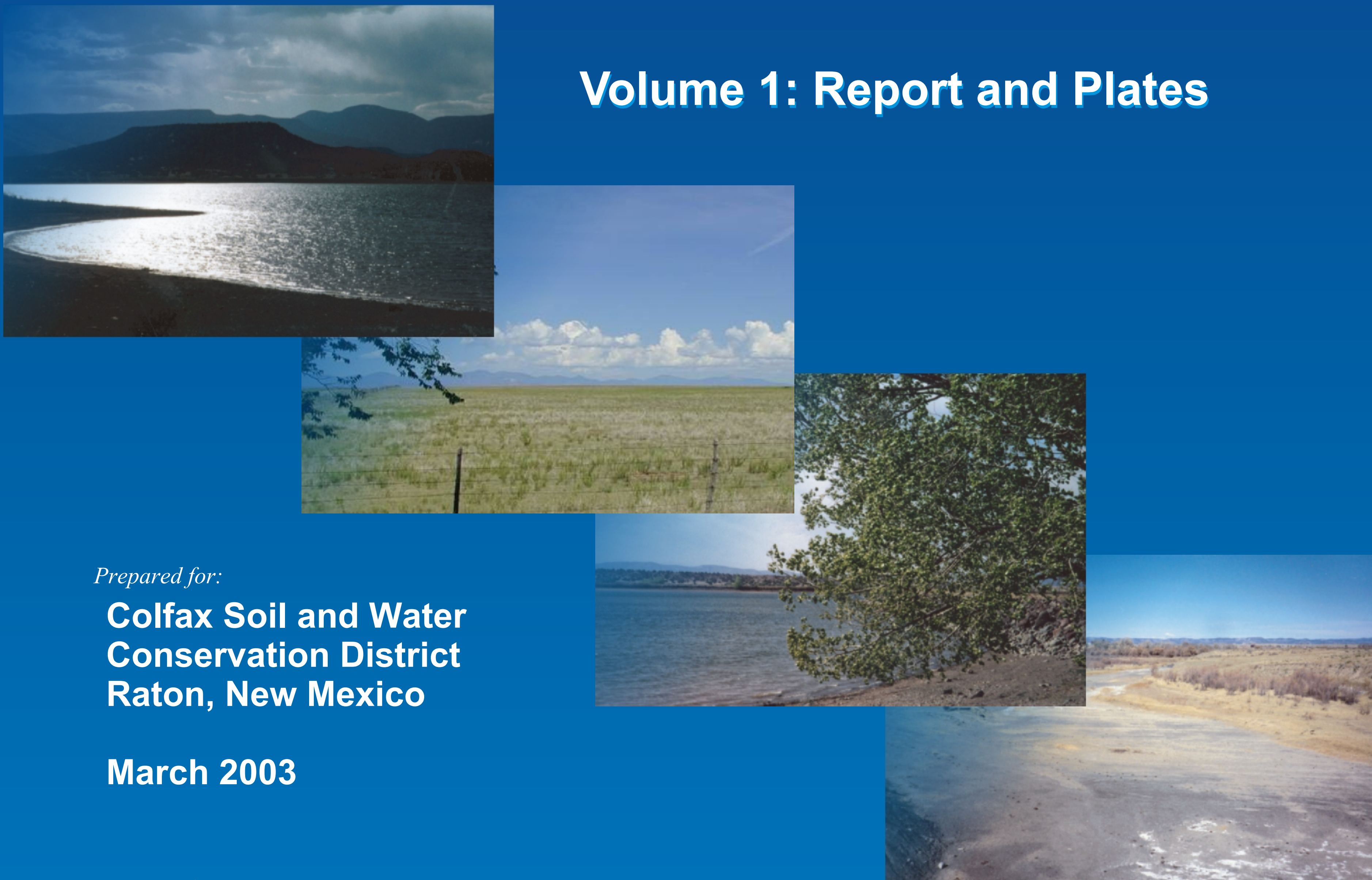
Colfax Regional Water Plan

Volume 1: Report and Plates



Prepared for:

Colfax Soil and Water Conservation District
Raton, New Mexico

March 2003

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Acronyms and Abbreviations

ARS	Arkansas River shiner
AWC	available water content
AWT	advanced water treatment
AWWA	American Water Works Association
bgs	below ground surface
cfs	cubic feet per second
cfu/100 mL	colony-forming units per 100 milliliters
cm/s	centimeters per second
DBS&A	Daniel B. Stephens & Associates, Inc.
EPA	U.S. Environmental Protection Agency
ET	evapotranspiration
ft/d	feet per day
ft/ft	foot per foot
FWS	Fish and Wildlife Service
GAC	granular activated carbon
gpcd	gallons per capita per day
gpd	gallons per day
gpm	gallons per minute
GWSI	USGS Ground Water Sites Inventory database
ISC	New Mexico Interstate Stream Commission
MCL	maximum contaminant level
mgd	million gallons per day
mg/L	milligrams per liter
mm	millimeters
mm/d	millimeters per day
msl	mean sea level
µg/L	micrograms per liter
µmhos/cm	micromhos per centimeter
NAWQA	National Water Quality Assessment Program
NMDA	New Mexico Department of Agriculture
NMDH	New Mexico Department of Health

Acronyms and Abbreviations
(Continued)

NMDWB	New Mexico Drinking Water Bureau
NMED	New Mexico Environment Department
NMWQCC	New Mexico Water Quality Control Commission
NM Const	New Mexico Constitution
NMSA	New Mexico Statutes Annotated
NOAA	National Oceanic and Atmospheric Administration
NOI	Notice of Intent
NCDC	National Climate Data Center
NPDES	National Pollutant Discharge Elimination System
NTU	nephelometric turbidity units
O&M	operations and maintenance
OSE	New Mexico Office of the State Engineer
PDSI	Palmer Drought Severity Index
RO	reverse osmosis
RUS	Rural Utilities Services
SAT	soil-aquifer treatment
SWCD	Colfax Soil and Water Conservation District
SPM	Southwest Planning and Marketing
TDS	total dissolved solids
TMDL	total maximum daily load
USBR	U.S. Bureau of Reclamation
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
USTs	underground storage tanks
WATERS	OSE Water Administration Technical Engineering Resource System database
WHPA	Wellhead Protection Area (model)
WRRI	New Mexico Water Resources Research Institute
WWTP	wastewater treatment plant
yd^3	cubic yards

Executive Summary

Executive Summary

The Colfax planning region, which includes all of Colfax County, is one of 16 planning regions in New Mexico that are in the process of developing a regional water plan. The purpose of regional water planning is to protect New Mexico water resources and to ensure that each region is prepared to meet future water demands. Regional water planning activities are funded through and overseen by the New Mexico Interstate Stream Commission.

All regional water planning activities in Colfax County are overseen by a steering committee consisting of representatives from the agricultural sector and municipalities, water rights holders, and others with water interests in the region. The designated fiscal agent for the Colfax planning region is the Colfax Soil and Water Conservation District, who retained the team of Daniel B. Stephens & Associates, Inc. and Southwest Planning and Marketing to complete this regional water plan.

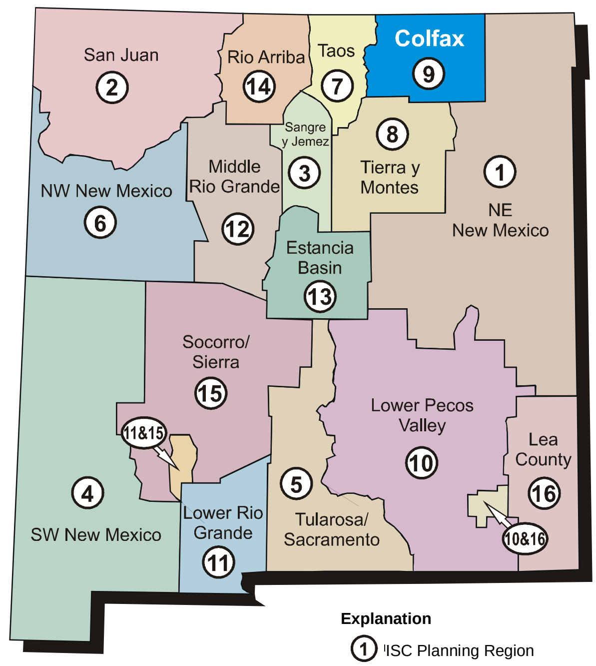
The New Mexico Interstate Stream Commission's *Regional Water Planning Handbook* (1994) serves as a guideline for regional water planning in New Mexico and has been used as an outline for the Colfax Regional Water Plan. According to the template, a regional water plan must address these questions:

- What is the region's available water supply?
- What is the region's water demand?
- What steps will the region undertake to meet future demand with the available supply?

To address the first water planning question, this plan discusses both the physical availability of water and water rights and legal constraints that affect the availability of water. To address the second question, historical and current water demand in the region was evaluated, and the results were used in conjunction with an analysis of projected population and economic growth to develop the future water demand projections presented in this plan. To address the third question, alternatives for meeting future demand were identified and evaluated.

Colfax Planning Region

Colfax County is located in northern New Mexico between Taos and Union Counties, just south of the Colorado border (Figure ES-1). The county covers an approximately 3,800-square-mile area. Elevations range from over 12,000 feet in the mountainous western part of the county to about 5,000 feet in the eastern plains areas. The mountains in Colfax County are part of the Sangre de Cristo Range. The eastern plains portion of the county includes several high mesas, which are part of the Raton Mesa Group, along the north edge of the Canadian River. Colfax County falls almost entirely within the Canadian River Basin.



Location of Colfax Planning Region

Figure ES-1

The county includes six incorporated areas: Raton, Springer, Cimarron, Maxwell, Eagle Nest, and Angel Fire. The population of Colfax County is currently about 14,000, with the most significant growth currently occurring in the Angel Fire/Eagle Nest area. Sizeable seasonal population fluctuations (at times exceeding the resident population) occur throughout the year due to tourism in the Angel Fire-Eagle Nest area and at the Philmont Boy Scout Ranch, the National Rifle Association Whittington Center, and two state parks.

Most of the land in the county is privately owned. Historically, tourism and coal mining have been the primary industries; however, mining activities are currently being phased out. Significant livestock grazing and agriculture take place in the eastern part of the county and the primary water use in the region is irrigated agriculture.

Water Rights

Water rights and legal issues were evaluated to understand constraints on the availability of the water supply. All diversions or withdrawals of surface water and groundwater require the user to have a water right from the State of New Mexico, as administered by the Office of the State Engineer. In Colfax County, water rights in most of the major streams have been fully appropriated, which means that no new water rights are available and water from that stream can only be obtained through purchase or lease from a current water rights holder. The adjudicated stream systems in the county are the Cimarron, Rayado, Dry Cimarron, Sugarite/Chico Rico, and Vermejo; the total amount of water adjudicated in these systems is about 120,000 acre-feet. The vast majority of these water rights are for irrigation, but some rights have been transferred to other uses in recent years.

All rights from Eagle Nest Reservoir on the Cimarron River, the largest reservoir in the county, are held under Permit 71. Diversion and storage rights under this permit have been conveyed to irrigators and the majority of the municipalities in the planning area, and additional storage space may be available. In 2002, the State of New Mexico purchased the reservoir from the C S Ranch.

Groundwater rights in New Mexico are administered through the declaration of groundwater basins that require a permit for groundwater withdrawals. Colfax County encompasses parts of two declared underground water basins: the western three-fourths of the county lies within the Canadian River Basin, while the southeastern corner of the county lies within the Tucumcari Basin. Groundwater in the northeastern part of the county is currently undeclared; therefore a permit is not required to withdraw groundwater in that area.

Water Supply

Colfax County currently meets more than 95 percent of its water supply needs with surface water. Most of the Colfax County area is drained by the Canadian River and its tributaries (Figure ES-2), and most of the surface water supply in Colfax County is associated with these major drainages. The Canadian River originates in southern Colorado and flows east, then south through the county. Major tributaries to the Canadian River are the Vermejo River and Cimarron River, which originate in the northern and/or western parts of the county. Important tributaries to the Cimarron River below Eagle Nest Reservoir are Ponil and Rayado Creeks.

