Appendix H

Agriculture Conservation Plan

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Appendix H. Agricultural Water Conservation

This appendix presents a general evaluation of agricultural water conservation and system efficiency measures that can result in increased delivery to water-short acreage in Colfax County. For most if not all irrigation systems in the county, improving individual system efficiency is a first step in this process, as significant amounts of water are lost in off-farm delivery structures, particularly in canals. Before on-farm conservation measures are contemplated, these types of system delivery improvements need to be addressed. Another major factor influencing the reduced efficiency of the larger irrigation systems in the county is impoundment siltation. The capacity of many of the reservoirs that serve these systems has been reduced by approximately 25 to 50 percent due to sediment accumulation.

If water lost to delivery inefficiencies can be reduced and reservoirs can be dredged to restore their original capacity, much more irrigation water can be made available for all existing farmed acreage. These improvements will, however, be costly and time consuming. After these steps are taken, the establishment of on-farm water-conservation techniques would further reduce crop water requirements and allow for additional acreage to be irrigated or for additional water to be applied to existing acreage.

Adjustments in water system management, including distribution and pricing of irrigation water, should also be factored into future improvement projects and programs. Consideration of these measures may be necessary to attract the major investment that is required for physical improvements.

This remainder of this appendix provides background information related to agricultural water use in Colfax County, discusses approaches to conserving agricultural water and improving irrigation efficiency, as well as related financial considerations, and provides recommendations for further actions to address agricultural water conservation.

H.1 Background Information

More than 80 percent of the water used in Colfax County goes into agricultural activities. Wilson and Lucero (1997) define irrigated agriculture as all "diversions of water for the irrigation of crops grown on farms, ranches, and wildlife refuges." Surface water is the primary source of water for irrigated agriculture in the county, although a small percentage of land is watered through the use of irrigation wells. According to Wilson and Lucero (1997), more than 94 percent of all irrigation water in Colfax County is applied by flood irrigation, with the balance applied using sprinkler type systems. The majority of irrigated agricultural land is in the central portion of Colfax County (Figure H-1).

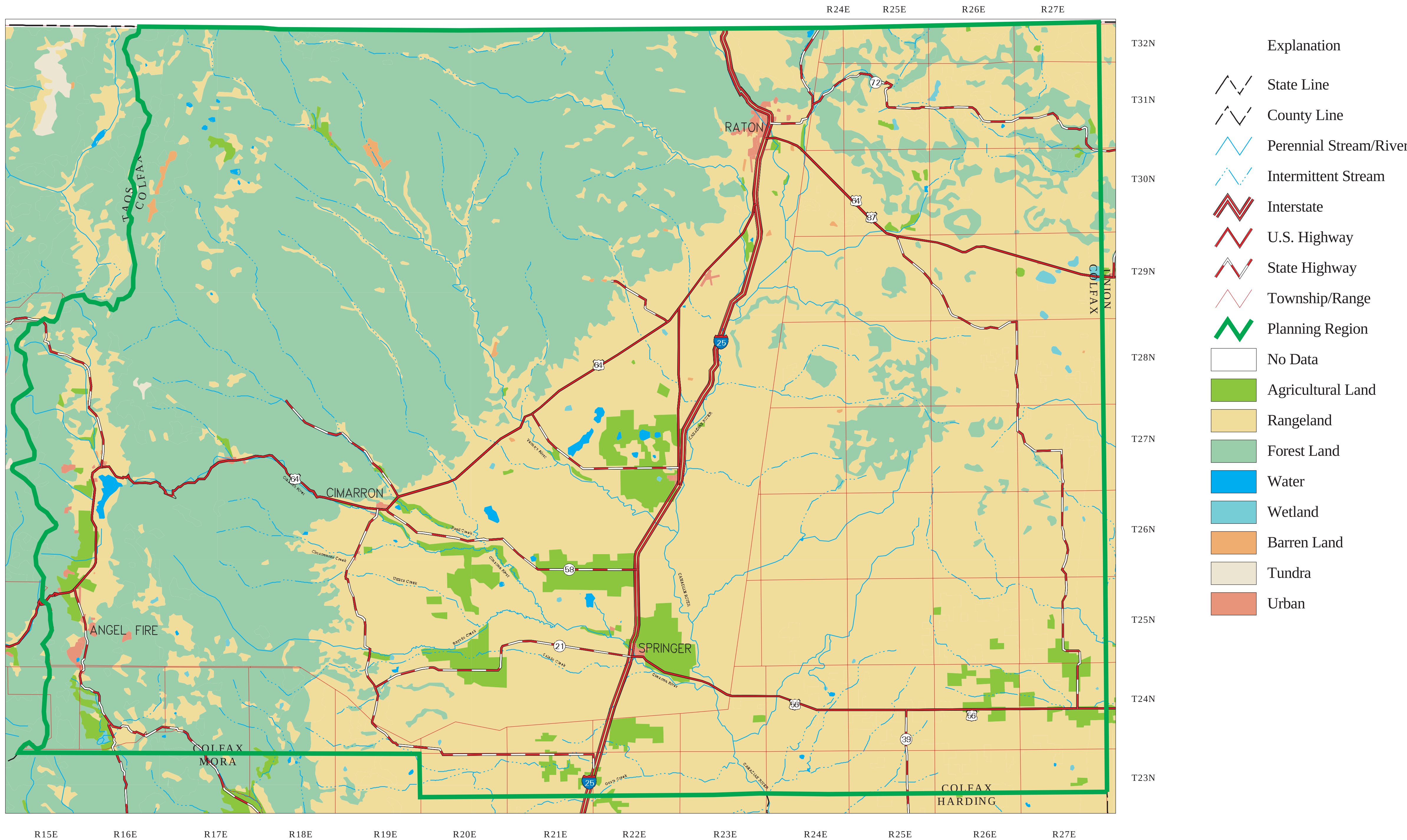
H.1.1 Overview of Irrigated Agriculture in Colfax County

The distribution of irrigated agricultural land in the planning region is shown in Figure H-1. A 1978 State Engineer Office (NM SEO) report lists 24 irrigation systems that operate within the county (Table H-1). According to recent surveys and the 1978 SEO report, these systems irrigate more than 43,500 acres. As shown in Table H-1, the Cimarron River serves as the source for more than half of all irrigation water in the county, with the balance coming predominantly from Rayado Creek, the Vermejo River, and Ponil Creek.

Published crop bulletins from 1960 to 1985 report alfalfa, hay, wheat, corn, oats, sorghum, barley, and dry beans grown in the county, with alfalfa by far the leading crop (Figure H-2, Attachment H1). Starting in the late 1980s, the variety of crops grown began to decline. With the exception of a small amount of sorghum in 1998, the New Mexico Department of Agriculture (NMDA) and U.S. Department of Agriculture (USDA) have reported essentially only wheat, alfalfa, and other hay crops grown in Colfax County for the past ten years (Figure H-2, Attachment H1).

Water withdrawn for agricultural irrigation is also used to water livestock. Wilson and Lucero (1997) report that in 1995, 737 acre-feet were withdrawn for this purpose, with about half of that amount obtained from wells. Additional detail on livestock water use is included in Section 6 of the main body of this Regional Water Plan.

Colfax County Water Plan
Landuse in the Region



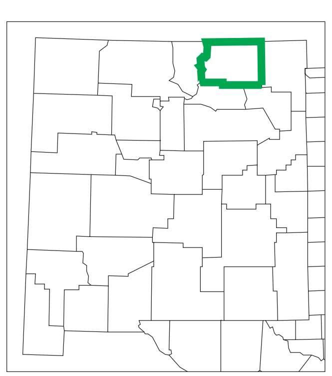
Produced by New Mexico Water Resources Research Institute, April 2002

Base map prepared by the U.S. Geological Survey

Compiled from digital data provided by the New Mexico Resource Geographic Information System Program (RGIS). Original base maps digitized from 1:500,000 mylar sheets and 100,000 paper maps for New Mexico. These data meets National Mapping Accuracy Standards for 1:500,000 and 1:100,000 scale maps. Landuse coverage developed by USGS/EPA at 1:250,000 scale. Boundary of the Colfax County Water Planning Region is based on New Mexico county boundaries, and surface drainage divides. The cadastral accuracy of the county boundaries where verified by the use of 1:100,000 Public Land Survey System (PLSS) from RGIS.

Horizontal accuracy: At the scale of 1:500,000 at least 90 percent of the points tested are within 1/30th inch (0.033 inch), or within 423 ground meters, of their true location.

