiency of 32% for all salinity areas in both states.



Salt Load Factor, SLF_e			
	Efficiency	SLF_e	SLR due to Upgrade from UF
Unimproved Flood	32%	100%	
Improved Flood PC	40%	63%	37%
Improved Flood +	45%	48%	52%
Improved Flood M	55%	28%	72%
Wheel line	65%	16%	84%
Center Pivot	75%	9%	91%
High Tech	85%	4%	96%

Figure 1. Salt Load Factors vs. Irrigation Efficiency. Last column reflects salt load reduction for improving irrigation from flood at 32% efficiency to an appropriate new efficiency from the second column, marked Efficiency.

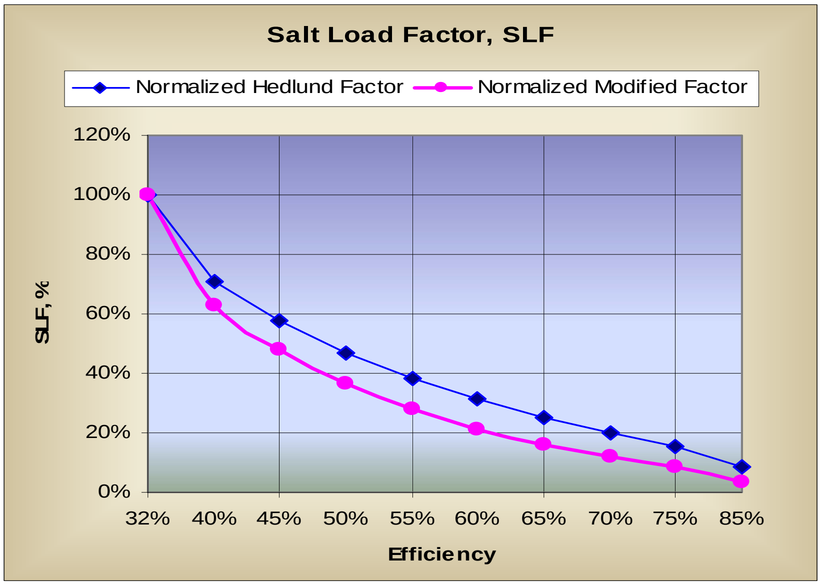


Figure 2 Graph of salt load factor, SLF. The upper line was used in the Ranking Worksheet FY2004 – FY2007. The lower line is used in new Salinity Worksheets for Ranking, beginning with FY2008 contracts and is mathematically defined above.

The adoption of this procedure will result in the following improvements from past procedures:

1. Assure that salt load reduction claims will not exceed EIS/EA expectations

2. Calculations from Colorado and Utah will use the same procedure and results will be comparable

3. Worksheet user inputs have been minimized, also minimizing opportunity for error

Appendix II - Salt Load Reduction Worksheet

COLORADO RIVER BASIN SALINITY CONTROL PROGRAM

Utah NRCS

WATER AND SALT SAVING WORKSHEET for Ranking

Version 070824

Client:		**Date:**	
Salinity Area:	**Dry Gulch**	**Planner:**	

Irrigation System Changes

System Before	Eff	System After	Eff	Acres	EIS Salt Load Tons/Ac	Effective Salt Load Reduction	Salt Load Reduction Tons
UF	32%	**Wheel Line**	65%	**40**	1.04	84%	35
			System Totals	**40**			**35**

Ditch Losses, Off-farm

	Feet Replaced		Tons /Mile	Tons Salt
			80.0	-

Contracts - On-farm

Contract Number	Date	Amount	Treatment Description	Treated Area	Interest Rate	FA	Amortized $/Acre FA+TA
		$		Acres	%	$/Acre	$/Acre
748D43yyXnnn	06/01/07	30,000	Pivot	**40**	4.875%	750	88
						-	-
						-	-
						-	-
						-	-
						-	-
Totals	**1**	**30,000**		**40**		**$750**	**$88**
						Tons/Ac	0.87