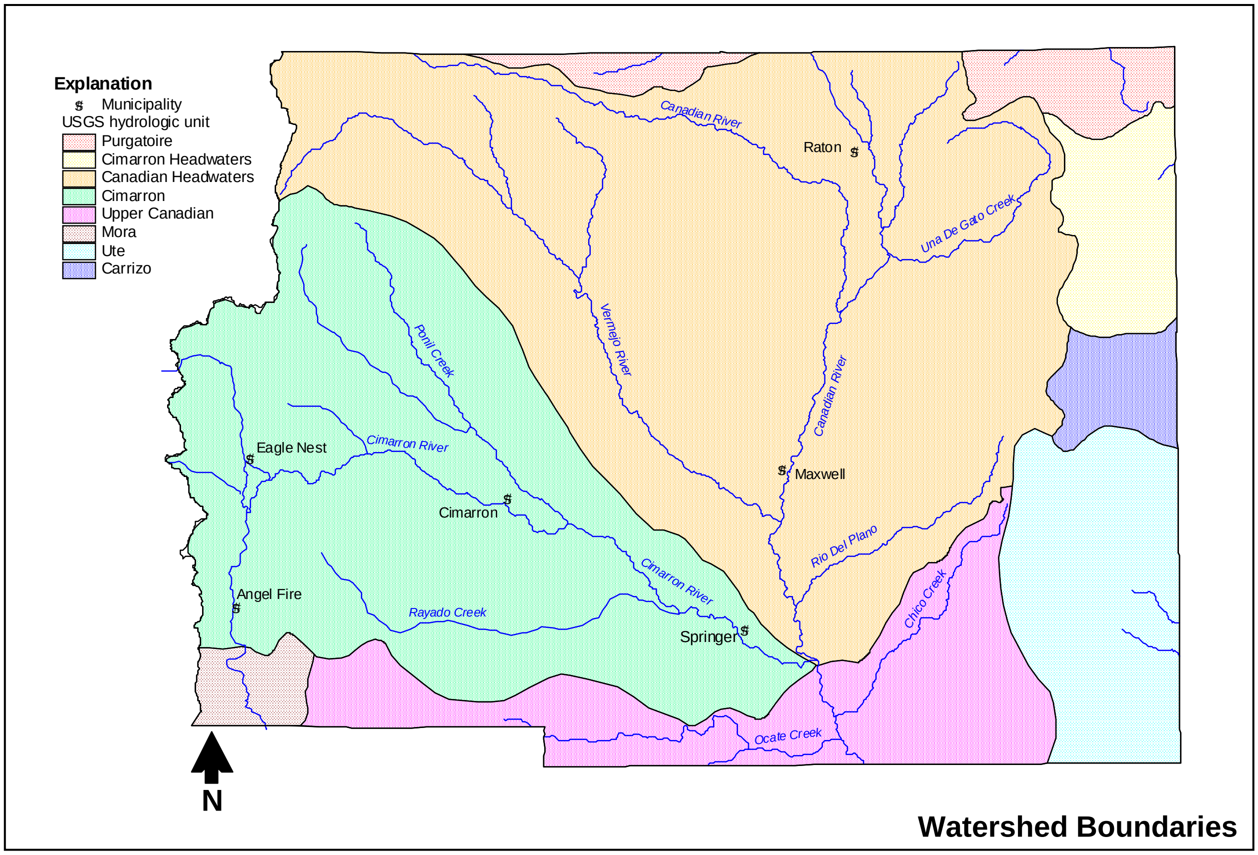


Figure ES-2

The surface water supply for Colfax County was evaluated using a combination of historical and statistical analyses of climate and streamflow data. The average temperature in Colfax County is fairly consistent, ranging between about 40°F and 50°F. Average temperatures have increased slightly over the period of record, mostly due to rising minimum temperatures. Precipitation varies across the county, influenced by location and somewhat by elevation, with average precipitation, including both snowmelt and rainfall, ranging from about 14 to 24 inches. Historical climate and streamflow data indicate that the last two years have been significantly drier than normal, with the 2002 water year (which ended on September 30, 2002) being one of the lowest years on record. With the exception of these last two years, however, the past 20 years have been wetter than the overall long-term record.

Streamflow records from five U.S. Geological Survey monitoring stations (the Rayado Creek, Cimarron below Eagle Nest, Ponil Creek, Vermejo near Dawson, and Canadian near Hebron streamflow gages) were evaluated to estimate the total yield in the region. Total streamflow from these gages represents most of the flow in the region (the exceptions being ungaged flows north and east of Raton and the ungaged tributaries below the stations). Significant additional flow is not contributed below these gages except in the wettest years, when ephemeral streams contribute substantial flows. The sum of the yields from the five watersheds (with yields from the Cimarron River below Eagle Nest Reservoir gage corrected for storage changes in the reservoir) indicated a median flow of approximately 45,500 acre-feet per year and minimum and maximum flows of about 11,400 and 146,800 acre-feet per year, respectively. These values represent the best overall characterization of the water supply for Colfax County.

The frequency of transitions from one category of water year (i.e., dry or wet) to another was also analyzed for the five upstream stations combined. This analysis evaluated the number of years, or fraction of time, that the water supply is less than the demand in order to determine the probabilities of experiencing drought for a number of successive years. The results indicated a high probability of having two dry or very dry years in a row, which emphasizes the importance of drought mitigation planning in the region.

Water yield data were also studied to determine the relationships between precipitation and runoff at the gaging stations. Only weak relationships were observed, likely because of the large size of the watersheds, the sparse distribution of precipitation gages, and the small fraction of precipitation that becomes runoff (10 percent or less).

The overall surface water quality in Colfax County is good, although some stream reaches have been listed as impaired, primarily due to stream bottom deposits, turbidity, and plant nutrients. The presence of these constituents does not necessarily mean the source is unacceptable for irrigation or municipal use. However, the vulnerability of the surface water supply to further degradation indicates that watershed protection should be a priority in Colfax County.

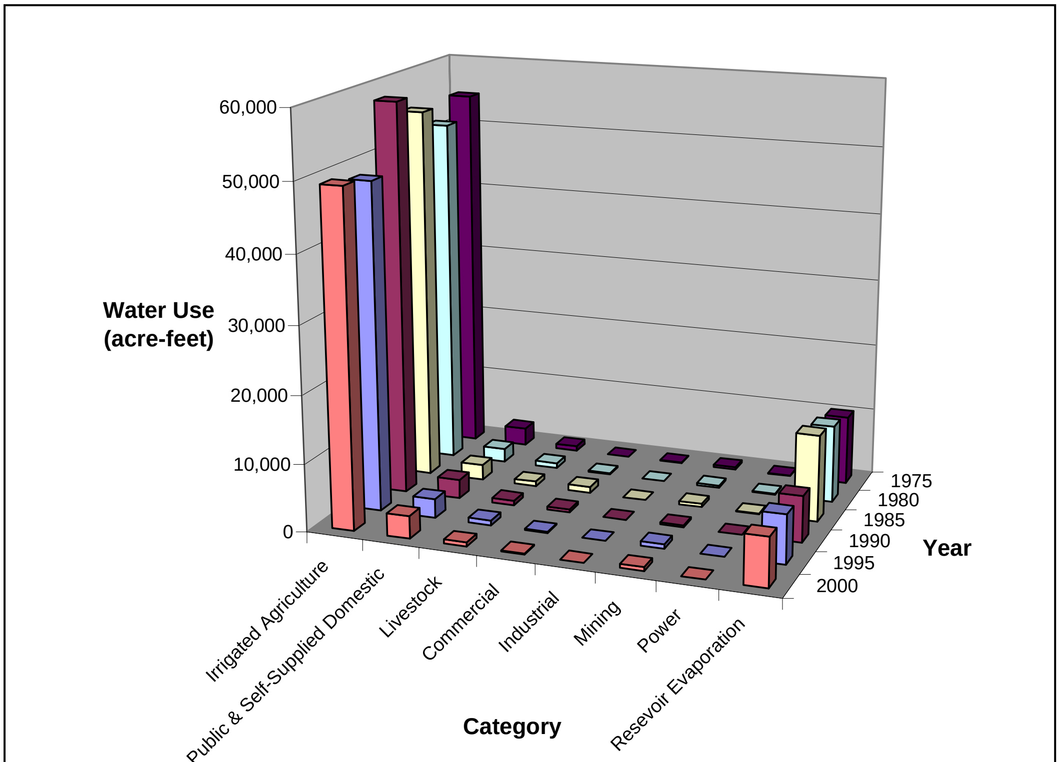
The largest and most viable source of groundwater is in the Moreno Valley, where Mesozoic and Paleozoic sandstone and siltstones serve as aquifers. Other groundwater resources in the region with potential for future groundwater development are alluvial deposits near stream channels, the Ogallala Formation, the Dakota Sandstone Formation, and intermixed alluvial and volcanic deposits of the Capulin Basin.

Groundwater quality in many parts of the county is poor, due to naturally high levels of total dissolved solids, and is unusable without treatment. Some groundwater in the area has also been contaminated as a result of leaking underground storage tanks and/or septic tanks. Although most of the recorded underground storage tank sites are located in areas where groundwater is not currently used, leaking septic tanks in the Moreno Valley and Ute Park could degrade a widely used groundwater source.

Water Demand

Present and historical water use was determined primarily based on information from the New Mexico Office of the State Engineer, which tracks water used in New Mexico according to the defined categories of public water supply, self-supplied domestic supply, irrigated agriculture, self-supplied livestock, self-supplied commercial, industrial, mining, and power, and reservoir evaporation. Historically, the largest demand sector in the region is irrigated agriculture (about 80 percent), followed by reservoir evaporation and public water supply (Figure ES-3). The amount of water used in the region is about 70,000 to 90,000 acre-feet per year, though many water rights in the region are generally unfulfilled and additional water would be used if available. The change in demand from year to year is based on crop requirements and reservoir evaporation, both of which vary depending on climatic conditions.

Agricultural acreage is expected to remain steady or decline slightly over the 40-year planning period. However, agricultural water demands may increase if lower precipitation occurs. Additionally, many of the holders of decreed agricultural water rights in the region do not regularly receive their full allotment of water, indicating that the agricultural demand for water is actually greater than the historical use records.



Total Withdrawals by Category in Colfax Planning Region

Figure ES-3

Two annual surface water budgets for Colfax County were prepared: one for an average climate year and one for a representative drought year. The water budget indicated that the largest depletions were due to evapotranspiration, while the next largest depletion is for irrigated agriculture.

Although surface water provides more than 95 percent of the water supply in Colfax County, the surface water supply is highly variable from year to year. Adequate storage is essential to managing the variable surface water supply. The ability of surface water flows to meet projected demands (based on fulfillment of adjudicated water rights) was evaluated in two ways:

- The first approach was to compare the sum of streamflow at the five tributary stations (Rayado, Ponil, Cimarron below Eagle Nest, Vermejo at Dawson, and Canadian at Hebron) to the corresponding demand of approximately 80,000 acre-feet (the total amount of water rights adjudicated by the Cimarron, Rayado and Vermejo Decrees).

- The second approach was to compare streamflow from the Canadian River at Taylor Springs gage, located near the downstream boundary of the planning region, below inflows from all major tributaries, to the estimated 120,000-acre-foot demand for the entire region (the sum of all decreed water rights). Before completing the comparison, the streamflow at the Canadian River at Taylor Springs gage was corrected to account for upstream depletions, which were assumed to be the average of the depletions reported by the Office of the State Engineer for the planning region.

These evaluations indicated that the supply is greater than or equal to 80 percent of the demand only 15 percent of the time (for the five upstream stations) or 11 percent of the time (for the Canadian River at Taylor Springs gage). Releases from storage can be used to help meet the needs of the region, but the storage is not adequate to provide for all of the unfulfilled water rights.

Alternatives for Meeting Future Demand

To identify alternatives for meeting future demand, the Steering Committee focused on three alternatives:

- *Drought planning*: The dependence of the region on highly variable surface water supplies makes the planning area vulnerable to drought conditions. Consequently, a drought contingency plan was prepared and is included as an appendix to this water plan.

- *Agricultural water conservation*: Approximately 80 percent of the water used in the region is for irrigated agriculture. Consequently, the identification of opportunities for more efficient use in this sector was given a high priority, and an agricultural water conservation plan was prepared (also included as an appendix to the water plan).