Projection: Universal Transverse Mercator, Zone 13, Units meters, NAD83.



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10 0 10 20 30 40 50 KILOMETERS

Figure H-1

Table H-1. Summary of Irrigation Systems in Colfax Water Planning Region
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Source	Diverter [a]	Type of Organization [b]	Approximate Irrigated Area [c] (acres)	Source of Information		Percentage of Total County Irrigated Acreage
				Date	Type	
Ponil Creek	Chase Ranch Ditch	CA	308	1929	Court adjudication	
	Antelope Valley Irrigation District	ID	5,000	1977	SEO records	
		Subtotal	5,308			12.15
Rayado Creek	North and South Abreu Ditches	CA	478	1969	CNIC Report	
	Farmers Development Company	IC	6,500	1929	Court adjudication	
	Antonio Jose Valdez Ditch	CA	95	1929	Court adjudication	
	Valdez-Porter Ditch	CA	440	1929	Court adjudication	
	Miami Water Users Association	CA	150	1968	ASCS records	
		Subtotal	7,663			17.54
Wheaton Creek	Upper Wheaton Ditch	CA	6	1969	CNIC Report	
	Upper Lucero Ditch	CA	25	1969	CNIC Report	
	Lower Lucero Ditch	CA	36	1969	CNIC Report	
	Middle Lucero Ditch	CA	4	1969	CNIC Report	
	Neurauter Ditch	CA	6	1969	CNIC Report	
		Subtotal	77			0.18
Chico Rico Creek	Red River Irrigation Company	IC	180 [d]	1977	SCS records	
		Subtotal	180			0.41

Source: NM SEO, 1978.

[a] Additional private diverters (i.e., C S Ranch diversions through Clouthier Reservoir on Rayado Creek and Clayton Lake on Salado Creek) are not included on this list. An updated agricultural survey is needed to reflect all current agricultural uses. This table provides only an initial estimate of irrigated acreage.

[b] Type of organization: CA = Community acequia
ID = Irrigation district
IC = Incorporated irrigation ditch

[c] Based on SEO (1978) acreage calculation

SEO = New Mexico State Engineer Office (currently known as the Office of the State Engineer [OSE])
CNIC = Conservation Needs Inventory Committee
ASCS = Agricultural Stabilization and Conservation Service
SCS = Soil Conservation Service

Table H-1. Summary of Irrigation Systems in Colfax Water Planning Region Page 2 of 2

Source	Diverter [a]	Type of Organization [b]	Approximate Irrigated Area [c] (acres)	Source of Information		Percentage of Total County Irrigated Acreage
				Date	Type	
Canadian River	Stockton Ditch	CA	369	1968	ASCS records	
		Subtotal	369			0.84
Vermejo River	Vermejo Conservancy District	CD	7,400	1977	SEO records	
		Subtotal	7,400			16.94
Ute Creek	Ute Creek Irrigation Company	IC	349	1969	CNIC Report	
		Subtotal	349			0.80
Cimarron River	Charles Springer Cattle Company	IC	8,000	1977	SEO records	
	Old Mill Ditch	CA	68	1929	Court adjudication	
	Clutton-Maxwell Ditch	CA	112	1929	Court adjudication	
	Porter-Morley Ditch	CA	424	1929	Court adjudication	
	Springer Ditch Company	IC	7,500	1977	SEO records	
	C S Main Canal	IC	5,661	1969	CNIC Report	
	North C S Canal	IC	566	1969	CNIC Report	
		Subtotal	22,331			51.11
Bonita Creek	Bonita Ditch	CA	16	1969	CNIC Report	
		Subtotal	16			0.04
		Total	43,693			

Source: NM SEO, 1978.

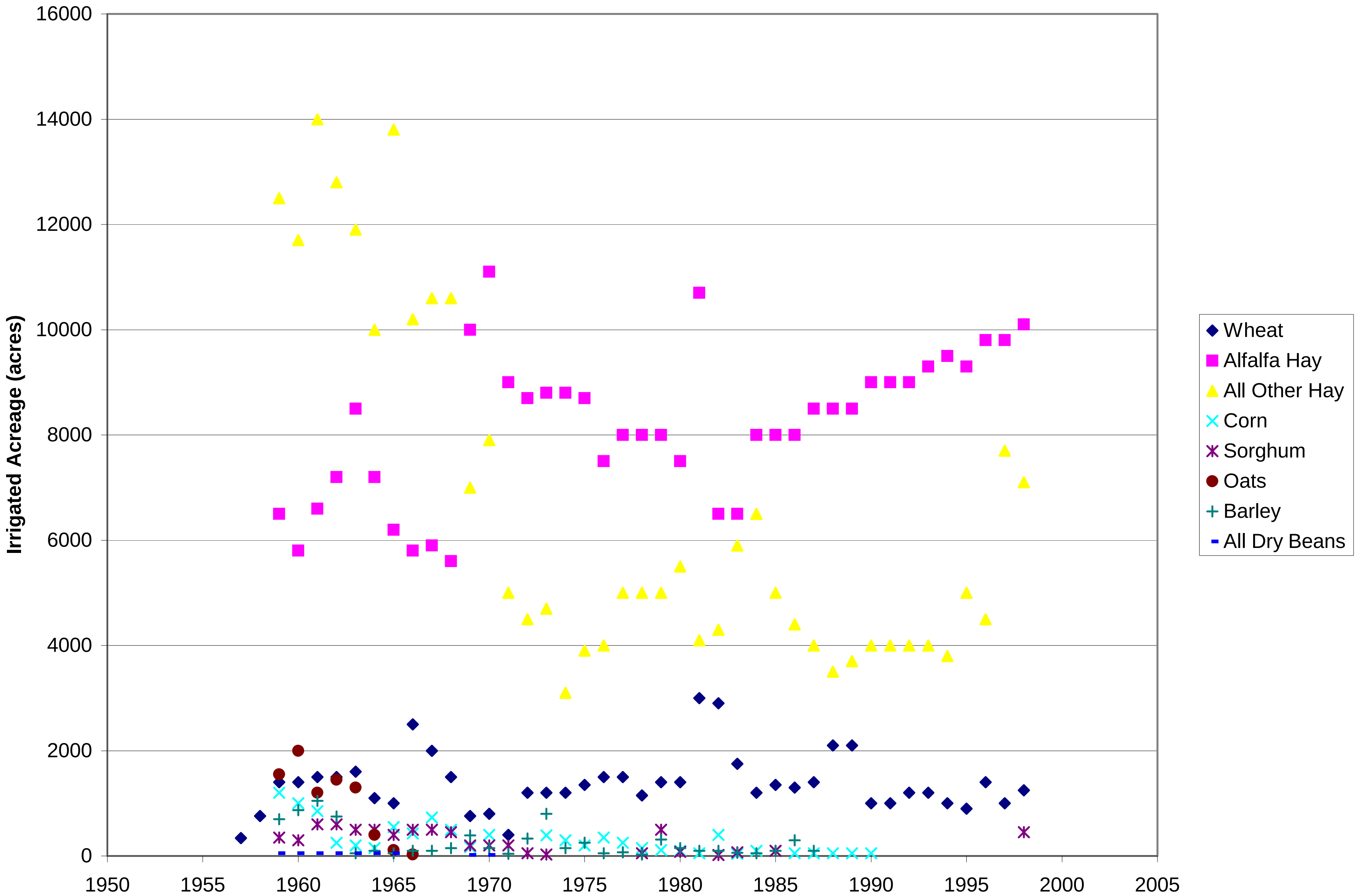
[a] Additional private diverters (i.e., C S Ranch diversions through Clouthier Reservoir on Rayado Creek and Clayton Lake on Salado Creek) are not included on this list. An updated agricultural survey is needed to reflect all current agricultural uses. This table provides only an initial estimate of irrigated acreage.

[b] Type of organization: CA = Community acequia
ID = Irrigation district
IC = Incorporated irrigation ditch

[c] Based on SEO (1978) acreage calculation

[d] USDA records indicate 996.7 acres for the Red River Irrigation Company

SEO = New Mexico State Engineer Office (currently known as the Office of the State Engineer [OSE])
CNIC = Conservation Needs Inventory Committee
ASCS = Agricultural Stabilization and Conservation Service
SCS = Soil Conservation Service



Sources: NMDA, 1962-1998
USDA, 1999

COLFAX REGIONAL WATER PLAN

Historical Irrigated Acreage by Crop in Colfax County

Daniel B. Stephens & Associates, Inc.