Amortized $/Ton, FA+TA	**$100**

Appendix III - 2002 – 2004 Cooperator's Survey Summary

Random Selection Number	**All**
Operation Name	**Price - San Rafael Totals***
Contract Number or Year/Years	**Various**

Irrigated Acres	**Flood**	**Wheel Line**	**Hand Line**	**Pivot**	**Total**
	0%	30%	18%	2%	50%
Is the contract active and the land being cropped? (Circle One)	**Yes**	**No**			
	94%	6%			
Crop Acres	**alfalfa**	**pasture**	**grains**	**other**	
	46%	28%	14%	11%	
Is the current irrigation system the same as designed and planned at start of contract? (Circle one)	**Substantially improved**	**Slightly improved**	**Same as designed**	**Slightly degraded**	**Substantially degraded**
	68%	14%	14%	1%	3%
Is water measured? (Circle one)	**Yes**	**No**			
	75%	25%			
If Yes, acre-ft/acre applied?					
Is soil moisture monitoring used for irrigation scheduling? (Circle one)	**Yes**	**No**			
	40%	60%			
If yes, what type? (Circle all that apply)	**"Feel" method**	**Tensio-meters**	**Gypsum blocks**	**Neutron probe**	**Remote sensing**
	94%	3%	3%	0%	0%
Are Evapotranspiration calculations used for irrigation timing? (Circle one)	**Yes**	**No**			
	13%	87%			
Have you attended any irrigation water management classes, workshops, or demonstrations? (Circle one)	**In the last 12 months?**	**In the last 2 years?**	**In the last 5 years?**	**Never?**	
	50%	14%	7%	29%	
Do you employ or use a consultant or service that advises irrigation scheduling? (Circle one)	**Yes**	**No**			
	36%	64%			
Have the changes in yield, labor used, irrigation operation and maintenance cost as well as other pre-harvest and harvest costs offset your share of the practice costs? (Circle one)	**Yes**	**No**			
	74%	26%			
My initial investment for the new system resulted in: (Circle one)	**Substantial economic gain**	**Minor economic gain**	**No economic change**	**Minor economic loss**	**Substantial economic loss**
	18%	55%	21%	6%	0%
Do you feel that there is an effect economically overall to your area and region from this program? (Circle one)	**Substantial positive effect**	**Slight positive effect**	**No effect**	**Slight negative effect**	**Substantial negative effect**
	53%	42%	1%	4%	0%
Has this project changed the quantity and quality of wildlife on your property? (Circle one)	**Substantial positive effect**	**Slight positive effect**	**No effect**	**Slight negative effect**	**Substantial negative effect**
	11%	21%	50%	13%	5%

Appendix IV - Price – San Rafael Rivers Unit Hay Production

Utah Crop Group - All Hay (Dry)					
Commodity	**Year**	**County**	**Harvested**	**Yield**	**Production**
			Acre	**T/Ac**	**Tons**
Hay All (Dry)	1985	PSR	20,300	3.46	70,200
Hay All (Dry)	1986	PSR	20,600	3.33	68,500
Hay All (Dry)	1987	PSR	22,800	3.53	80,400
Hay All (Dry)	1988	PSR	20,900	3.38	70,700
Hay All (Dry)	1989	PSR	18,700	2.93	54,800
Hay All (Dry)	1990	PSR	20,500	2.82	57,800
Hay All (Dry)	1991	PSR	20,700	3.01	62,300
Hay All (Dry)	1992	PSR	19,800	2.92	57,900
Hay All (Dry)	1993	PSR	22,100	3.43	75,800
Hay All (Dry)	1994	PSR	23,200	3.18	73,800
Hay All (Dry)	1995	PSR	23,500	3.09	72,600
Hay All (Dry)	1996	PSR	23,400	2.99	69,900
Hay All (Dry)	1997	PSR	23,800	3.51	83,500
Hay All (Dry)	1998	PSR	23,800	3.52	83,800
Hay All (Dry)	1999	PSR	21,300	3.52	75,000
Hay All (Dry)	2000	PSR	23,100	3.30	76,200
Hay All (Dry)	2001	PSR	22,500	3.24	73,000
Hay All (Dry)	2002	PSR	22,100	3.11	68,700
Hay All (Dry)	2003	PSR	23,400	3.29	77,000
Hay All (Dry)	2004	PSR	24,500	3.16	77,500
Hay All (Dry)	2005	PSR	23,700	3.35	79,500
Hay All (Dry)	2006	PSR	25,100	3.15	79,000