- *Watershed protection*: To protect surface water supply from potential water quality degradation and/or catastrophic forest fires, watershed protection was identified as a key priority. A watershed group for the Canadian Headwaters watershed was formed through the regional water planning process, and technical support was provided to the Cimarron watershed group, which has received funding from the New Mexico Environment Department. An analysis of possible watershed management actions that could affect water yields indicated that measurable increases in surface water yields are most likely to occur from thinning at least 25 percent of the vegetation in areas higher than 9,000 feet in elevation.

In addition to these key alternatives, other priority alternatives identified by the steering committee for analysis within this *Regional Water Plan* include:

- Implementing dredging projects to improve storage in reservoirs and ponds
- Developing county and city ordinances for conservation
- Pursuing water rights transfers or leases to help supply projected demand
- Appropriating and reserving groundwater for the region
- Developing 40-year water plans and securing water to meet future demands (municipalities and other local entities)
- Developing and implementing county-wide septic tank and other water quality control ordinances
- Recycling municipal wastewater for agricultural and recreational use
- Implementing growth management and land use planning
- Providing public outreach and educational activities

These alternatives were analyzed and found to be feasible if financing can be secured. Accordingly, the steering committee developed an implementation schedule for the alternatives described in the plan and identified actions that will support alternative implementation. Adherence to the implementation schedule will be partially dependent on obtaining funds necessary to complete the projects identified.

Several other important alternatives were not analyzed in detail within this plan, but are recommended for additional actions such as further study, pilot projects, or eventual implementation:

- Implement efficiencies in municipal water supply management (e.g., leak detection)
- Remove invasive vegetation; revegetate to reduce riparian evapotranspiration
- Xeriscape to conserve municipal water
- Implement efficiencies in industrial uses such as mining
- Pursue underground storage of available water
- Build additional water storage capacity
- Consider cloud seeding projects
- Build a regional delivery system to tie in municipal systems (Cimarron, Springer, Maxwell, Miami, and Raton)
- Maintain treatment plant in municipalities and upgrade mains and other infrastructure
- Construct wastewater treatment systems to replace septic tanks in the Moreno Valley and other parts of the county
- Implement nonpoint source management projects

- Draft and implement source water and wellhead protection plans for key water supplies
- Monitor methane gas extraction activities for potential impacts to groundwater quality/availability and consider potential reuse of water
- Develop and enact county/municipal regulations regarding domestic wells
- Establish regional water banking (accounting) system
- Actively manage existing storage facilities to optimize efficient use of water/storage
- Establish a mechanism to better manage water delivery throughout Colfax County
- Establish a Canadian River Water Master (in addition to the Cimarron-Rayado Water Master)

Section 1

Introduction

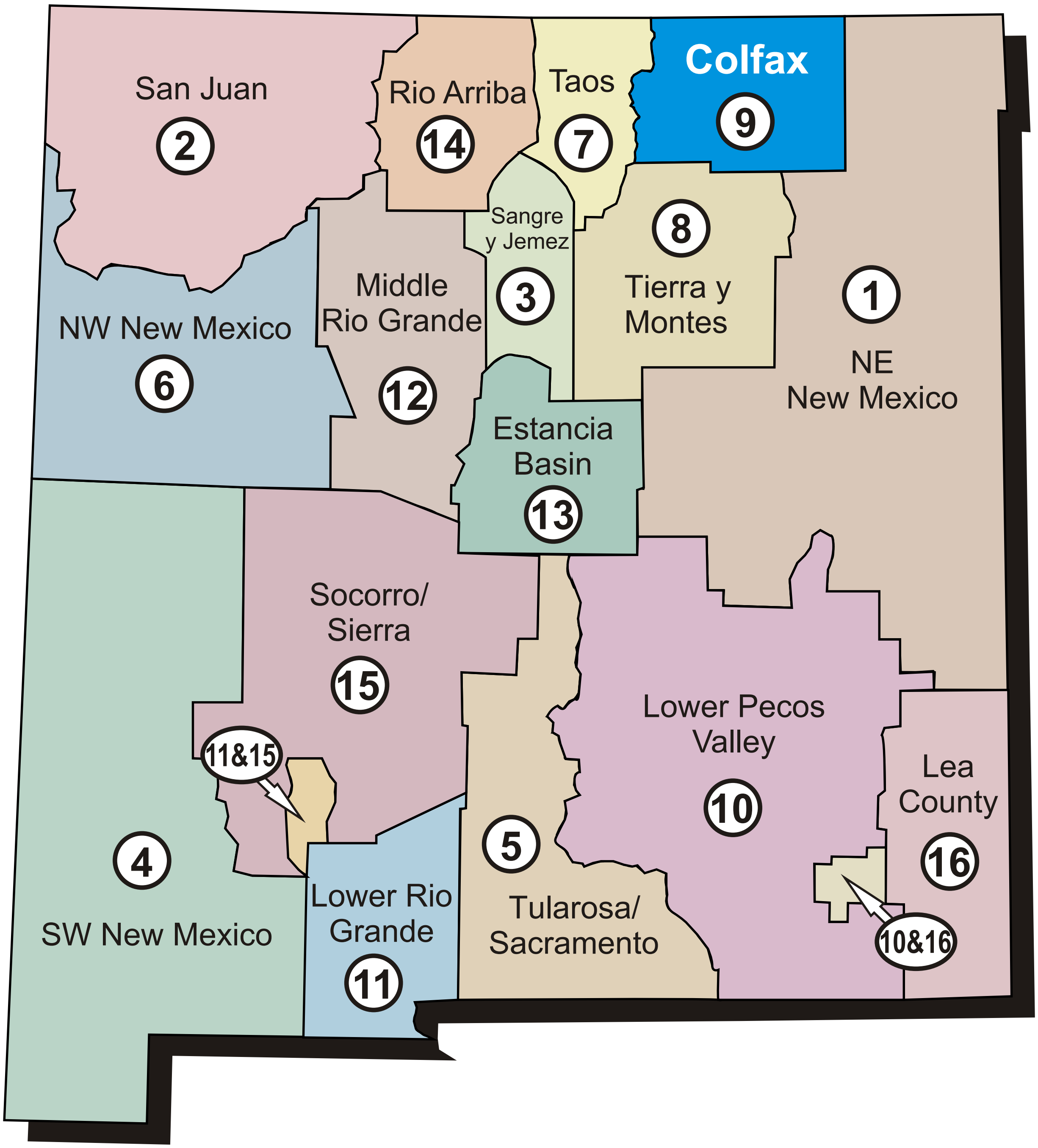
1. Introduction

The Colfax planning region, which includes all of Colfax County (Figure 1-1), is one of 16 planning regions in the State of New Mexico that are in the process of developing a regional water plan. Regional water planning was initiated in New Mexico in 1987, its primary purpose being to protect New Mexico water resources and to ensure that each region is prepared to meet future water demands. Regional water planning activities are funded through and overseen by the New Mexico Interstate Stream Commission (ISC).

The designated fiscal agent for the Colfax planning region is the Colfax Soil and Water Conservation District (SWCD). The Colfax SWCD retained the team of Daniel B. Stephens & Associates, Inc. (DBS&A) and Southwest Planning and Marketing (SPM) to complete this regional water plan, and regional water planning activities to develop the plan were initiated by DBS&A in 2000. All of these regional water planning activities have been overseen by a 19-member steering committee consisting of representatives of agriculture, municipalities, water rights holders, and others with water interests in the region. Additional information on the steering committee is provided in Section 2.

1.1 Previous Water Planning Efforts in the Region

Prior to the current regional water planning efforts, only one previous water planning study was funded by the ISC. This study was completed by Resource Technology Incorporated and culminated in the development of a regional water plan. The focus of the 1991 plan was a surface water model and analysis of the surface water system, which indicated that most locations showed a shortage of surface water (RTI, 1991). However, this plan was completed prior to the development of the regional water planning template (ISC, 1994) and did not include all of the information required by the template.



Explanation

(1) ISC Planning Region

COLFAX REGIONAL WATER PLAN

Location of Colfax Planning Region

Figure 1-1

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1.2 Information Sources

Additional previous efforts outside of the ISC planning program were considered for their relevance to this regional water plan. Reference materials pertaining to the water supply and water quality in Colfax County were compiled and reviewed. A bibliography of those reference materials is included in Appendix A. Appendix A also includes annotations for the documents that contained information most relevant to the planning region.

Much of the information used in the water supply and water quality assessment was derived from climate and hydrologic records available electronically from state and federal agencies:

- Climatic data were obtained through Earthinfo, a subscription service that compiles climate data from the National Climatic Data Center and provides them electronically.

- Streamflow data through water year 1997 were obtained from the United States Geological Survey (USGS) web site (USGS, 2001). Streamflow data for water years 1998 and 1999 were obtained from Robert Gold, USGS Public Information Officer for the state of New Mexico. Streamflow data for water years 2000 through 2001 and provisional data for 2002 were obtained from the USGS web site (USGS, 2002).

- Water quality data from the USGS Ground Water Sites Inventory (GWSI) database, as well as data on groundwater wells, were also obtained from the USGS Public Information Officer for New Mexico.

- Information on water rights and wells was obtained from the New Mexico Office of the State Engineer (OSE) WATERS Database (NM OSE, 2001, 2002).

- Monthly Palmer Drought Severity Index (PDSI) data from 1980 through 1999 were obtained from Ted Sammis, New Mexico State Climatologist. PDSI data for 2000 through 2002 were obtained from the National Climate Data Center web site (NCDC, 2002).

- Information on National Pollutant Discharge Elimination System (NPDES) permits, underground storage tanks (USTs), and total maximum daily loads (TMDLs) was obtained from the New Mexico Environment Department web site (NMED, 2001a, 2001c, 2002).

- Land use, geology, and other reference maps were prepared by the New Mexico Water Resources Research Institute and are provided in Appendix B.

- Information on water rights and administrative decrees was provided by the OSE and Jim Hollis, OSE Cimarron Water Master.

Information on historical water use was obtained primarily from the OSE. Records regarding municipal water use were obtained directly from the municipalities, and records regarding agricultural and livestock water use were obtained from the New Mexico and U.S. Departments of Agriculture (NMDA and USDA, respectively). Additional information on the sources of data and information used in this plan is included in Sections 4, 5, and 6.

1.3 Organization of the Regional Water Plan

Regional water planning in New Mexico is guided by the template outlined in the ISC Regional Water Planning Handbook (ISC, 1994), which defines the scope and content of regional water plans. According to the template, a regional water plan must address five key questions

1. What is the water supply available to the region?

2. What is the region's current and projected future demand for water?

3. What are the region's alternatives for using available supplies to meet projected future water demands, including reduction of demand, to the extent needed, to live within available supplies?

4. What are the advantages and disadvantages of each alternative with respect to local values and criteria?

5. What are the best water supply alternatives and how will they be implemented?

This regional water plan is organized to be consistent with the regional water planning template (ISC, 1994) and to address the five water planning questions:

- Background information regarding the process used to develop the plan and the characteristics of the planning area is provided in Sections 2 and 3, respectively.

- To address the first question, this report discusses both the water rights and legal constraints that affect the availability of water (Section 4) and the physical availability of surface and groundwater, as well as water quality constraints (Section 5).

- To address the second question, historical and current water demand in the region was evaluated, and projected population and economic growth were analyzed. Based on the results, projections of future water demand were developed and are presented herein (Section 6). A discussion of the ability of the supply to meet demand and the water budget of the region is included in Section 7.

- Water planning questions 3 and 4 are addressed in Section 8, Water Plan Alternatives.

- Water planning question 5, the plan for implementation of alternatives, is also included in Section 8.

During the first year of the recent water planning effort, the steering committee identified drought planning and agriculture water conservation as key water planning issues. Consequently, additional effort was directed at these alternatives, resulting in a drought plan and an agriculture conservation plan that are considerably more detailed than the feasibility analysis completed for the other alternatives. The completed drought plan and agricultural conservation plan are included as appendices to this document.

Section 2

Public Participation

2. Public Participation

The Colfax County regional water planning process has used a broad-based, grass-roots approach to regional water planning. All phases of regional water planning have been conducted to maximize public participation, and all public involvement activities have been carefully documented to capture the full range of views expressed.

At the outset of the planning efforts, a Public Involvement Plan was developed to outline the approaches to be used to maximize public involvement during the Colfax County regional water planning process. The plan addressed the following issues:

- Formation of steering committee
- Public meetings
- Focus groups
- Communication with the public
- Documentation of public participation

Activities undertaken to implement this plan are described in Sections 2.1 and 2.2.