Figure H-2

H.1.2 Water Rights

As discussed in Section 4.4 of the main body of this Regional Water Plan, water rights for the majority of entities and individuals in Colfax County were adjudicated in the early part of this century. Regardless of the type of entity that manages water deliveries for irrigation, water rights remain with the owner to whom they were legally adjudicated or transferred under New Mexico water law.

Water users either own the water rights or have a contract (lease) that allows them to use water for which they pay a fee. Generally, irrigation and conservancy districts are organized around water rights holders, and the individual districts do not own water unless they own land and have the water rights that go with that land. A water company usually owns the water rights, and individual users on the system own shares in the company that allow them to use specific amounts of water.

Most of the water rights holders in the county have an irrigation duty of 1.5 acre-feet per acre. This amount was used in the calculations regarding potential water savings.

H.1.3 Irrigation Organizations in Colfax County

The majority of irrigated agricultural land is in the central portion of Colfax County (Figure H-1). A closeup of this portion of the county is shown in Figure H-3. The background is an October 1999 LANDSAT 7 satellite image, with irrigated lands shown in bright red-orange. In addition, this figure shows the diversion points and irrigation canals in the area.

As part of the development of this agricultural conservation plan, DBS&A conducted a survey of the major irrigation systems in Colfax County (Table H-2). In general, the irrigable acres reported by the irrigation systems are consistent with the amounts shown in Table H-1, which came from a 1978 New Mexico State Engineer Office report. In some cases there is a difference in the reported size of the irrigation district as shown on Table H-1 and the area under irrigation as shown in Figure H-3. Discrepancies could be due to several reasons, such as overall irrigation water availability or, most likely, the time of year that the image was obtained.

Figure H-3 Irrigation Districts

Table H-2. Summary of Interviews Regarding Colfax County Irrigation Systems
Page 1 of 3

Interview Information	Irrigation System			
	Antelope Valley Irrigation District	Miami Water Users Association	Vermejo Conservancy District	Springer Ditch Company
Interviewee	Frank Burton	Tony Searer	Joe Hronich	Tommy Crawford
Interview date	January 29, 2002	January 29, 2002	January 30, 2002	January 30, 2002
Estimated number of acres in district	5000	6500	7289	7500
Approximate number of acres irrigated each season	2500	4000	5831 (80% of total acreage)	Not known
Number of unirrigated acres that are farmed	0	0	0	0
Any canal lining	Two 36" PVC siphons, each one mile long	One small PVC underground pipe is old and in disrepair.	Some ditches were lined in the 1960s, but are now in much disrepair.	Some ditches are lined in straightaways, none lined on curves. There is a 4' concrete siphon. Four pipelines were put in about 10 to 15 years ago.
Irrigation return flows	No return flow; every bit of water used.	No return flow; every bit of water used.	No return flow. When there is enough water it flows back to the Canadian River.	No return flow
What crops are grown	Alfalfa	Brome hay, brome and alfalfa, and other types of grass hay	Alfalfa hay; some (~20%) wheat and oats	Alfalfa, grass, brome, hay, very little cereal grains
Cuttings per year	3	1 or 2	3	3

ac-ft = Acre-foot ac-in = Acre-inch

Table H-2. Summary of Interviews Regarding Colfax County Irrigation Systems
Page 2 of 3

Interview Information	Irrigation System			
	Antelope Valley Irrigation District	Miami Water Users Association	Vermejo Conservancy District	Springer Ditch Company
Amount of water diverted	1600 to 1700 ac-ft	2500 ac-ft	11,000 ac-ft	Water Master lets 6,000 ac-ft out of the Lake.
Method of measuring water	A weir below Lake #3 is used by the Water Master to measure the amount of water released.	The Water Master measures how much water is let out of the lake. Flow into each farmer's field is also measured to see how much water is being received.	Lake level is measured monthly. Each farmer has a measuring device at his/her field that is monitored twice a day when water is being received.	Ditch rider measures water at each shareholder's property using a measuring device installed at the property.
Frequency of shortfalls in fulfillment of the water rights	Full 1.5 ac-ft water right never filled.	Full water right never filled.	About once in 10 years, but times when no one received their proration have historically occurred.	Full water right never filled.
Amount of water they receive in a wet year	The maximum they have ever received is 9.5 ac-in	12 to 14 ac-in	Full proration (1.5 ac-ft) plus some to keep the system running.	9 ac-in
Water available in a dry year	1 ac-in	6 to 8 ac-in (0 in some years)	9 ac-in (0 at times in the past)	5 ac-in
Water available in an average year	4 to 5 ac-in	9 to 12 ac-in	12 to 18 ac-in	7 ac-in
Water allocation method during shortfalls	Available water distributed equally	Available water distributed equally	Divided equally among all shareholders (equal water for equal shares)	Equal amount for an equal share.
Written drought policy	None	None	None	None

ac-ft = Acre-foot ac-in = Acre-inch

Table H-2. Summary of Interviews Regarding Colfax County Irrigation Systems
Page 3 of 3

Interview Information	Irrigation System: Antelope Valley Irrigation District	Irrigation System: Miami Water Users Association	Irrigation System: Vermejo Conservancy District	Irrigation System: Springer Ditch Company
Surface water diversion location	Cimarron River Ponil Creek Cerrasosa Creek	Rayado Creek	Vermejo River Tributary to Canadian River	Cimarron River (at Ponil Creek confluence)
Total reservoir storage	Lake #2: 2200 ac-ft current maximum Lake #3: 300 ac-ft	Miami Lake: 2500 ac-ft	Lake #12: ~1500 ac-ft Lake #13: ~5000 ac-ft in the best shape Lake #14: ~780 ac-ft Lake #2: ~2000 ac-ft; Stubblefield: ~13,490 ac-ft	Springer Lake: 4000 ac-ft
Approximate reduction in reservoir storage due to silt	50%	40%	35%	25%
Recommendations for water conservation	Pipeline, silt removal, dam stabilization to use entire capacity	Pipeline	Lining ditches or pipeline	More pipeline

ac-ft = Acre-foot ac-in = Acre-inch

Individual irrigators may divert directly from a stream system or, in some cases, a well. In most cases, however, agricultural water use takes place within irrigation or conservancy districts, or an entity such as a water company supplies the water used for irrigation. Each type of organization (i.e., water companies, irrigation and conservancy districts) has a different statutory mandate, and the purpose, authority, power, and duties of each entity define the activities it may undertake. The irrigation and conservancy districts are organized under NMSA 73-9-1 to 62 and NMSA 73-14-1 to 88. The original purpose for creating these entities was to facilitate delivery of water and to be able to secure loans to construct the irrigation works necessary for the delivery of the water. Whatever the organizational structure of the entity in charge of delivering agricultural water, agricultural water conservation can be most easily facilitated by working directly with these water providers since they often manage the delivery systems where losses occur.

Sections H1.3.1 through H.1.3.5 briefly describe the county's major irrigation systems, and Table H-2 summarizes pertinent information regarding these systems. Water supplies provided through Eagle Nest Permit 71 are discussed in Section 4.

H.1.3.1 Antelope Valley Irrigation District

Agricultural land in the Antelope Valley Irrigation District is located near the intersection of State Highway 58 and Interstate 25 (Figure H-3). Water is diverted from both Ponil and Cerrasosa Creeks into Antelope Valley Lake No. 2 and then on to Lake No. 3 for delivery to individual landowners (Burton, 2002). The total irrigable acreage in the district is 5,000 acres (Burton, 2002; NM SEO, 1978).

This district has never received their full 1.5 acre-foot allotment. The most they have ever received is 9.5 inches per acre, and in a typical year they receive about 4 inches per acre (Burton, 2002). Alfalfa is the primary crop grown in the district, with growers usually harvesting three crops per year (Burton, 2002).

H.1.3.2 Springer Ditch Company

Shareholder land in the Springer Ditch Company is located near the Town of Springer and is mostly east of Interstate 25 (Figure H-3). Water is diverted from the Cimarron River (where the

Cimarron and Ponil come together) into Springer Lake. Water for the Town of Springer, which is also a shareholder in the Ditch Company, is delivered to the two Springer city reservoirs (Crawford, 2002). The total irrigable acreage in the district is 7,500 acres (Crawford, 2002).