Glossary and Acronyms

Average salt pickup – The increase in the amount of salt carried by a stream as it flows as a result of inflows containing increase salt from dissolution of the soil. Usually expressed as tons/acre-foot.

Annual average salt load – The average estimated annual salt load carried by a stream, based on a period of record of several years. Usually expressed as tons/year.

Application efficiency – The portion of the irrigation water delivered to the field that is consumed by the crop, expressed as a percentage of the total delivery volume.

Applied Practices – Functioning practices for which Federal cost share dollars have been expended.

BSPP – Basin States Parallel Program

Bureau of Reclamation (Reclamation) – A branch of the U.S. Department of Interior charged with water interests in the United States. Reclamation is the lead agency for salinity control in the Colorado River.

Catch can testing – a procedure whereby dozens of containers are spread out under a sprinkler system in an array, to determine how much water is being applied to different spots of ground under the sprinkler to evaluate uniformity.

cfs – Cubic feet per second or second-feet.

Cover Map – a map categorizing land use based on surface cover, e.g. urban, crop type, wetlands, etc.

Crop Consumptive Use (CU) – The amount of water required by the crop for optimal production. It is dependant on many factors including altitude, temperature, wind, humidity, and solar radiation.

CRSCP – Colorado River Salinity Control Program

Daubenmire cover class frame – An instrument used to quantify vegetation cover and species frequency occurrences within a sampling transect or plot.

Deep Percolation – The amount of irrigation water that percolates below the root zone of the crop, usually expressed in acre-feet.

Dissolved salt or Total Dissolved Solids (TDS) – The amount of cations and anions in a sample of water, usually expressed in milligrams/liter, but often expressed in Tons/Acre-foot for salinity control programs.

Distribution Uniformity (DU) – A measure of how evenly the irrigation water is applied to the field. If DU is poor, more water is needed to assure that the entire crop has an adequate supply.

EQIP – Environmental Quality Improvement Program

Evapotranspiration (ET) - The amount of water used by the crop. ET is generally synonymous with CU and is frequently mathematically modeled from weather station data.

Financial Assistance (FA) – The Federal cost share of conservation practices. FA is normally 60% of total cost of conservation practices.

Gated Pipe – Water delivery pipe with individual, evenly spaced gates to spread water evenly across the top of a field.

Hand line – An irrigation system composed of separate joints of aluminum pipe, each with one sprinkler, designed to irrigate for a period of time and be moved to the next parallel strip of land.

Improved Flood – Increasing the efficiency of flood irrigation systems with control and measurement structures, corrugations, land-leveling, gated pipe, etc.

Irrigation Water Management (IWM) – Using practices and procedures to maximize water use efficiency by applying the right amount of water at the right place at the right time.

Leakage – Water loss from ditches and canals through fissures, cracks or other channels through the soil, either known or unknown.

National Agricultural Statistics Service (NASS) - A branch of the U.S. Department of Agriculture (USDA)

Natural Resource Conservation Service (NRCS) A branch of the U.S. Department of Agriculture (USDA) charged with providing technical assistance to agricultural interests and programs.

Periodic Move – A sprinkler system designed to irrigate in one position for a set amount of time, then be periodically moved to a new position by hand or on wheels repeatedly until the field is covered.

Pivot or Center Pivot – A sprinkler system that uses moving towers to rotate a sprinkler lateral about a pivot point.