2.1 Public Involvement in the Planning Process

Involvement of all key stakeholders is a critical objective for successful regional water planning, and a concentrated effort was made to involve local stakeholders from the beginning of the planning effort. Hence, the first step in the Colfax regional water planning efforts was to hold a public meeting for the purpose of establishing a steering committee comprised of local stakeholders that would guide the planning efforts. That initial stakeholder meeting was publicly advertised and held in Raton on May 9, 2000, with approximately 30 people in attendance. During the meeting, the attendees went through the following steps to begin forming the steering committee. First, the group identified the interests requiring representation. The group next named some of the organizations that could represent those various interests. Following the development of the list, the group then prioritized the interests, with the intent of having the majority of the participants be from the private sector rather than in the public sector.

Based on this prioritized list, the following members were selected, either at that initial stakeholder meeting or at the first steering committee meeting on August 8, 2000:

- James Marchetti, Colfax County Commission
- Dan Campbell, Raton Water Works
- Edith Clarke, Miami Domestic Water Users and Miami Water Users
- Bill Sauble, rancher
- Linda Libby, Village of Angel Fire
- Mary Lou Kern, Colfax Soil & Water Conservation District
- Julia Stafford, C S Cattle Company
- Ralph Schubert, rancher and developer
- Sam Montoya, Pittsburg & Midway Coal Company
- Leslie Skinner Fernandez, conservationist/recreationist
- Bob Ricklefs, Philmont Scout Ranch
- Jim Hollis, Cimarron Water Master, Office of the State Engineer
- Jan Dye, New Mexico Environment Department
- Gretchen Sammis, Colfax Soil & Water Conservation District
- Charlie Walker, Natural Resource Conservation Service
- Jim Baker, Vermejo Park Ranch
- Lino Paiz, Village of Cimarron
- Maggie Trujillo, rancher
- Laura Danielson, Village of Springer

In addition to these primary steering committee members, each member appointed an alternate to fill in for them should they be unable to attend a meeting. A few of the original steering committee members have left their positions or have otherwise not chosen to continue their involvement. However, most of the original steering committee, or substitute members from their organizations, have remained involved.

This steering committee has been the core entity leading the water planning process in the Colfax County region, guiding the overall planning process and providing input on the public involvement process. Since its formation in August 2000, the committee has met quarterly in

Raton, with the last meeting held on November 14, 2002. The steering committee's strategy to maximize public involvement is discussed in Section 2.2.

All activities pertaining to public participation have been documented, including notices of meetings, meeting notes from steering committee and public meetings, meeting sign-in sheets, and comment forms turned in at public meetings. Copies of meeting notes and notices are provided in Appendices C1 and C2.

2.2 Strategy to Maximize Public Involvement

Each quarterly steering committee has been facilitated to ensure that it was participatory and inclusive. Notice of the steering committee meetings was given prior to the meeting dates, and meetings were open to the public. To encourage meaningful public involvement, it was determined at the first meeting of the steering committee that members of the public would be permitted to participate at any time during committee meetings. This policy was to be reassessed if it became unworkable; however, that was never felt to be necessary. The steering committee meetings have generally been well attended, with 20 to 30 people typically present.

In addition to the steering committee meetings, a series of public meetings were conducted to encourage full participation by the public. These public meetings were held in three locations throughout the planning area and were scheduled at 7 p.m. on a weeknight chosen to avoid local sporting events or other conflicts. Two rounds of public meetings were held: one in January 2001 and one in August 2002. These meetings are summarized in Section 2.2.1.

The steering committee also identified four stakeholder groups to involve in more detailed discussion as part of the regional water planning effort. These focus groups are discussed in Section 2.2.2.

2.2.1 Public Meetings

The January 2001 public meetings were held in Angel Fire, Raton, and Springer on January 23, 24, and 25, 2001, respectively. The meetings had been advertised as described in Section 2.2.3. Meetings began at 7:00 p.m. and ended no later than 9:00 p.m. There were 12 attendees at Angel Fire, 18 at Raton, and 21 at Springer.

Joanne Hilton of DBS&A and Bruce Poster of Southwest Planning & Marketing led the meetings and involved the audiences in discussions of regional water planning. Following a presentation that described the purpose of regional water planning and the process being used in Colfax County, the audience shared its vision for the region and suggested goals for regional water planning. An initial list of alternatives for meeting future water demand was presented, and the public was given an opportunity to add to or revise the list. Ms. Hilton and Mr. Poster then presented information on regional water supply and regional water demand and solicited suggestions for strategies to be incorporated into the plan.

A second round of public meetings were held on August 26, 27, and 28, 2002 in Raton, Springer, and Angel Fire, respectively, again beginning at 7:00 p.m. and ending no later than 9:00 p.m. The meetings had been advertised as described in Section 2.2.3. There were 8 attendees at Raton, 11 at Springer, and 6 at Angel Fire

Ms. Hilton and Mr. Poster described the purpose of regional water planning, the process being used in Colfax County, findings on regional water supply and regional water demand, and the results of an analysis of alternatives for meeting future water demand. In addition, a presentation on agricultural water conservation was provided at the Springer meeting.

After the presentation, the audience had an opportunity to respond to each of the following questions:

- Do you have any questions about the alternatives?
- Have we left out any alternatives that should be included in the plan?
- Do any of the proposed alternatives have important social or environmental impacts?
- Are any of the proposed alternatives politically unacceptable?

In addition to providing verbal input, meeting participants as well as other members of the community had the opportunity to provide written comments on forms provided to the public prior to and during all public meetings.

2.2.2 Focus Groups

Based on suggestions from steering committee members on when and where to meet, the following four focus groups were convened:

- Recreation/tourism industry: October 23, 2001, 1:00 to 3:00 p.m., Cimarron City Hall
- Local officials: October 23, 4:00 to 6:00 p.m., Cimarron City Hall
- Businesses: October 24, 2:00 to 4:00 p.m., Raton Post Office
- Agriculture/livestock industry: October 24, 6:00 to 8:00 p.m., Springer City Hall

Committee members also offered advice on whom to invite, and local governments, chambers of commerce, and farm and livestock groups assisted in developing lists of potential participants. Each potential participant was personally contacted, and followup reminder calls were made to confirmed participants. Attendance ranged from a low of 2 at the business group to 6 at the recreation/tourism group, 8 (representing three cities and the county) at the local officials group, and 11 at the agriculture/livestock group.

Each focus group began with a statement of the purpose of the group and introductions. Joanne Hilton and Bruce Poster discussed information on regional water planning and the Colfax County effort to date. A number of handouts were provided, including materials on regional vision and goals, the process for selecting alternatives, and the preliminary list of alternatives to be evaluated. The bulk of each meeting was spent obtaining feedback about which alternatives were of the greatest interest and feasibility. At the ends of the meetings, participants were informed about opportunities for staying involved in the regional water planning process.

A second meeting of the local officials group was held at the end of the planning process, on November 14, 2002, at the Raton post office. Joanne Hilton and Bruce Poster provided an update of the Colfax County effort and presented the *Draft Regional Water Plan*. Copies of the draft plan were distributed, and the officials were asked to take the plan back to the next meeting of their governing bodies for acceptance, prior to the plan's being submitted to the Interstate Stream Commission.

2.2.3 Communication with the Public

A mailing list of steering committee members and other stakeholders in the planning region has been maintained throughout the water planning efforts. The initial stakeholder list included the attendees at the May 2000 public meeting and the individuals identified as potential steering committee members. Thereafter the list has been updated after every meeting to include everyone who has signed in at a steering committee or public meeting. This ever-evolving list has been used to notify the entire stakeholder group of each steering committee and public meeting and of documents that are available for review.

In addition to mailing notices of steering committee and public meetings to everyone on the extensive stakeholder list, press releases announcing the public meetings were issued to newspapers (*Raton Range, Sangre de Cristo Chronicle, Springer Tribune, Journal North*) and to KRTN radio in Raton. Calendar listings were placed in the newspapers to announce both public meetings and steering committee meetings, and display advertisements were placed in newspapers for the public meetings. In addition, notices were posted at post offices and stores in several of the communities (e.g., Cimarron, Miami, Maxwell, Eagle Nest) and distributed by the County Extension Agent at the County Fair. Notifications were also sent to members of the Raton and Angel Fire chambers of commerce. Finally, steering committee members and other stakeholders helped get the word out about public meetings.

A schedule of placements and examples of press releases and advertisements are provided in Appendix C2. Sample materials that were handed out at steering committee and public meetings are provided in Appendix C3.

2.3 Public Welfare

Based on the input from the January meetings, the steering committee developed a regional vision and goals for regional water planning:

- Regional vision
  - Healthy environment
  - Open space protection
  - Quality recreation
  - Natural resource conservation
  - Adequate water availability
  - Respect for private property rights
  - Multiple use cooperation
  - Healthy communities
  - Healthy regional economy

- Goals for regional water planning
  - Cooperation
  - Optimize natural occurrence
  - Protect water rights
  - Locally planned growth
  - Conserve and recycle
  - Provide accurate data
  - Healthy resource management
  - Enact necessary legislation
  - Educate the public

Additional detail on this vision and the goals of the region is provided in Appendix C1.

At the May 2002 steering committee meeting, the group approved the following public welfare statement: "Public welfare in Colfax County includes the regional vision and goals as expressed in the Regional Water Plan and other local ordinances, regulations, and policies to protect water resources."

Section 3

Background

3. Background

This section provides a general overview of the characteristics of the Colfax planning region. Additional detail on the climate, water resources, and demographics of the region is provided in Sections 5 and 6. Maps illustrating the land use and general features of the region were prepared by the New Mexico Water Resources Research Institute and are provided in Appendix B.

3.1 General Description of the Planning Region

Colfax County is located in northern New Mexico between Taos and Union Counties and just south of the Colorado border (Figure 1-1). The total area of Colfax County is approximately 3,800 square miles. Elevations range from over 12,000 feet above mean sea level (msl) in the mountainous western part of the county to about 5,000 feet in the eastern plains areas. Piedmont plains, high plateaus, and mesas are common geomorphic features in areas of the county (Appendix B, Figure B-1).

The county includes parts of two major physiographic provinces:

- The westernmost portion of the county encompasses part of the Southern Rocky Mountains Province, including the Cimarron Range and the eastern slopes of the Taos Range within the Sangre de Cristo Mountains. This province is characterized by high mountain areas with elevations ranging from 7,000 to more than 12,000 feet msl.

- The remainder of the county falls within the Raton Section of the Great Plains Province. This area is characterized by pediments, plains, and high plateaus dissected by the Canadian, Vermejo, and Cimarron River systems, with surface elevations ranging from 5,500 to 7,000 feet msl. This topography is punctuated by volcanic cindercones and mantled by basalt flows in parts of the northeast and eastern portions of the county.

Vegetation in the county is greatly influenced by the elevation differences and ranges from the spruce, fir, pine, and aspen forests of the mountains through a transition of open piñon-juniper to the grasslands of the plains. Mountain grasslands exist in the Moreno Valley surrounding Eagle Nest Lake. Natural resources in the area include coal and methane gas.

3.1.1 Climate

The varied terrain of Colfax County, which ranges from the Rocky Mountains to the High Plains, results in significant climate variations. For example, temperatures range from lows that are well below 0 degrees Fahrenheit (°F) in the mountains to highs in excess of 100°F in the plains.

The average temperature in Colfax County for 1950 through 1999 was fairly consistent, ranging between about 40 and 50°F. Average temperatures increased slightly over the period of record, mostly due to rising minimum temperatures.

Precipitation also varies across the county, influenced by location and somewhat by elevation. Weather systems may enter the county from the west (Pacific), northeast (Arctic air masses from the plains), and southwest (Gulf of Mexico), and systems from each point of origin bring unique sets of temperatures and moisture to the county. Average precipitation, including both snowmelt and rainfall, ranges from about 14 to 24 inches.

3.1.2 Major Surface and Groundwater Sources

Colfax County lies almost entirely within the Canadian River Basin, which is part of the larger Arkansas-White-Red River Basin. Surface water, which supplies more than 95 percent of the water currently used in Colfax County, originates primarily in the mountains in the western and northern parts of the county and flows generally east and south to the Canadian River, through which it flows out of the county (Figure 3-1). East of the Canadian River, slopes are relatively gentle, as altitudes in the eastern plains are generally less than 7,000 feet. The eastern plains area includes high mesas of the Raton Mesa Group along the north edge of the Canadian River. West of the river lie the Southern Rocky Mountains, and slopes in this area are very steep (Herkenhoff and Summers, 1977). Surface water availability varies greatly from year to year, depending on the amount of precipitation in the region. Section 5.1 further describes surface water sources in the planning region.