The Ditch Company has also never received its full 1.5 acre-foot allotment. The most water ever received in one year (during the irrigation season) is 9 inches per acre, which is only 50 percent of its adjudicated water right. In a typical year the company receives about 7 inches per acre (Crawford, 2002). The primary crops grown in the area are alfalfa, grass, and brome hay, all of which produce three cuttings per year (Crawford, 2002).

H.1.3.3 Miami Water Users Association

Miami Water Users Association agricultural land is located on both sides of State Highway 21 near the Town of Miami (Figure H-3). Water is diverted from Rayado Creek into Miami Lake; this diversion also supplies the town of Miami (Searer, 2002; NM SEO, 1978). The total irrigable acreage in the district is 6,500 acres (Searer, 2002).

This association has never received its full 1.5 acre-foot allotment. The most ever received is 12 to 14 inches per acre. In an average year the association receives about 9 to 12 inches per acre (Searer, 2002). The primary crops grown are brome and alfalfa hay, which yield 1 to 2 cuttings per year (Searer, 2002).

H.1.3.4 Vermejo Conservancy District

The Vermejo Conservancy District is located west of Interstate 25 near the Town of Maxwell (Figure H-3). In addition to farm lands, the district also includes the Maxwell National Wildlife Refuge.

Congress authorized the Vermejo Project in 1955, which allowed the U.S. Bureau of Reclamation (USBR) to construct improvements and rehabilitate the existing facilities (USBR, 1983). In the current system water is diverted from the Vermejo River into Stubblefield Reservoir and Laguna Madre (Hronich, 2002). The District also diverts water from Chico Rico Creek, a tributary to the Canadian River (USBR, 1983). The total irrigable acreage in the district is 7,300 acres (Hronich, 2002).

The conservancy district normally receives the full 1.5-acre-foot allotment. The primary crops grown are alfalfa hay (approximately 80 percent) and wheat and oats (approximately 20 percent) with usually three harvests per year (Hronich, 2002).

H.1.3.5 Acequias and Other Irrigation Systems

Table H-1 lists 20 other acequias and irrigation systems that reportedly serve a combined area that is less than the total area served by the four major systems noted above. For the purposes of this report, DBS&A’s analysis focused on the four larger systems described in Sections H.1.3.1 through H.1.3.4, as these larger systems are the most likely entities to begin implementation of conservation measures. However, much of the information provided is applicable to other agricultural systems as well.

H.2 Improvements to Conserve Water and Increase Efficiency

Agricultural water conservation is well studied and documented. A large amount of irrigation water management and planning conservation information is downloadable from the Internet along with the names and contact numbers of government and private sector experts who are available to assist. In New Mexico, USDA, Natural Resources Conservation Service (NRCS), and State of New Mexico government staff are also readily available to give advice and to help any irrigation manager and/or user develop and implement a large or small water management and/or conservation plan. Several irrigation and/or conservancy districts in southern Colorado, just north of New Mexico, have active and successful water management and conservation programs that are supported by the NRCS and USBR.

Non-government agencies are also active in assisting farmers and irrigators with conservation. In particular, the Irrigation Association (www.irrigation.org), founded in 1949, is a non-profit trade organization whose members represent all segments of the irrigation industry. One of the principal goals of the organization is to provide the membership with a full array of programs and services that will help them keep pace with the industry's rapidly changing technology.

The association is also dedicated to promoting water and soil conservation through proper water management. In 1990, the association formally adopted a water conservation policy that stresses the importance of improving irrigation efficiency. The Irrigation Association advocates that any long-range conservation planning should incorporate the following ten goals:

1. Measure all water use.

2. Price water so as to recognize its finite nature. Pricing mechanisms should provide incentives to water users who conserve water as well as penalties for those who waste it.

3. Hold all water users responsible for protecting the quantity and quality of water resources at their disposal.

4. Create financial incentives to reward users for efficient irrigation. Key elements to observe are farm layout and farm operations and maintenance, combined with effective water use, scheduling, and management practices.

5. Create educational programs on a regional level that emphasize to all water users the absolute necessity of supporting regulatory policies that reward conservative and efficient water use.

6. Support water reclamation initiatives including, where practical, the use of reclaimed water from municipal, industrial, agricultural, and other available sources.

7. Increase support for developing new water resources, along with conveyance and storage facilities that enhance dependable water supplies, with proper consideration given to legitimate environmental concerns.

8. Promote participation by all users in water conservation planning as an ongoing program. These plans must be in place prior to a critical need and must encourage each water user to accept a fair share of any water conservation effort.

9. Institute studies to identify water use and misuse by all users in order to collect data on which to base decisions regarding equitable water distribution during periods of shortage.

10. Promote policies that allow for the lease, sale, or transfer of established water rights and/or water without jeopardizing established water rights.

This section discusses several initiatives recommended for Colfax regional water planners. These initiatives can be grouped under some of these ten recommendations; however, any system wishing to embrace conservation as a serious part of their operational plan must first develop its own system water management plan. The Vermejo Conservancy recently took a first step in that direction by completing a long-term water conservation plan.

One of the most important components of agricultural conservation, and therefore the focus of many of the initiatives presented, is the efficiency of the irrigation system. Irrigation efficiency is a measurement of the ratio of the quantity of water withdrawn from some source to the quantity actually applied to agricultural fields. The higher the irrigation efficiency, the more withdrawn water farmers have available for irrigating additional acreage or increasing the amount of water applied to existing farmed acreage. In a perfect system, irrigation efficiency would be 100 percent, with all water withdrawn being available for crop irrigation. From a practical standpoint, however, an irrigation efficiency greater than 80 percent is considered a reasonable goal for a system that is conservation conscious. In Colfax County, efficiencies currently are much lower, with as much as 50 percent of delivery water lost to seepage (Section H.3.2).

H.2.1 Industrial Agriculture vs. Supplemental Income Agriculture

Two types of agriculture are present in Colfax County: (1) larger farms where farmers derive their primary income from agriculture (referred to as industrial agriculture for the purpose of this report) and (2) agricultural land where the income earned from it is secondary to an income from another source (referred to as supplemental income agriculture). The distinction between these two types of farming is typically the amount of time, effort, and money applied to farming. In industrial agriculture, farmers typically pay more for their water and invest more in on-farm irrigation and farming infrastructure, whereas supplemental income farmers may be less likely to spend time and money to operate and/or improve their farms. Irrigation systems may serve either one type exclusively or both types of agriculture.

The type of agriculture (industrial or supplemental income) becomes an issue when an irrigation system seeks to implement management and conservation planning, physical and structural changes, or programmatic shifts in the way it does its business. Such planning and changes are normally more acceptable to farmers who carry on agriculture as their primary means of earning and income; however, in Colfax County, where irrigators have never or haven't in many years received their water allotment, such system improvements are necessary to increase the amount of water reaching every farmer’s fields.

H.2.2 Water System Management

The streamlining of water conservancy requires four fundamental components:

- Water measurement and accounting system
- Water pricing based on efficiency procedures
- Informed and educated water users
- A water conservation director or coordinator

To help optimize these components, each individual water system should adopt a water management plan that includes the following:

- Procedures should be developed for quantifying irrigation withdrawals and depletions, tabulating the irrigated acreage for individual cropping patterns by the type of irrigation system, measuring water, budgeting water, and scheduling water deliveries. The plan should take into consideration average, low, and high water availability projections.

- Consumptive irrigation requirements (CIR), indices of the cropping patterns, irrigation methods, sources of water, and overall depletion and withdrawals of water in each system, should be determined to help direct the management of the system (Section H.2.2.1, Attachment H2).

- A conservation plan for both off- and on-farm water delivery should be developed and implemented. Development of such a plan will require a detailed understanding of each system's sources of water, its users, the crops they grow, and each of their farms. The plan should identify needed improvements and should include financing provisions.

- Drought contingency plans are an essential part of the planning process as well. Examination of water rights and stream flow records and a detailed investigation of the strengths and weaknesses of each system are required to develop the data upon which this plan will be founded and from which an approximate water measurement and accounting system can be developed.

A water management plan developed in one year can be used and modified in each successive year.

Developing and implementing either a long- or short-term irrigation water conservation plan in any one of the county's irrigation systems will be a challenging undertaking for its management staff and the users of the system, whether it be an acequia, a water company, or an irrigation district. It will require commitment, energy, and public participation as well as agreement to change. Developing effective plans will also require some amount of additional outside expertise, time, and money.

H.2.2.1 Measurement

Effective source withdrawal and farm delivery water measurement is essential for developing and implementing a sound water management plan. Without effective water measurement it will not be possible to know if the plan's goals are being achieved.