Planned Practices – Practices for which Federal cost share dollars have been obligated by contract.

Ranking – A process by which applications for federal funds are prioritized based on their effectiveness in achieving Federal goals.

Return Flow – The fraction of deep percolation that is not consumed by plants, animals, or evaporation and returns to the river system, carrying salt.

Salts – Any chemical compound that is dissolved from the soil and carried to the river system by water. Salt concentration is frequently expressed as “Total Dissolved Solids” measured in parts per million (ppm) or milligrams per liter (mg/l). For salinity control work, it is often converted to Tons per acre-foot of water.

Salt load – The amount of dissolved salt carried by a flowing stream

Salt Pickup – The difference in salt load measured above and below an irrigated treatment area

Seepage – Fairly uniform percolation of water into the soil from ditches and canals.

Salt Load Reduction – A measure of the annual tons of salt prevented from entering the waters of the Colorado River. As applied to agriculture, salt load reduction is achieved by reducing seepage and deep percolation from over-irrigating.

Soil Conservation Service – The predecessor agency to NRCS.

Technical Assistance (TA) – The cost of technical assistance provided by Federal Agencies to design, monitor, and evaluate practice installation and operation, and to train and consult with cooperators. TA is generally assumed to be 40% of the total cost of conservation practices.

Uniformity – A mathematical expression representing how evenly water is applied to a plot of ground by a sprinkler system. The two most common measures used by NRCS are Christiansen Uniformity (CCU) and Distribution Uniformity (DU).

Utah Division of Wildlife Resources (UDWR or DWR) – The State of Utah's agency for managing wildlife resources.

Wheel line, Wheeline, Sideroll – A sprinkler system designed to be moved periodically by rolling the sprinkler lateral on large wheels.

WHIP – Wildlife Habitat Incentives Program, a Farm bill program instituted in 1997, designed to create, restore, and enhance wildlife habitat.

Water Budget – An accounting for the amount of water entering (irrigation and precipitation) and the amount of water leaving (evaporation, CU, deep percolation) a given plot of land to determine efficiency and estimate deep percolation.

Yield (or Crop Yield) – The amount of a given crop harvested from an acre of ground. Yield is usually expressed as Tons/Acre or Bushels/Acre, depending on the crop.

References

1. U.S. Department of the Interior, Bureau of Reclamation, Price – San Rafael Rivers Unit, Utah, Planning Report/Final Environmental Impact Statement, December, 1993.
2. "Salt Primer – Water and Salt Budgets", John C. Hedlund, Soil Conservation Service, 1994.
3. "FRAMEWORK PLAN FOR MONITORING AND EVALUATING THE COLORADO RIVER SALINITY CONTROLL PROGRAMS of the U.S. Department of Agriculture (USDA)-Natural Resources Conservation Service (NRCS)", May, 2002.
4. "QUALITY OF WATER COLORADO RIVER BASIN – Progress Report #20", U.S. Department of the Interior, 2001.
5. "Colorado River Salinity Control Program, Uintah Basin Unit, Monitoring and Evaluation Reports", 1989 – 2001.
6. 2002 Final Mason Report 1016021. An Excel spreadsheet by David Mason, National Salinity Program Manager, NRCS Headquarters.
7. "Colorado River Salinity Control Program, Uintah Basin Unit, Monitoring and Evaluation, 2001 Report", Draper, Brent W., Goins, Donald J., Lundstrom, D. Nick.
8. "Colorado River Salinity Control Program, Uintah Basin Unit, Monitoring and Evaluation, 2005 Report", USDA-NRCS.
9. Habitat Evaluation Procedures, U.S. Fish and Wildlife Service 1980.
10. 1987, 1992, 1997, 2003 "Census of Agriculture", United Stated Department of Agriculture, National Agricultural Statistics Service.
11. "USDA Salinity Report Uintah Basin Unit, Utah, January 1979", Review Report, January, 1987.