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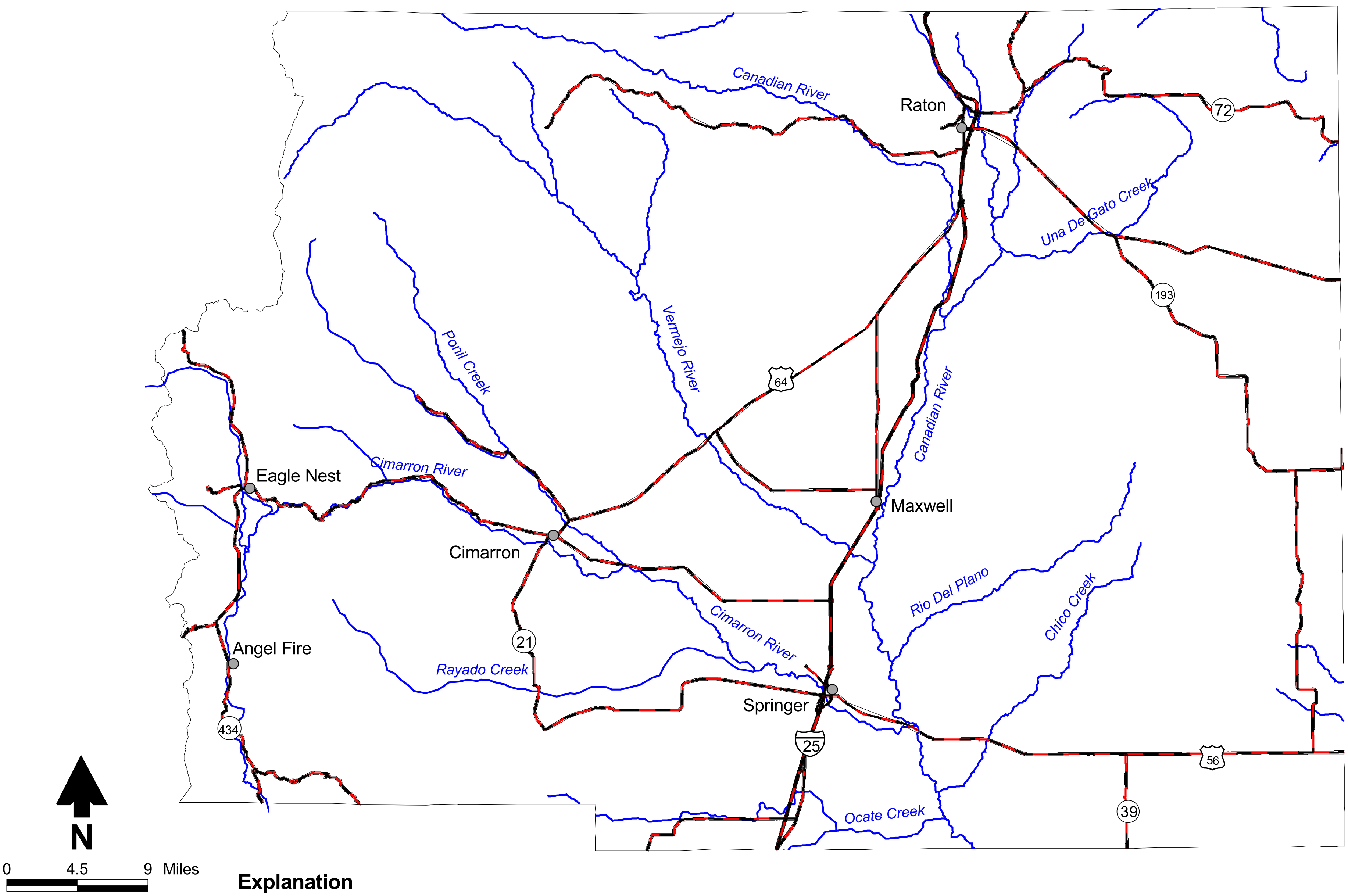

COLFAX REGIONAL WATER PLAN

Major Surface Drainages in Colfax Planning Region

Figure 3-1

Daniel B. Stephens & Associates, Inc.

11-6-02 11:30AM

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The occurrence of groundwater in Colfax County is controlled by the varying hydrogeologic conditions of the two physiographic provinces: the Southern Rocky Mountains Province and the Raton Section of the Great Plains Province. Hydrogeologic conditions are also dependent upon localized geologic structures, stratigraphy, and geologic formation lithologies, which are described more fully in Section 5.2. Development of groundwater resources in Colfax County has been minimal to date and has focused primarily in the Moreno Valley area around Angel Fire. Geologic formations with the best potential for groundwater resource development include:

- Alluvial deposits
- Tertiary-age Ogallala Formation
- Cretaceous-age Dakota Sandstone Formation
- Mesozoic and Paleozoic sandstones and siltstones of the Moreno Valley (main source of water for Angel Fire)
- Intermixed alluvial and volcanic deposits of the Capulin Basin

3.1.3 Demographics, Economic Situation and Land Use

The county includes six incorporated areas: Raton, Springer, Cimarron, Maxwell, Eagle Nest, and Angel Fire. Raton is the largest municipality, with a population of approximately 7,700; Springer and Cimarron, the second and third largest towns, have populations of approximately 1,300 and 800, respectively. The total population of Colfax County has fluctuated between 12,000 and 14,000 over the last 40 years and is currently about 14,000 (New Mexico EDD, 2002). However, sizeable seasonal population fluctuations (at times totaling many times the resident population) occur throughout the year due to tourism in the Angel Fire-Eagle Nest area as well as at the Philmont Boy Scout Ranch, the National Rifle Association (NRA) Whittington Center, and two state parks (Sugarite Canyon and Cimarron Canyon).

Most of the land in the county is privately owned (Appendix B, Figure B-2). Tourism and coal mining have been the primary industries; however, the coal mines in the county are in the process of closing. Significant livestock grazing and agriculture take place in the eastern part of the county (Appendix B, Figure B-3). More than 2 million acres of land is held by 208 farms, most of which produce cattle as their major commodity (New Mexico EDD, 2002).

Although agriculture is a significant industry in Colfax County, the number of people employed is small relative to other industries in the county. The largest employment category in the county is state, local, or federal government, which employs more than 1,500 county residents. The hotel and food service industry employs the second largest group of workers, followed by retail trade, other services, health and social services, construction, manufacturing, and mining (New Mexico EDD, 2002). The mining industry has the highest average weekly wage followed by wholesale trade, while hotel and food service employees are among the lowest paid. In 2000, the average per capita income was $19,638 and there were 501 established businesses with more than $115,500,000 in gross receipts from retail trade (New Mexico EDD, 2002).

These statistics will change with the closing of the York Canyon mine, which is currently in progress. Although it is possible that the mine could reopen at some future date, this closing will result in the loss of 126 high-paying jobs in the near future.

3.2 Overview of Historical Water Use in the Region

Based on OSE water use categories, irrigated agriculture has historically been and continues to be by far the largest water use in Colfax County, accounting for around 80 percent of total withdrawals in 1995 and 2000. The second largest water use is reservoir evaporation, which was 12 percent of total withdrawals in 1995 and 2000. The remaining uses of water in the county are public and domestic water supply (around 3 percent of total withdrawals) and livestock, mining, and commercial applications (a combined 1 to 2 percent of withdrawals). A comparison of water use records for 1975 and 2000 shows little overall change in the proportionate uses of water in the Colfax County area (Sorensen, 1977; Wilson, 2002); however, the overall amount of water withdrawn in the county decreased by approximately 10,000 acre-feet, from around 70,000 acre-feet in 1975 to approximately 60,000 acre-feet in 2000. Section 6 provides a more in-depth discussion of historical and current water use and demand.

Section 4

Legal and
Water Rights Issues

4. Legal and Water Rights Issues Related to Colfax County Regional Water Planning

In addition to hydrologic constraints, legal issues may also limit the use of the existing and future water supplies. For planning purposes, and particularly as regional water planners identify alternatives for meeting future demand, legal issues will determine in part which alternatives may be feasible. This section identifies potential legal issues, including those raised by members of the steering committee. Each legal issue is defined and evaluated as to its relation to regional water planning and its potential to affect future water supplies.

4.1 Relevant Water Laws

New Mexico water laws affecting Colfax County are found in the New Mexico Constitution, New Mexico Statutes Annotated (NMSA), and the case law interpreting and applying the existing law. Additional legal constraints include OSE regulations governing groundwater and surface water as well as OSE policy for administering various groundwater basins throughout the state. Background information regarding New Mexico water law is provided in Appendix D1; the particular relevance of these laws and regulations to Colfax County is discussed in Sections 4.2.

Federal laws potentially affecting water management in Colfax County include the Clean Water Act, Safe Drinking Water Act, and the Endangered Species Act. As decision-makers pursue individual alternatives and projects, other types of state and federal laws must be reviewed to identify project-specific legal issues. The relevance of these laws in Colfax County is discussed in Sections 4.2 and 4.3.

4.2 Federal and State Legal Issues

Federal and state legal and water rights issues raise no obstacles to pursuing the objectives of the *Colfax County Regional Water Plan.* Legal issues relating to water resource management in Colfax County are discussed in Sections 4.2.1 through 4.2.3.

4.2.1 Federal Endangered Species Act: Arkansas Shiner in the Canadian River

There is concern that the federal Endangered Species Act may be invoked in the planning region with regard to a threatened species called the Arkansas River shiner (ARS), as the Fish and Wildlife Service (FWS) has identified the Canadian River as the habitat for the ARS. The habitat of concern, however, is located downstream of Colfax County. Additionally, in its 1998 federal register notice listing the species as threatened, the FWS stated that "aggregations of Arkansas River shiners in the reach between Ute Reservoir and Lake Meredith are stable and not declining." The notice states that construction of the Conchas Reservoir in 1938 ultimately led to the extirpation of upstream population (Vol. 63, Fed. Reg. 64791).

Since the ARS no longer inhabits the portions of the Canadian River and upstream tributaries found in Colfax County, the listing of this species should have no impact on water use in the county. Additionally, since the populations in New Mexico below Ute Reservoir appear to be stable, it is unlikely that changes to the flow regime of the Canadian River in New Mexico will be necessary to accommodate this species. If the species population below Ute Reservoir begins to decline, the FWS might require changes in the timing and quantities of releases from the reservoir; however, such changes would have little or no effect on water management in Colfax County.

During the 40-year planning horizon, it is possible that additional species could be listed. Colfax County managers should continue to monitor endangered and threatened species lists for potential impacts to the county.

4.2.2 Canadian River Compact

The Canadian River Compact has three state signatories: New Mexico, Oklahoma, and Texas. The Compact governs apportionment of the Canadian River as it flows from its headwaters along the Colorado/New Mexico border, through New Mexico and Texas, and finally to Oklahoma where the river empties into the Arkansas River. Of interest to Colfax County is Article IV(a) of the Compact, which states that New Mexico shall have "free and unrestricted use of all waters originating in the drainage basin of the Canadian River above Conchas Dam"

(NMSA 75-15-2). As Colfax County is located entirely above Conchas Dam, use of the Canadian River in the county is “free and unrestricted.” Water management and planning decisions in Colfax County should therefore raise no issues under the Canadian River Compact.

4.2.3 Methane Gas Extraction

Members of the steering committee have expressed concern regarding methane gas extraction in the region and its potential impact on the water supply. Although the activity may not directly impact water supply nor represent a legal issue per se, it has the potential to impact the amount of groundwater supplies and therefore is addressed as part of the regional water planning process.

In Colfax County and across the border in Colorado, methane gas well development has increased in recent years. Approximately 350 methane gas extraction wells are located in Colfax County, and another 50 to 100 are planned each year for the next four years (personal communication with Roy Johnson, Oil Conservation Division, November 2002).