A management area's measurement method should be adequate to track water deliveries to each water user. Thorough water measurement is an effective tool for both the water user and the district about the quantity, scheduling, budgeting, and location of the water use. At the farm, ranch, and wildlife refuge level, water measurement aids in meeting water requirements for proper crop moisture, thereby reducing erosion, fertilizer leaching, and drainage problems. Many of the techniques for water measurement are discussed briefly here; further detail regarding these techniques is provided by the USBR (1997b) and Wilson (1992).

A commonly used water measurement technique is to determine the theoretical consumptive use (U) or evapotranspiration (ET) of water by the individual crops in each type of irrigation system. Agricultural consumptive use of water is generally not directly measured, but is instead estimated based on a model of crop water needs. For the Colfax regional water planning study, consumptive use was estimated for crops grown in the region using the Blaney-Criddle method (Blaney and Criddle, 1950, 1962). This method was created during studies conducted in New Mexico in 1939 and 1940 for the Pecos River Joint Investigation initiated by the National Resources Planning Board. It factors in air temperature, daylight hours, and a crop-specific coefficient to determine the amount of water required to achieve viable crop yields.

The results of the Blaney Criddle calculation of consumptive use can be used in conjunction with rainfall estimates to estimate the amount of irrigation water required, known as the consumptive irrigation requirement (CIR), for every farm and each crop in the water system. This is done by subtracting the total annual effective rainfall (Attachment H2) from the consumptive use:

$$CIR = U - Re \text{ (acre-feet/acre)} \qquad (4)$$

where CIR = Consumptive irrigation requirement

U = Consumptive use

Re = Effective rainfall

The results of this calculation for the crops grown in Colfax County are provided in Table H-3. The method and results of the calculations for the planning region are discussed in more detail in Attachment H2.

A variation of this is the CIR_a method, used in cases in which the cropping pattern includes multiple-cropped acreage, that is, acreage in which two or more crops are produced in the same year. In this case, the CIR is multiplied by a ratio of the gross irrigated acreage to the net irrigated acreage to yield the CIR for the cropping pattern:

$$CIR_a = CIR\left(\frac{A_g}{A_g - A_m}\right) \quad (5)$$

where A_g = Gross acreage

A_m = Multi-cropped acreage

The results of these calculations provide a baseline consumptive water use per acre of irrigated land, which may then be used to assemble a detailed watering schedule, identify areas where additional efficiency can be achieved, and implement a billing system based on consumptive requirements.

Table H-3. Consumptive Irrigation Requirement for Crops Grown in Colfax Water Planning Region

Crop	Consumptive Use (inches)	Consumptive Irrigation Requirement [a] (inches)
Alfalfa	37.18	23.62
All other hay	34.04	20.48
Corn	23.57	10.01
Wheat	19.86	6.30
Oats	14.13	0.57
Barley	14.13	0.57
Sorghums	17.95	4.39
Dry beans	15.39	1.83

[a] Consumptive use less total annual effective rainfall

While the estimated consumptive use per acre is helpful in planning, the actual water consumption of individual users will need to be measured for billing and other purposes, such as helping growers carefully assess their irrigation supplies. Water use can be measured in the field using physical measurement devices such as flow meters and flumes placed throughout the management area. The most efficient water measurement system would evaluate flows at all points in the delivery system where a flow diversion takes place, including the diversions, canals, laterals, farm turnouts, and tailwaters. These measurements will provide a ledger sheet of deliveries and possibly returns from users down the conveyance system to the water management, thereby enabling a billing system by tracking water deliveries to individual users. Depending on the complexity of the management area, commercially available computer software or custom software may be required to track deliveries throughout the system.

H.2.2.2 Water Pricing

Billing procedures and rates must be directly correlated with water deliveries in order to provide an economic incentive for efficient water use. Designing a water pricing structure based on information on irrigated acreage, water application methods, growing season, and water use measurement will ensure that water costs are fair to all consumers. When developing the pricing structure, planners must ensure that revenues will be sufficient to cover operating costs and fund improvements or future development. The specific structure will be dependent on the objectives of the water management district.

Quantity-based charges based on blocked increments, or base price per unit of water sold up to a certain amount, encourage efficient water use when combined with increases in the unit price of water per delivery increase. Several tiers of unit prices per range of water quantity may exist within a pricing structure. Various pricing structures based on incentive pricing are discussed in more detail in the USBR *Incentive Pricing Handbook for Agricultural Water Districts* (1997a).

New Mexico water systems are currently charging between $10 and $50 per acre-foot of water delivered for agricultural purposes. These amounts need to be compared with those charged in other states for water used in similar systems. Some systems in Colfax County also charge a user, member, or shareholder fee. Once appropriate levels of fees are determined, collection must then be addressed. Some systems adopt a policy stating that those who do not pay their fees will be penalized for non- or late payment, and continued non-collection of fees for a given period could result in water cutoff.

H.2.2.3 Scheduling

Properly scheduling water deliveries provides for the allocation of water in accordance with actual and projected crop use, rainfall, cultural practices, delivery system carrying capacity, and field irrigation characteristics. Demands for water within an irrigation district are based on crop production, planning, and scheduling decisions made at the farm level and are variable even within a farm due to crop selection, irrigation techniques, and soil characteristics. System-wide irrigation scheduling bases the timing of water deliveries on the aggregated needs of individual on-farm requirements. System-wide scheduling requires information on crop water requirements, soil moisture, acreage for each type of crop grown, and ET rates in order to forecast water requirements for the entire system.

On-farm irrigation scheduling must coincide with system-wide scheduling to maintain crop and soil appearance and water availability and to determine ET rates and allowable soil moisture depletions. Seasonal variations in ET rates and precipitation will affect the irrigation schedule, and adjustments will have to be made to accommodate both water requirements and conservation objectives.

Several computer programs based on climate information and soil conditions may aid the district in forecasting irrigation needs. One such program is the California Irrigation Management Information System (CIMIS), developed by the California Department of Natural Resources, which uses automated weather stations to provide up-to-the-minute ET information. Yet another system, developed especially for personal computers, uses soil moisture probes to forecast irrigation needs. Examination of available information management systems, water budgeting, and climate patterns will help determine the best management practices with regard to irrigation scheduling.

H.2.3 Infrastructure Improvements

Water lost between a point of withdrawal and the point of application can be significant. These inefficiencies cause unnecessary water supply shortages that in turn result in idle or fallow acreage, limiting the crops grown on farms, ranches, and wildlife refuges, and reducing agricultural income. Identifying and adopting water management measures and improving off- and on-farm infrastructure will increase efficiency, conserve water, and result in higher agricultural incomes.

Canals, laterals, and reservoirs experience significant water losses due to seepage, leakage, evaporation, and transpiration by plants growing near the unlined channels and laterals. Wilson and Lucero (1997) estimate off-farm canal losses at 37 percent on average throughout the state of New Mexico. Many factors affect seepage and evaporative losses, including soil characteristics, silt deposition, water depth and surface area, water velocity, depth of groundwater, and ground slope. Characteristics that indicate significant seepage losses include visible seepage, water logging on adjacent properties, presence of riparian phreatophytes, and return flow problems.

Lining canals, laterals, and reservoirs, installing piping systems (rather than channel delivery systems), or increasing storage capacity will increase the efficiency of energy use and water use, production, and distribution, and may reduce water losses to less than 10 percent in some instances. A reevaluation of conveyance systems on a county-wide basis may be of some benefit in identifying opportunities for implementing these improvements to gain efficiencies in distributory canals that may serve more than one water user. The various options for reducing conveyance water losses are discussed in Sections H.2.3.1 through H.2.3.3.

H.2.3.1 Canal Lining

Lining canals improves system efficiencies while increasing delivery and possibly improving water quality. Additional benefits are reduced maintenance, increased safety, and reduced erosion. Canal lining systems can also be built in a manner that does not degrade the aesthetics in and around suburban areas. Perforated or semipermeable linings can be installed in some reaches of canals to promote and maintain desirable vegetation; however, the steering committee indicated that this may not be necessary in Colfax County

The degree of seepage loss reduction due to canal lining depends on the site characteristics and type of lining used. Common methods and materials used for canal linings are concrete, plastic linings, and clay or soil sealant (Table H-4). Because many factors influence the type of lining chosen, no single lining can be recommended to correct all seepage loss situations. In addition to initial installation costs, other factors to consider in decisions regarding lining materials are their effectiveness, durability, and maintenance costs (Table H-5).