The water-related issue in methane gas production is that it requires the dewatering of coal deposits, thereby removing from groundwater storage large quantities of groundwater of variable quality. Quantities of water extracted depend on factors such as the specific coal seam and the length of time the well has been in operation. One figure given for the amount of water the dewatering process produces in Colfax County is roughly 50 to 100 barrels (1 barrel = 42 gallons) of water per day per well (personal communication with Roy Johnson, Oil Conservation Division, November 2002). The extracted water is generally located at a depth of approximately 2,000 feet and is reinjected as wastewater at depths of 6,000 to 7,000 feet, where the water quality is naturally quite poor. If extracted water is beneficially used and not reinjected, a water right permit is required and no impairment of existing rights can occur (NMSA 72-12A 1-13).

While the water produced from the coal dewatering process typically has approximately 2,000 to 3,000 mg/L total dissolved solids, in some places the water quality of the produced water is good, with total dissolved solids concentrations of 50 to 250 mg/L. However, the presence of this high-quality water usually correlates with pump tests indicating that the coal cannot be economically dewatered, and producers therefore do not develop operations in those areas. The water quality data that have been collected from the exploratory wells in Colfax County (personal communication with Roy Johnson, Oil Conservation Division, February 19, 2001) could be useful in identifying potential locations to develop further water supplies if necessary.

Another water-related issue raised by coal bed methane extraction is the potential for migration of methane into water supply wells. Presumably, the dewatering operations at depths of 2,500 feet do not impact shallow wells used to supply irrigation, municipal, and domestic needs. However, because methane gas extraction results in the production and reinjection of large amounts of groundwater, water managers should continue to monitor this issue.

4.3 Water Quality Standards

Federal and state laws can place constraints on water supply availability by requiring that water quality meet specific standards. When water quality does not meet these standards, water managers may be required to curtail certain activities or implement measures to improve the water quality. For example, the federal Clean Water Act and New Mexico surface water quality standards passed under that Act require permits for any discharges to "waters of the United States." These permits are based on water quality requirements and can place limitations on discharges to surface water. Additionally, the Act requires that water quality in streams and lakes also meet state standards. States are required to report water quality to the U.S. Environmental Protection Agency (EPA) and conduct total maximum daily load (TMDL) activities for surface waters not meeting standards (Section 5.3.3). As a result of a TMDL, discharge permit limitations can be made stricter, and efforts to improve the watershed are usually implemented.

State law controls discharges to groundwater through the New Mexico Water Quality Act. One goal of the Act is to prevent discharges to groundwater that would impair water quality. The NMED requires groundwater discharge plans for almost all types of activities that can impact groundwater quality.

The Safe Drinking Water Act sets the standards for water that is used as a drinking water supply. It also creates programs, such as wellhead protection and sole source aquifer designation, to protect drinking water aquifers. Water quality issues, including TMDL requirements, in the Colfax Region are discussed in more detail in Section 5.3.

4.4 Water Rights Administration and Relevant Lawsuits in Colfax County

Assessment of the available water supply includes not only determining what groundwater and surface water resources exist in the planning area, but also ascertaining how much of that water has been appropriated to other users, making it unavailable for use by the planning region. This section discusses the various specific water rights that exist in the Colfax County planning area.

As discussed in Section 5.2, the OSE has the authority to delineate groundwater basins that require a permit for groundwater withdrawals, referred to as “declared underground water basins.” In order to withdraw water from these declared basins, a user must have applied water to beneficial use prior to the basin declaration, thus creating a prebasin water right, or the user must obtain a water permit from the OSE that specifies (1) how much water a user can withdraw within any given year, (2) the location and type of well that will be used to withdraw the water, and (3) the use to which the water will be put. Diversion of water from New Mexico’s surface waters also requires obtaining a water right from the OSE. Surface water appropriations follow the same standards as groundwater rights. Basic issues regarding water law in New Mexico, including the system of water appropriations or water rights and methods of obtaining water rights, are discussed in Appendix D1.

4.4.1 Surface Water Adjudications and Administration

A water rights adjudication is a lawsuit that determines the right to use the waters of any stream system (NMSA 72-4-17). New Mexico courts have interpreted the intent of the legislature in creating this provision by stating "it was evident design of the legislature by this act to have adjudicated and settled by judicial decree, all water rights in state and to have determined the amount of water to which each water user was entitled so that the distribution of water could be facilitated and unappropriated water be determined in order that it might be utilized” *(Snow v.*

Abalos, 18 NM 681, 1914). Adjudications are beneficial for regional water planning because they clearly establish the priority dates, water duty (the amount of water allowed to be diverted for each acre of land irrigated), and amounts of water rights available in the planning area.

Many stream systems in New Mexico have not yet been completely adjudicated, and in some cases, adjudications begun over 30 years ago are still underway. In Colfax County, however, most of the major streams have been adjudicated, which means that stream-related water rights in the region have been finalized and decreed. Generally, an adjudicated stream is considered “fully appropriated,” which means that no new water rights are available and water from that stream can only be obtained through purchase or lease from a current water rights holder.

This principle was demonstrated in 1982, when an application to appropriate 10,500 acre-feet of water in the Rayado River stream system was denied by the State Engineer. In issuing an opinion to the applicant, the State Engineer stated there is no "unappropriated water on the Rayado River" (NM SEO, 1982).

Streams that are not yet adjudicated can also be considered fully appropriated. For example, in the October 15, 1990 report by the Special Master in *Oklahoma v. New Mexico,* the Special Master found that “all the waters in the Canadian River drainage basin in New Mexico above Conchas Dam had been appropriated and developed by works constructed or authorized for construction as of 1950” (Muys, 1990, p. 61). Thus even though the Canadian River in Colfax County has not been adjudicated, it is considered fully appropriated.

The adjudications regarding streams in Colfax County are discussed in Sections 4.1.1.1 through 4.1.1.5. The discussions in these sections focus on the total amount of water rights granted and any other specific criteria related to those water rights.

These decrees were issued prior to the 1940s, and many of those water rights have since been transferred. The water master for the Cimarron and Rayado systems has kept a detailed account of water transfers, which has allowed for an accurate description of the water rights as currently held, and those owners are specified in the discussion of those streams. Other systems do not have a water master, and therefore no comprehensive record of transfers within each system has been maintained. The rather extensive research needed to track the changes in ownership of each water right originally adjudicated is beyond the scope of this project, and owners in those systems are thus not specified in the following discussions. Since the water rights have not been examined individually for changes in ownership, forfeiture, or abandonment, the total number of water rights listed per decree does not necessarily reflect the current number of valid water rights and is subject to some margin of error.

4.4.1.1 Cimarron Decree

The decree adjudicating the Cimarron stream system (Decree No. 5054) was issued on December 20, 1929. The Court relinquished jurisdiction over the management of the rights adjudicated under the decree to the OSE on June 1, 1932. This Order and Decree No. 5054 covers all claims on the Cimarron River and the Cimarroncito and Ponil Creeks. The duty of water under the decree is 1.5 acre-feet per acre of irrigated land and 1.0 acre-feet per acre of irrigated pasture. The total number of water rights adjudicated under the decree was approximately 40,000 acre-feet.

The individual water rights on the Cimarron River, Rayado, Cimarroncito and Ponil Creeks and tributaries, and Eagle Nest Reservoir, based on information provided by Jim Hollis, the Cimarron-Rayado Water Master, are shown on Plate 1 and Table D2-1 (Appendix D2). The permits and ownership information for the rights identified on the plate have not been compared to the paper files held in the OSE water rights files and may change periodically as transactions occur. However, this schematic provides an overview of the existing water rights and priorities in the Canadian River Basin, which will help in evaluating various options for meeting future demand in that area.

The water rights in Eagle Nest Reservoir are outlined and defined in License 71, commonly know as Permit 71, which was obtained by the C S Cattle Company when the Eagle Nest Reservoir was built. All rights in the reservoir are governed by that permit and have a priority date of 1907. Until early 2002, the C S Cattle Company still retained the permit, but had contracted water rights to numerous entities (Table 4-1). At that time, however, the State of New Mexico, through the Department of Game and Fish, purchased Eagle Nest Lake and Permit 71. Ownership of the contracted water rights did not change as a result of the sale. The

State of New Mexico has not issued a policy regarding agency administration, contract management, and issuance of future contracts under Permit 71.

Permit 71 allows for one-time bulk sales when water is available and for three categories of water contracts: first tier, second tier, and storage contracts:

- First tier contracts have no termination date, are limited to the acre-feet defined in the contract, and have the priority date of June 12, 1907. The acre-feet in those contracts must be delivered to the land, which means that the Permit 71 holder (formerly C S Cattle Company, currently the State of New Mexico) is responsible for conveyance losses and evaporation. First tier contract holders can agree to be subject to the Eagle Nest regulations (Eagle Nest Corporation, 1991), in which case they may retain carryover storage for unused water rights from one year's allotment. If they do not agree to adopt the regulations, their contracts have no carryover storage; that is, if the allotted number of acre-feet are not fully used in one year, they cannot be carried over and retained in the reservoir for the next year, nor can they get credit for that water. The existing first tier contracts and maximum contract amounts (in acre-feet) are listed in Table 4-1.

- Second tier contracts are junior to first tier contracts with a priority date as of the signing of the individual contract (Table 4-1). These contracts are subject to the Eagle Nest Reservoir regulations (Eagle Nest Corporation, 1991). Carryover of unused water is allowed, and deliveries are measured at the reservoir outlet rather than on the land. Therefore, these contracts are subject to conveyance losses.

- Storage contracts are express contractual rights and are only available if a water rights contract explicitly provides for this type of right (Eagle Nest Corporation, 1991). A storage right allows the contract holder to store certain quantities of water in Eagle Nest Lake for contractually determined amounts of time. Without express storage rights, contract users are required to beneficially use all the water allocated to them in a single year or lose claim to that water (Eagle Nest Corporation, 1991). In the case of specific contract users who have not adopted the Eagle Nest regulations, the terms and

Table 4-1. Permit 71 Water Contract Users

Water Right/Storage Holder	Diversion	Tier 1st	Tier 2nd	Amount (ac-ft/yr)	Priority Date	Other Provisions
Annual Water Contracts						
C S Cattle Company	---	X		1,115	1907	• Delivery points are specified by individual contracts. • Carriage losses to the delivery point is borne by the Holder of Permit 71. • All proportionally share drought shortages. • Annual duty is 1.5 ac-ft/acre. • The 1991 Eagle Nest Corporation Regulations do not apply, unless specifically adopted by the 1st tier user.
Village of Angel Fire [a]	---	X		250		
Pittsburg & Midway Coal Mining	---	X		50		
Vermejo Park, LLC	---	X		85		
Vermejo Park, LLC	---	X		1,000		
City of Raton	---	X		3,612		
UU Bar Ranch	---	X		266		
David and Judy Hughes	---	X		1,000		
Hanson-Trujillo (Solvangen Farms)	---	X		1,047		
Philmont Scout Ranch	---	X		1,000		
Swope Land and Livestock Co.	---	X		314		
Town of Springer	---	X		300		
Total 1st Tier Contracts				10,039		
City of Raton	---		X	50	04/15/83 [b]	• Delivery point is at Eagle Nest Reservoir • Carriage loss is borne by the 2nd tier contract holder • Annual duty is 1.5 ac-ft/acre. • Annual allocation not received unless the 1st tier contracts receive 100% • Contracts are subject to the Regulations
Agua Fria Enterprises, Inc.	---		X	250	06/01/84 [b]	
PICS Investment Company	---		X	15	02/15/85 [b]	
Robert S. Gordon [c]	---		X	2	06/21/85 [b]	
Valley Mix, Ltd. [d]	---		X	3	09/20/85 [b]	
Village of Angel Fire	---		X	25	01/02/94 [b]	
Village of Eagle Nest	---		X	30	02/01/95 [b]	
Agua Fria Enterprises, Inc.	---		X	750	09/01/99 [b]	
Total 2nd Tier Contracts				1,125		
Water storage contracts						
City of Raton	Direct	X		15,000	---	• Stored water is the separate property of the storage contract holder. • Stored water is subject to annual evaporation losses. • Storage contract holders fill their available space with portions of their annual Permit 71 allocations that they elect to store for future use. • Delivery of stored water is made at the request of the storage contract owner.
Town of Springer	Direct	X		1,000	---	
Village of Angel Fire [a]	Direct/ well/lake	X		750	---	
Robert S. Gordon, MD [c]	Well		X	6	---	
Agua Fria Enterprises, Inc.	Lake/ direct		X	1,500	---	
PICS Investment Company	Well		X	45	---	
Valley Mix, Ltd. [d]	Well		X	9	---	
Agua Fria Enterprises, Inc.	Lake/ direct		X	3,750	---	
Village of Eagle Nest	Well		X	30	---	
Total reservoir water storage space owned				22,090		

--- = Not applicable

[a] Under contract
[b] Permit 71 internal priority (established by the date of each contract)
[c] To Village of Angel Fire
[d] To David Bagley

conditions for storage rights are identified in the existing contract documents (personal communication with Julia Davis Stafford, C S Cattle Company, October 2002). Stored waters are subject to a yearly evaporation loss.