Table H-4. Conceptual Cost Estimate for Distributory Canal Lining
Colfax Water Planning Region

Description	Lining Material ($/sq ft)				Subgrade Preparation ($/sq ft)	Installation ($/sq ft)	Overhead and profit (%)	Total ($/sq ft)
	Geomembrane	Geotextile	Shotcrete	Other costs				
4-mil PE geocomposite with polyfiber-reinforced shotcrete cover	0.30	---	0.87	0.06	0.26	0.65	17	2.50
30-mil VLDPE textured geomembrane with 16-ounce geotextile cushion and unreinforced shotcrete cover	0.25	0.12	0.87	None	0.26	0.65	17	2.52
40-mil PVC with 3-inch grout-filled mattress	0.35	---	0.65	0.45	0.12	0.60	17	2.54
Exposed 80-mil HDPE textured geomembrane	0.70	0.12	---	---	0.26	0.10	17	1.38
3-inch Unreinforced grout-filled mattress	---	---	0.65	0.45	0.04	0.50	17	1.92
Spray-applied polyurethane foam with Urethane 500/550 protective coating	---	---	---	2.41	0.04	1.25	17	4.33
Shotcrete, steel fiber-reinforced, 25 lb/yd^3	---	---	1.08	0.11	0.04	0.65	17	2.20
Shotcrete, polyfiber-reinforced, 1 lb/yd^3	---	---	1.08	0.06	0.04	0.65	17	2.14
Unreinforced shotcrete	---	---	1.08	---	0.04	0.65	17	2.07
Exposed GCL, Bentomat DN	0.29	---	---	---	0.26	0.10	17	0.76

Source: USBR, 2001.
$/sq ft = Cost per square foot
PE = Polyethylene
--- = Not used
VLDPE = Very low density polyethylene
PVC = Polyvinyl chloride
HDPE = High density polyethylene
lb/yd^3 = Pounds per cubic yard
GCL = Geosynthetic clay layer

Table H-5. Performance and Maintenance Characteristics of Selected Lining Materials

Type of Lining	Effectiveness in Reducing Seepage (%)	Durability (years)	Maintenance ($/ft^2/yr)
Concrete	70	40-60	0.005
Exposed geomembrane	90	20-40	0.01
Fluid-applied geomembrane	90	10-20	0.01
Concrete with geomembrane underliner	95	40-60	0.005

Source: USBR, 1999
$/ft^2/yr = Cost per square foot per year

Lining main and off-farm distributory canals (D-canal) on each system in Colfax County is the best solution to conserve water and increase system efficiencies. Table H-6 summarizes the D-canals in Colfax County, provides a rough estimate of costs to line 67 percent of all D-canals in each system in the county, and illustrates potential water savings throughout the county. The costs in Table H-6 are based on the following assumptions:

- Although it is recommended that 100 percent of the canals eventually be lined to maximize conservation savings, for the purpose of developing a preliminary estimate of potential savings, it was assumed that 67 percent (two-thirds) of the canals would be lined. Operational or financing issues may prevent lining of all canals, but a significant amount of savings can still be realized through lining 67 percent of the canals.

- Lining of D-canals would reduce the percentage of water lost to approximately 20 percent (irrigators interviewed estimated that current water losses in Colfax County canals are greater than the 37 percent average for the entire state).

- The estimated per-foot construction cost for a soil-stabilized base, shotcrete-type lining is $22.77 ($2.20 [Table H-4] times 9 square feet of canal area per linear foot plus a 15 percent contingency). (This unit cost would decrease as the amount of lining footage increases.)

Table H-6. Estimated Distributory Canal Details
Colfax Water Planning Region
Page 1 of 2

Source	Diverter	Approximate Irrigated Area (acres)	Estimated Amount of Water Diverted [a] (ac-ft)	Estimated Total Length of D-Canals (feet)	Estimated Total D-Canal Water Losses (ac-ft)	Estimated Cost for Lining 67% of D-Canals ($)	Estimated Total Water Saved (ac-ft)
Ponil Creek	Chase Ranch Ditch	308	462	12,320	171	187,953	92
	Antelope Valley Irrigation Ditch	5,000	7,500	200,000	2,775	3,051,180	1,487
	Subtotal	5308	7,962				
Rayado Creek	North and South Abreu Ditches	478	717	19,120	265	291,693	142
	Farmers Development Company	6,500	9,750	260,000	3,608	3,966,534	1,934
	Antonio Jose Valdez Ditch	95	143	3,800	53	57,972	28
	Valdez-Porter Ditch	440	660	17,600	244	268,504	131
	Miami Water Users Association	150	225	6,000	83	91,535	45
	Subtotal	7663	11,495				
Wheaton Creek	Upper Wheaton Ditch	6	9	240	3	3,661	2
	Upper Lucero Ditch	25	38	1,000	14	15,256	7
	Lower Lucero Ditch	36	54	1,440	20	21,968	11
	Middle Lucero Ditch	4	6	160	2	2,441	1
	Neuraute Ditch	6	9	240	3	3,661	2
	Subtotal	77	116				
Chico Rico Creek	Red River Irrigation Company	180	270	7,200	100	109,842	54
	Subtotal	180	270				
Canadian River	Stockton Ditch	369	554	14,760	205	225,177	110
	Subtotal	369	554				
Vermejo River	Vermejo Conservancy District	7,400	11,100	296,000	4,107	4,515,746	2,201
	Subtotal	7,400	11,100				

[a] Assumes an irrigation duty of 1.5 acre-feet (ac-ft) per acre (although this amount is not always available; however, estimates based on this assumption provide the maximum amount that could be withdrawn).

Table H-6. Estimated Distributory Canal Details
Colfax Water Planning Region
Page 2 of 2

Source	Diverter	Approximate Irrigated Area (acres)	Estimated Amount of Water Diverted [a] (ac-ft)	Estimated Total Length of D-Canals (feet)	Estimated Total D-Canal Water Losses (ac-ft)	Estimated Cost for Lining 67% of D-Canals ($)	Estimated Total Water Saved (ac-ft)
Ute Creek	Ute Creek Irrigation Company	349	524	13,960	194	212,972	104
	Subtotal	349	524				
Cimarron River	Charles Springer Cattle Company	8,000	12,000	320,000	4,440	4,881,888	2,380
	Old Mill Ditch	68	102	2,720	38	41,496	20
	Clutton-Maxwell Ditch	112	168	4,480	62	68,346	33
	Porter-Morley Ditch	424	636	16,960	235	258,740	126
	Springer Ditch Company	7,500	11,250	300,000	4,163	4,576,770	2,231
	C S Main Canal	5,661	8,492	226,440	3,142	3,454,546	1,684
	North C S Canal	566	849	22,640	314	345,394	168
	Subtotal	22,331	33,497				
Bonita Creek	Bonita Ditch	16	24	640	9	9,764	5
	Subtotal	16	24				
	Total	43,693	65,540	1,747,720	24,250	26,663,042	12,998

[a] Assumes an irrigation duty of 1.5 acre-feet (ac-ft) per acre (although this amount is not always available; however, estimates based on this assumption provide the maximum amount that could be withdrawn).

- For every irrigated acre in each system, there are 40 feet of D-canals. This figure is based on known D-canal lengths in the Vermejo Irrigation District (47 feet of D-canal per acre over the entire system) and nine other acequias included in a recent study of the Santa Cruz Irrigation District (SCID) (37 feet of D-canal per acre irrigated) (DBS&A, 2002).

The information in Table H-6 is intended to provide an overview of costs and potential water savings in Colfax County. However, each system needs to address this issue individually.

H.2.3.2 Piping

Similar seepage reduction benefits may be accomplished through the replacement of unlined conveyances with piping, which also has the benefits of system pressurization and reduction of evaporative losses. Piping may be constructed of an assortment of materials such as polyethylene, polyvinyl chloride (PVC), corrugated metal, cast-in-place concrete, and reinforced concrete. Again, the selection of material depends largely on the site-specific conditions, hydraulic considerations, and material availability and cost.

In theory, closed conduits or piping systems as an alternative irrigation water conveyance offer even more water savings than canal lining systems. Although lined canals eliminate or greatly reduce seepage, they still allow water evaporation losses, while in a piped irrigation system, evaporation can be largely diminished. Other factors that must be addressed, however, when considering the use of pipes as irrigation water conveyances are more intensive irrigation system design, increased construction quality control, more thorough operations and maintenance, and overall cost issues.