The majority of towns in Colfax County have first and second tier and storage contracts. Reservoir storage of municipal water supplies provides for improved planning and a safety factor for times of shortage.

4.4.1.2 The Rayado Decree

The rights to use the waters within the Rayado system were set out in Decree No. 4482, dated July 1925). The total number of water rights in the decree as described in a 1935 hydrographic survey was 12,169.5 acre feet (Bliss, 1935). The State Engineer created the Rayado Water District on April 15, 1940. The Rayado system is managed by the same water master as the Cimarron system.

The Rayado decree contains a number of provisional water rights conditioned upon the construction of irrigation works. A hydrographic survey conducted in 1935 updates the decree, either documenting the construction of irrigation works or canceling the provisional applications where irrigation works had not been constructed. The current water rights in the Rayado system are schematically depicted on Plate 2.

4.4.1.3 Dry Cimarron Decree

The Dry Cimarron and its tributaries were adjudicated in 1933 when the final decree was issued (No. 5902, February 16, 1933). The purpose of the decree was “to determine the rights of the respective claimants to divert, impound and beneficially use the waters to the Dry Cimarron River and its tributaries.” The decree sets forth a duty of water equal to 1.5 acre-feet per acre of land. Most of the water rights on the Dry Cimarron are in Union County; only 778 acre-feet of the rights fall in Colfax County.

The decree discusses 69 separate water rights and includes special provisions describing the agreement among the parties regarding the management of diversions along the ditches where the rights are taken (McCuistion, Juehn, Wiggins, Rutledge, Gripe, and Behimer ditches). The decree allows for livestock watering off the majority of the ditches.

4.4.1.4 Sugarite/Chico Rico Decree

Decree No. 4605 was entered September 25, 1935 in the District Court of Colfax County. More than 40,000 acre-feet per year of water rights were adjudicated in this decree, almost all of which were for irrigation purposes, with some reservoir storage and stock watering rights. The water rights finalized in the decree lie wholly within Colfax County.

As with the previous adjudication decrees, the court fixed the water duty at 1.5 acre-feet per acre of irrigated land. In accordance with New Mexico water law (Appendix D1), the decree states that the water rights adjudicated in the decree are subject to prior appropriation and beneficial use.

The significant (more than 1000 acre-feet) water rights holders under this decree are:

- City of Raton
- Cherokee & Pittsburg Coal and Mining Company
- Maxwell Ditch and Reservoir Company
- John F. Vail
- Santa Fe National Company
- Town of Springer
- Brannin
- T.O. Ranch Company

4.4.1.5 The Vermejo Decree

The final decree of the Vermejo adjudication (Decree No. 7201) was entered November 21, 1941. The decree sets a 1.5-acre-foot duty of water for the majority of the water rights holders; however, some individuals have a 2.0-acre-foot water duty. As with the other decrees, it recognizes the prior appropriation system of senior and junior rights and allows for domestic and stock watering rights from the Vermejo River. The majority of the water rights lie within what is now the Vermejo Conservancy District. The total number of water rights recognized was approximately 27,000 acre feet.

4.4.2 Groundwater Administration

There are two declared groundwater basins in Colfax County: the Canadian underground water basin, which includes parts of Mora County, and a small part of the Tucumcari Basin. Because the Canadian Basin consists mostly of stream-related groundwater, it is subject to limitations on appropriation. Generally, the OSE considers surface waters in the State of New Mexico to be fully appropriated and no new appropriations are allowed. In the case of stream related groundwater resources, a groundwater appropriation is not allowed unless surface water rights are purchased to offset the effects to streams from groundwater pumping (personal communication with OSE staff, 2001). In limited, emergency situations, the OSE rules and regulations allow for minimal appropriations. Section 1-15.6.4 states that “applications to appropriate water will not be granted in declared underground water basins that are stream related, if the State Engineer finds that the appropriations will take 0.1 acre-feet or more from a fully-appropriated stream within the year the permit will be exercised” (N.M.A.C. 1-15.6.4, 1995).

The question of groundwater appropriation near the Cimarron system was litigated in the early 1980s when C S Cattle Ranch protested applications to appropriate groundwater submitted by the Village of Angel Fire. This case went to District Court where the judge issued an opinion in favor of C S Cattle Ranch. This case clarifies that groundwater and surface water are interconnected and that no appropriations of groundwater in this area are allowed *(Angel Fire Corp. v. C.S. Cattle Co., 96 N.M. 651, 1981)*.

Groundwater users, other than those with private domestic wells, are listed in Table 4-2. This list was derived from the OSE WATERS database, which did not list amounts for all water rights holders; in addition, the list has not been independently verified. It is therefore possible that additional groundwater rights exist in the planning region.

A potentially significant issue for groundwater administration in Colfax County is the impact of existing domestic wells on senior water right holders. Additionally, septic systems in various

Table 4-2. Water Rights Information for Non-Domestic Wells

File Number	Owner	Type of Use	Amount (acre-feet)	Well File Number / Descriptor
CR 00227	Village of Maxwell	Municipal	235	S-1 through S-13
CR 00440	Village of Angel Fire	Industrial	0	EX-1 through EX-33, S-7 S11 through S-14
CR 00440 A	Angel Fire Service Corporation	Industrial	0	A-EX 34 through A-EX-43 A-S-1 through A-S-10
CR 00441	Ken Smith	Industrial	NA	NA
CR 00888	Dan Dinsmore (Bagely)	Industrial	NA	NA
CR 00899	GFI, Inc.	Commercial	23	EX (exploratory) S (supplemental)
CR 00970	Val Verde Water Association	Municipal	0	NA
CR 01020 B	Religious Order of Spectrum I	Commercial	0	NA
CR 01022	Carolyn Ann Brewer	Municipal	NA	NA
CR 01385	William Press	Irrigation	NA	NA
CR 01727	W.D. Zillweger	Observation	NA	EXP (exploratory)
CR 02153	A.M Chudnow	Municipal	Up to 3	DCL (declaration)
CR 02343	Cross Diamond Partnership	Agriculture	32	NA
CR 02560	South Central Colfax County	Commercial	Up to 3	NA
CR 02595	W.J. Machook	Exploration	Up to 3	NA
CR 02626	Deana Kay Murray	Exploration	Up to 3	NA
CR 02627	Deana Kay Murray	Exploration	Up to 3	NA
CR 02662	Eddie Jeffers	Exploration	Up to 3	NA
CR 02720	William S Gill	Commercial	Up to 3	NA
CR 02773	Ann Martin	Exploration	Up to 3	NA
CR 02920	Dehaven-Todd Ltd. Partnership	Exploration	Up to 3	NA
CR 02923	Troy B. Ford	Exploration	Up to 3	NA
CR 02965	Robert Morrow	Exploration	Up to 3	NA
CR 03826	Vermejo Conservancy District	Exploration	0	NA

Source: OSE WATERS database. (May not be complete. Current status of the water rights listed in this table should be researched in the paper files available at the Office of the State Engineer.)

NA = Information not available

parts of the region, especially the Moreno Valley, present potential sources of contamination for existing domestic water rights and potentially other water rights in the region; water quality issues related to septic systems are discussed in Section 5.3.2.

Domestic well permits are granted automatically by the OSE under NMSA 72-12-1 and thus are not subject either to evaluation of potential impairment or to protest or permit conditions. Applicants simply file a permit with the OSE and are then entitled by statute to use up to 3 ac-ft/yr. The cumulative impact of these wells could potentially impair fulfillment of existing senior water rights, especially in drought years, and due to the lack of a protest mechanism, senior water right holders have no recourse to prevent such impairment. Domestic wells are thus a challenge for the priority administration in the planning region, particularly in areas where a significant number of new homes have been built or are planned, such as Angel Fire and Eagle Nest.

The domestic well problem is common throughout New Mexico, and different strategies have been proposed during various legislative sessions (OSE, 2001). In 2002, the New Mexico legislature gave limited authority to municipalities to manage domestic well permitting (NMSA 3-53-1.1). Under this statute, municipalities can restrict the location of domestic wells, except on property zoned for agriculture, if the property line of the domestic well permit applicant is located within 300 feet of a municipal water distribution line. However, the municipality cannot require the applicant to hook up to the city distribution system if the cost of doing so exceeds the cost of drilling the domestic well.

In the 46th Legislature (2003), domestic well legislation has also been introduced. House Bill 484 and Senate Bill 307 both propose limiting the permit amount to 1 acre-foot rather than the 3 acre-feet currently allowed. Pending the results of the 2003 session and possible administrative changes at the OSE, domestic well expansion will continue to affect groundwater administration in Colfax County.

Municipalities should consider drafting ordinances under the new statutory authority to manage the location of domestic wells. The steering committee has also recommended that Colfax

County consider developing ordinances under county police power to address issues associated with domestic wells.

4.5 Summary and Conclusion

Federal and state legal and water rights issues raise no obstacles to pursuing the alternatives and objectives of the Colfax County Regional Water Plan. As individual alternatives develop into projects and initiatives requiring feasibility studies, legal issues such as water right transfers and state and federal permit requirements should be addressed as part of the feasibility evaluation. Section 8 provides an overview of alternatives that are primarily legal in nature (e.g., water right transfers, declaration of groundwater basins, and 40-year water plans).

Conclusions and recommendations regarding particular issues with potential legal ramifications are:

- The development of methane gas deposits should be monitored, as dewatering activities can affect water quality and water levels near production wells in the county.

- With regard to the Arkansas River shiner, federal action should be monitored, even though it is unlikely to have a direct impact on Colfax County.

- The Canadian Compact places no restrictions on use of water in Colfax County.

Section 5

Water Resources

5. Water Resources

This section provides an overview of the water supply in the region, including both surface and groundwater supplies (Sections 5.1 and 5.2) and water quality (Section 5.3). Summary information on the water supply of the region relative to the demands for water use is provided in Section 7.

5.1 Surface Water Supply

Surface water originates primarily in the mountains in the western and northern parts of the county and flows generally east and south to the Canadian River, through which it flows out of the county. Major surface drainages and watersheds in Colfax County are shown on Figure 3-1 and Figure B-4 in Appendix B. Section 5.1.1 describes surface water drainage in the planning region. Data sources used for the evaluation of the surface water supply are discussed in Section 5.1.2.

Surface water supplies more than 95 percent of the water currently used in Colfax County. Yet surface water availability varies greatly from year to year, with the highest flow years supplying many times more water than the drier years. Therefore, an understanding of the frequency of flows of various magnitudes is essential in evaluating the available water supply in Colfax County. Since the availability of surface water from year to year is dependent on the amount of precipitation in the region, historical climatic trends are discussed in Section 5.1.3. An analysis of streamflow data in the region is presented in Section 5.1.4. The methods used to forecast streamflow in the Colfax planning region are discussed in Section 5.1.5.

5.1.1 General Hydrologic Setting

Nearly all of the surface waters of Colfax County lie within the Arkansas/White/Red River basin, which ultimately drains to the Mississippi River. The Arkansas/White/Red River Basin in Colfax County is mostly drained by the Canadian River and its tributaries. Within Colfax County there are five sub-basins that drain into the Canadian River: the Cimarron, Mora, Canadian Headwaters, Upper Canadian, and Ute sub-basins (Figure 5-1). The Purgatoire sub-basin drains northeastward into the Arkansas River in Colorado, and the Cimarron Headwaters and Carrizo sub-basins drain east toward Oklahoma.