Piped off-farm systems also demand the construction and recurring operation and maintenance of desiltation basins (sand traps) at the system intake structure in order to prevent to the extent possible all debris and sand from entering the pipes. If this issue is not addressed, piping systems can become seriously clogged and extremely difficult to troubleshoot. In this instance, off-farm irrigation piping systems require the planning, design, and construction of pipe cleanout structures that can allow access to short reaches of the pipe to carry out maintenance.

Considering these issues, it is difficult to compare the use of pipe systems as an alternative to canal lining systems as a measure to improve water conveyance efficiency. A straight comparison in terms of cost per linear foot for the piped alternative must include the distributed costs over the entire length of the irrigation system for greater design time, more intensive construction inspection, design and construction of desilting and debris chambers and their follow-on operation and maintenance, and the cost for pipe cleanouts.

Typically, piping in irrigation systems is used in canal reaches where maintenance due to adjacent cut/fill slope erosion is an issue, on difficult access sections, or for certain special structures such as intake-sections, siphons, and cross drainage works. Because of the increased operations and maintenance time required, piping may be a more feasible option for smaller on-farm canal systems where individual farmers are more easily able to devote intensive operation and maintenance to their water conveyance systems.

H.2.3.3 Increased Storage Capacity

In Colfax County, the larger irrigation districts rely on storage reservoirs for flow augmentation and equalization. These reservoirs, which are often isolated and self-contained, are the focal point for demands by the conveyance system. Additional infrastructure improvements such as installing reservoir lining, dredging reservoirs, or constructing additional reservoirs can achieve increased water efficiency and conservation:

- As with canal lining, lining reservoirs will provide erosion control, reduced percolation, increased safety, and potential regulation and increased storage.

- Dredging reservoirs on a periodic basis to remove debris from the storage system will increase reservoir capacity and eliminate many operating problems, including controlling aquatic growth that consumes water and reducing sedimentation along the conveyance system.

- The construction of additional reservoirs will also increase storage capacity, amassing a more reliable source of water supply in addition to increasing the water delivery capacity.

Many of the reservoirs in Colfax County are 25 to 50 percent full of sediment. Dredging these during dry years would be extremely beneficial in increasing the irrigation water for all users, while failing to do so will result in continued sedimentation and the continued incremental reduction of water available each year. As discussed in Section 8.3, however, costs of dredging need to be compared to the costs of new storage to determine the most viable option for each system.

Reservoir dredging is expensive and time-consuming. Successful operations will require the construction of bypass canals around these reservoirs while they are out of service. In addition, nearby spoil areas must be located within 2,000 feet of each reservoir to stockpile excavated material. Removal of all the accumulated sediment from a reservoir whose capacity is 3,000 acre-feet but is 40 percent filled by sediment is estimated to cost close to $4 million; a small portion of this cost could be recouped by using the dredged sediment as fill dirt for other construction activities within the county. Such a dredging project would take about six months to complete, excluding the planning and design phase. Nevertheless, a program of repairing these reservoirs over, for instance, a 10-year period may make sense. Additional information on reservoir dredging is included in Section 8.3 of the main body of this Regional Water Plan.

H.2.4 On-Farm Improvements

Several more recently developed on-farm technologies are available to increase the efficiency of production agriculture irrigation systems (many of these techniques are used by farms in southern Colorado). While they appear attractive and do save significant quantities of water, their introduction in Colfax County's irrigation systems should be looked upon as a third step in system improvement, behind the development of viable and meaningful water management plans and off-farm infrastructure needs (Sections H.2.2 and H.2.3). Some farms in Colfax County may benefit from these technologies; however, the widespread application of such on-farm techniques may be years away. Nevertheless, individual farmers who find that improvements such as gated piping and more efficient sprinkler systems provide significant water savings in their operations may choose to implement on-farm measures at any time. For future planning purposes, these technologies are summarized below and discussed in more detail in Attachment H3.

- *Surge valves:* For some fields currently using furrow irrigation, surge valves can be added to increase application efficiencies and reduce deep percolation losses of irrigation water. The principle behind surge irrigation is to apply water in spurts or surges interspersed with “soaking” periods that allow the water to percolate into the soil before the next application. This method of irrigation advances the water more quickly and efficiently through the field than continuous irrigation. Surge valves typically improve furrow irrigation efficiency by an average of 10 to 40 percent, depending on soil type, land slope, and the length of the runs, and some growers have cut irrigation amounts by as much as 50 percent. Given these and other benefits (Attachment H3), surge irrigation is relatively inexpensive. However, the use of surge valves requires more farmer time and daily adjustment, and irregularities in farm topography, which can be covered by flood irrigation, are not compatible with surge techniques (Attachment H3). In Colfax County, many of the fields would not be suitable for surge irrigation without leveling.

- *Gated piping:* Pipeline conveyance systems, either underground or aboveground, are often installed to reduce labor and maintenance costs, as well as water losses to seepage, evaporation, spills, and non-crop vegetative consumption. One form of aboveground pipeline, gated pipe, distributes water to gravity-flow systems from individual gates (valves) along the pipe. In this method of irrigation, a moveable plug passes slowly through a long section of gated pipe, causing water to gradually cease flowing into the first rows irrigated as the plug progresses down the pipe. Improved water management is achieved by varying the speed of the plug, which controls the timing of water flows into each furrow.

- *Sprinkler systems:* Sprinkler systems are well suited for germinating seed and establishing ground cover for crops like lettuce, alfalfa, and sod because they can provide the light, frequent applications that are desirable for this purpose. Many types of sprinkler devices/systems are available today, including rotating head sprinklers (apply water in circular pattern), low-pressure spray nozzles (often used on center pivot and linear move systems or in orchards), under-tree rotating heads that keep the spray below tree foliage, and perforated pipe that sprays water from small-diameter holes in pipes. Land leveling is not normally required, thus making sprinkler irrigation easier to apply in Colfax County than other methods such as surge valves.

- *Drip/micro-irrigation systems:* Drip/micro-irrigation methods can conserve water because they deliver water directly to the root zone through emitters placed along a water delivery line (typically a polyethylene hose). Drip/micro-irrigation systems are of three main types: (1) aboveground drip systems, (2) buried drip systems, and (3) aboveground microspray and microsprinkler systems.

- *Soil treatments:* Water available to plants depends not only on the amount of rainfall and/or irrigation, but also on the physical, chemical, and biological properties of the soil. Soil characteristics such as structure, density, and amount and type of organic content can severely restrict the downward percolation of water into the soil. In situ moisture conservation, in which all rainfall is conserved where it falls and no runoff is permitted, can be achieved through covers or mulches, soil tilling, contour cultivation, and terracing. Such moisture conservation measures should be encouraged on lands with marginal rainfall.

- *Crop management:* Crop management can be used to reduce water losses and optimize water use in any farming system. Planting density and crop mix have an effect on the hydrologic characteristics of the system. Increased plant density can increase the soil cover by crops and thus decrease evaporation losses (although it can also increase water uptake from the soil). Mixing plants that use moisture mainly from the top layer with plants such as fruit and other trees that tap water beyond the reach of the annuals may yield more abundant crop production while protecting critical top soils.

Further information on the irrigation methods described above is available in the manual *Selection of Irrigation Methods for Agriculture*, prepared by the On-Farm Irrigation Committee of the Irrigation and Drainage Division of the American Society of Civil Engineers (Burt et al., 2000). This manual also discusses other types of irrigation systems not covered in this report.

H.3 Financing of Agricultural Conservation Programs

The cost of water conservation improvements such as canal lining, reservoir dredging, and gated piping often deters irrigation associations from maximizing their water efficiency. In determining whether the cost of improvements warrants financing, it is useful to compare the cost of the improvements versus the value of the water, that is, how much the water is worth. The value of a crop at market and the quantity of water needed to produce that crop can be analyzed to assign a dollar value to each acre-foot of water. Once this dollar value has been determined, a cost/benefit analysis can be done for each water conservation improvement alternative to help an irrigation association decide what improvements are most worthwhile to undertake. An example of a cost/benefit analysis for selected infrastructure improvements is provided in Sections H.3.1 through H.3.5.

H.3.1 Cost of Improvements

The costs of the most promising infrastructure improvements (Sections H.3.3) are:

- *Canal lining:* According to a June 2001 report by the USBR (2001), canal lining can cost between $0.76 and $4.33 per square foot depending on the lining material, which ranges from bentonite clay lining to impervious plastics, and method of application. Table H-4 shows a sample of some of the lining costs from the USBR report (2001).

- *Reservoir dredging:* The greatest variable in the cost of reservoir dredging is the transportation of the spoils off-site. The conceptual cost for the dredging ranges from $3,000 to $14,000 per acre-foot of sediment removed. The cost range depends on the type of dredging used and the location of sediment disposal (on- or off-site).

H.3.2 Water Savings from Improvements

Canal lining can virtually stop canal loses due to water seepage. Concrete lining has been shown to reduce seepage by 85 percent, while concrete combined with a plastic geomembrane reduces seepage by 95 percent (USBR, 1999). Most of the Colfax County irrigation associations interviewed for this analysis estimated their water loses from the ditch to be around 50 percent. An irrigation district in Colfax County could, therefore, theoretically increase their available water supply significantly by installing concrete liners. Section H.2.3.1 projected a 20 percent savings of withdrawn water lost to seepage by lining just 67 percent of all D-canals. This calculation assumed that current seepage losses are 37 percent; an even greater water savings would be realized if current seepage losses are actually closer to 50 percent.

Even more water can be saved if linings are installed on main canals and on large on-farm canals. Every amount of water saved allows more acreage to be irrigated and/or allows more water to be applied to existing acreage. Since Colfax County irrigators routinely receive substantially less water than their water right allotments, saving water will not result in a loss of the water right but rather will allow the fulfillment of the right.

Water supplies are increased directly by adding new storage capacity or by dredging reservoirs. A larger reservoir can deliver more water to downstream users. The irrigation associations interviewed estimated that siltation of the reservoirs had decreased their capacity by approximately 25 to 50 percent. By dredging the reservoirs to original volumes, irrigation associations could deliver almost double the amount of water they are delivering now.

On-farm irrigation improvements such as gated piping and surge valves have been shown to decrease water use by 50 percent. Using modern farming techniques could allow farmers to double the acreage they are irrigating or plant higher-value crops that require more water.

H.3.3 System Improvement Cost/Benefit Analysis

A cost/benefit calculation consists simply of dividing the benefits (water savings expressed in dollars) of the project by the costs of the project. If the cost/benefit ratio is less than one, the cost of the project outweighs the benefits; if the resulting ratio is greater than one, the benefits of the project are greater than the costs. The larger the cost/benefit ratio, the more beneficial the project.

The first step in the cost/benefit evaluation is to determine the value of water in dollars. Each irrigation association can decide what value they want to assign to the water. This may be based on the market value of water rights, the amount each user pays in water fees, or the value of the crop produced with the water. Once the value of water has been determined, the next step is to determine how much water a given improvement will save each year. Water savings from canal lining and reservoir dredging are discussed in Section H.3.2. Other resources such as the USDA and vendors of irrigation products can provide estimates of water savings from various improvements.

When the water savings from a given technology is determined, the value of the water can be multiplied by the quantity of water saved. This value is the “benefit” of implementing the technology for a year.

Next, the “cost” of the improvement will be calculated. By knowing the initial costs, design life, and maintenance costs of any given improvement, the life-cycle cost ($/yr) can be calculated. The benefit cost in water savings can then be divided by the life-cycle cost of the improvement to determine the cost/benefit ratio.

External investors, including federal and state funding sources, will use such techniques when making decisions about funding and levels of funding any project. Another factor that will come into play is the future prospects for the long-term viability of the irrigation system itself. Adopting water management and conservation plans, charging correct prices for water use, and using innovative techniques such as water banking are signals to investors that their funds will be going to systems where there is forward thinking and a greater likelihood of future successes.

H.3.4 Benefits of Increased Water Supply

With a greater supply of irrigation water, farmers could increase their irrigated acreage and/or increase the water applied to existing farmed land. By planting more crops, farmers have the opportunity to increase annual incomes. In their interviews with DBS&A, irrigation associations in Colfax County indicated that the type of crops grown was dependent on the amount of water available. If additional water supplies were available, farmers would have the option to plant higher value crops that require more water or are not as drought tolerant.

Typical crops grown throughout the state of New Mexico in the year 2000, along with their value, are outlined in Table H-7.

The most efficient use of the available resources can be determined through an evaluation of the types of crops that can be grown in Colfax County's climate, the amount of water required to grow these crops, and the value these crops would bring at market.

Table H-7. Value of Typical Crops Grown in New Mexico in 2000

Crop	Average Yield per Acre	Market Price per Unit ($)	Value per Acre ($)
Wheat	24 bushels	2.65	63.60
Hay	4.39 tons	120.00	526.80
Alfalfa	5.2 tons	122.00	634.40
Sorghum	25 bushels	2.05	51.25
Corn	160 bushels	2.50	400.00
Potatoes	385 Cwt.	4.25	1,636.25
Chile	5.2 tons	494.00	2,568.80
Onions	460 Cwt.	9.25	4,255.00
Pecans	1,180 pounds	1.37	1,616.60

Source: NMDA, 2000 Cwt. = 100 weight (100 lb)

H.3.5 Sources of Funding

Water conservation projects can be expensive, but social, economic, and environmental benefits are realized when great and steady supplies of water are available. Because of these benefits, state and federal agencies provide funding to assist irrigation associations with water conservation improvements, including infrastructure improvements and technical assistance. Prior to developing a capital project plan, it is recommended that an irrigation system study its existing and future operations, including its potential to remain viable through the engagement of new farmers and the planting of crops that bring a reasonable rate of economic return. The more prepared an applicant system is in terms of its management and planning, the better it will do when seeking external funding for any improvement.

Some of the major sources of funding are listed below:

- The U.S. Army Corps of Engineers offers a funding program for irrigation system infrastructure improvements. This program consists of a 75 percent grant for projects such as canal lining, reservoir dredging, and flow control and measuring appurtenances. The program works in conjunction with a similar program offered by the New Mexico Interstate Stream Commission (ISC) that assists systems taking advantage of the Corps program. The ISC program provides grant funding for an additional 15 percent of a given project's improvements, leaving just 10 percent of the total cost to be funded by the irrigation organization.

- Low-interest loans are available to systems through the New Mexico Finance Authority (NMFA) and the USDA. These loans could provide funds for the 10 percent not covered by the above funding.

- The USBR offers various project funds in grants and loans for all types of infrastructure projects.

- The State of New Mexico Water Trust Board funds selected water projects in New Mexico.

- The State of New Mexico Capital Outlay Program offers grant funds for approved projects that are championed by local State representatives and senators.

- The NRCS Environmental Quality Incentives Program provides financial and technical assistance to farmers and ranchers to implement structural and management conservation practices on eligible agricultural land.

H.4 Summary and Recommendations

Based on the information in this section, DBS&A offers the following recommendations:

- For some time, irrigation systems in the county have not received their normal allotment of water in order to provide their share of diverted water rights to their users. In many cases this shortage is a result of system inefficiencies, due in part to irrigation infrastructure that is in need of repair, and significant amounts of water are lost in off-farm delivery structures, particularly in canals. The successful repair of and improvements to this infrastructure would address much of this problem.

- These off-farm system repairs and improvements should be the initial focus of conservation efforts.

- Irrigation system management in all county systems is hampered by lack of user participation and funds. This situation requires further study with the recognition of the types of farming now ongoing in the county and with a view to a desired vision of future farming in each system. Each system needs to develop a picture of its future through such studies and then develop appropriate water management and water conservation plans.

- Each system should name a Water Conservation Officer who is or becomes educated in water conservation techniques that can work for each of the individual systems today as well as those that might be applicable tomorrow.

- Each system should develop a workable management plan for today and the future and a capital improvement plan to correct off-farm canal losses and repair existing reservoir impoundments through dredging of accumulated sediment. The capital improvement plan can serve as the basis for obtaining external funding for its projects.

- Each system should seek legal advice on water banking within its own system boundaries or perhaps within county boundaries. An acceptable system or county-wide water banking program could help conserve farm water now without any physical/structural or programmatic improvements.

- A user education program on water conservation and irrigation system management needs to be undertaken to help farmers in Colfax County understand the issues that face the future of farming in the county so they can make sound decisions on issues that can improve and sustain the county's farming future. Such an education program might also attract younger and new farmers into Colfax County agriculture in the future.

- Reservoir dredging should be undertaken if funds are available. Increasing storage in the area will provide for improved water management.

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