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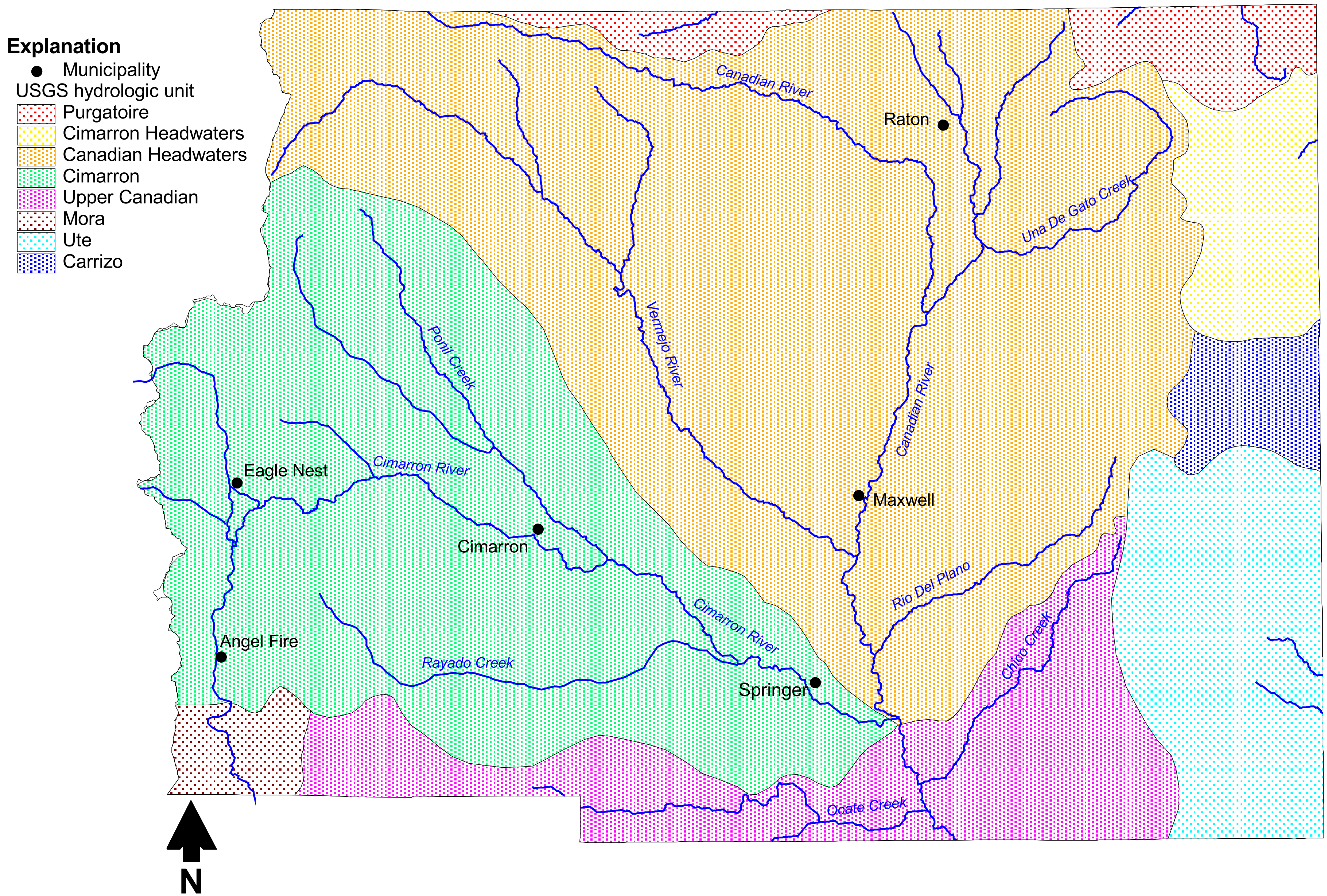

COLFAX REGIONAL WATER PLAN
Watershed Boundaries

Figure 5-1

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The Canadian River originates in southern Colorado and flows east, then south through the county (Figure 3-1). Major tributaries to the Canadian River are the Vermejo River and Cimarron River, which originate in the northern and/or western parts of the county. Important tributaries to the Cimarron River below Eagle Nest Reservoir are Ponil and Rayado Creeks. Most of the surface water supply in Colfax County is associated with these major drainages.

There are a number of dams, reservoirs, and lakes in Colfax County (Appendix B, Figure B-5). Only one of these, Eagle Nest Reservoir, is of sufficient size to significantly affect the timing and magnitude of runoff. The other waterbodies are either high up in the drainage basins or fed by diversions from stream networks, and although they do have some influence on the surface water hydrology and have important storage benefits, they do not have as great an effect on surface flows as does Eagle Nest Reservoir. Table 5-1 provides summary information for all reservoirs in the county.

5.1.2 Data Sources

In order to assess climatological conditions and the surface water supply in Colfax County, National Oceanic and Atmospheric Administration (NOAA) climatological records and USGS streamflow records were compiled and assessed for completeness and quality. The length of the period of record was also considered, as a consistent period of record is required for comparison of climate and streamflow records from different stations. At the time that the surface water analysis was originally conducted (2000), a 50-year period of record (1950 through 1999) was selected for analysis for the following reasons:

- Records were most consistent and complete for this time period.
- More locations had records available for this time period than for the early part of the century.
- The available records for the time period provided for greater geographic coverage and were thus more representative of an overall range of climatic and streamflow conditions.

Table 5-1. Colfax County Reservoir Summary
Page 1 of 2

Reservoir [a]	Purpose [b]	Operator	Total Storage Capacity (acre-feet)	Net Evaporation Rate [c] (ft/yr)	Surface Water Withdrawal (acre-feet)	Surface Water Depletion (acre-feet)
Antelope Valley No. 2 (Cimarron River)	IR	Antelope Valley Irrigation District	4,478	3.31	926.80	926.80
Antelope Valley No. 3 (Cimarron River)	IR	Antelope Valley Irrigation District	280	3.31	264.80	264.80
Armstrong Reservoir	IR, REC	Private	---	2.84	8.52	8.52
Brown Reservoir	UK	---	---	3.17	47.55	47.55
Chico Springs Reservoir	IR	---	---	3.25	16.25	16.25
Cimarron Reservoir (Cimarron River)	PS	---	---	2.25	33.75	33.75
Cimarroncito Reservoir	PS	Village of Cimarron	92	2.25	15.75	15.75
Clayton Lake [d]	IR	C S Ranch	---	---	---	---
Clouthier Lake [d]	IR	C S Ranch	---	---	---	---
Crews Reservoir	LS	---	---	2.84	17.04	17.04
Eagle Nest Lake (Cimarron River)	PS, IR, REC	State of New Mexico	79,120 [e]	1.57	3,475.00	3,475.00
French Lake	IR	Vermejo Park	463	3.33	166.50	166.50
Hagadorn Reservoir No. 5 (Chicoso Creek)	IR	---	264	2.42	60.50	60.50
Jaritas Reservoir	UK	---	---	3.58	14.32	14.32
Jaritas Reservoirs Nos. 1 and 2	IR	Private	1,760	3.50	700.00	700.00
Juaquilla Reservoir	UK	---	---	3.25	32.50	32.50
Kitrell Reservoir	UK	---	---	3.09	15.45	15.45
Lake Alice (Chicorico Creek)	PS, REC	---	100	2.50	5.00	5.00
Lake Maloya (Chicorico Creek)	IR, PS	City of Raton	5,250	1.49	163.90	163.90
Lewis Reservoir (Cimarroncita Creek)	IR	---	156	3.33	49.95	49.95

Source: Data compiled by B.C. Wilson, New Mexico Office of the State Engineer, unless otherwise noted.
FC = Flood control
FW = Fish and wildlife
ft/yr = Feet per year
--- = Information not available
PS = Public water supply
LS = Livestock

[a] Reservoirs included in this listing are man-made and supplied by surface water.
[b] IR
REC
UK = Information not available
[c] Net evaporation equals gross evaporation minus precipitation.
[d] Source: C S Ranch, personal communication
[e] Source: Ortiz et al., 2000

Table 5-1. Colfax County Reservoir Summary
Page 2 of 2

Reservoir [a]	Purpose [b]	Operator	Total Storage Capacity (acre-feet)	Net Evaporation Rate [c] (ft/yr)	Surface Water Withdrawal (acre-feet)	Surface Water Depletion (acre-feet)
Maxwell No. 11 Reservoir	FC, FW, IR, REC	Vermejo Conservancy District	637	3.08	369.60	369.60
Maxwell No. 12 Reservoir	FC, FW, IR, REC	Vermejo Conservancy District	3,430	3.08	646.80	646.80
Maxwell No. 13 Reservoir	FC, FW, IR, REC	Vermejo Conservancy District	4,951	3.08	677.60	677.60
Maxwell No. 14 Reservoir	FC, FW, IR, REC	Vermejo Conservancy District	780	3.08	215.60	215.60
Maxwell No. 2 Reservoir	FC, FW, IR, REC	Vermejo Conservancy District	---	3.08	924.00	924.00
Miami Lake No. 2	IR, REC	Miami Water Users Association	2,552	3.17	443.80	443.80
Monte Verde (Lebus) Lake	REC	---	435	1.25	32.50	32.50
Rito Del Plano Reservoir	IR	Sauble Ranch Company	300	3.17	158.50	158.50
Sauble Arroyo Reservoir	LS	---	---	3.17	25.36	25.36
Springer Arroyo Reservoir	LS	---	---	3.25	29.25	29.25
Springer City Reservoirs (2)	PS	---	353	3.25	48.75	48.75
Springer Lake	IR	Springer Ditch Company	3,792	3.25	877.50	877.50
Stubblefield Reservoir	FC, IR, REC	Vermejo Conservancy District	16,074	2.92	1,635.20	1,635.20
Throttle Reservoir (Gato Creek)	IR	T.O. Ranch Company	2,850	2.92	350.40	350.40
Tom Jack Reservoir	IR	---	---	3.25	9.75	9.75
Urraca Reservoir (Urraca Creek)	PS	---	94	2.50	22.50	22.50
Ute Creek Reservoir	IR	---	324	2.42	2.42	2.42
Van Bruggen Reservoir (Vermejo River)	UK	---	111	2.76	11.04	11.04
Websters Lake (Cimarron River Tributary)	PS	Philmont Scout Ranch	700	2.50	75.00	75.00

Source: Data compiled by B.C. Wilson, New Mexico Office of the State Engineer, unless otherwise noted.
FC = Flood control
FW = Fish and wildlife
ft/yr = Feet per year
--- = Information not available
PS = Public water supply
LS = Livestock

[a] Reservoirs included in this listing are man-made and supplied by surface water.
[b] IR
REC
UK = Information not available
[c] Net evaporation equals gross evaporation minus precipitation.
[d] Source: C S Ranch, personal communication
[e] Source: Ortiz et al., 2000

- Very large flood flows that occurred in the early 1940s tend to skew the data toward wetter conditions than may be expected in the future.

Temperature, precipitation, and streamflow records for stations with data available for this period of record were analyzed in detail, as discussed in Sections 5.1.3 and 5.1.4. Although most of the analyses discussed herein are based on the 1950 to 1999 period of record used in the original surface water analyses conducted in 2000, hydrographs and climatic graphs have been updated through water year 2002 (ending September 30, 2002) for locations with available data (Ponil Creek and Eagle Nest releases are not yet available). However, the 2002 streamflow data are provisional, meaning that they have not been fully checked for accuracy by the USGS.

5.1.3 Summary of Climatic Conditions

The varied terrain of Colfax County, which ranges from the Rocky Mountains to the High Plains, results in significant climate variations. For example, temperatures range from lows well below 0 degrees Fahrenheit (°F) in the mountains to highs in excess of 100°F in the plains.

A number of climate data collection stations are located in Colfax County (Figure 5-2). However, some of the stations did not have data for the period of record selected for analysis (1950 through 1999), and incomplete and missing data at other stations compromised their use as well. Table 5-2 lists the periods of record for all the weather stations in Colfax County and identifies the 12 stations analyzed in detail. These stations were selected based on location, how well they represented conditions in the county, and completeness of the records. The stations that were not analyzed had only very short period of records (less than 5 years).

Figure 5-3 shows the temperature ranges and long-term average temperature for the period of record at 9 of the 12 stations (temperature data were limited for Abbot 1 SE and not available for Black Lake or Cunico Ranch). Tabulated temperature data are included in Appendix F3. As shown in Figure 5-3, the average temperature at the 9 stations for 1950 through 1999 was fairly consistent, ranging between about 40 and 50 degrees Fahrenheit (Figure 5-3). Average temperatures showed a slight increase over the period of record, with most of the increase coming from rising minimum temperatures.

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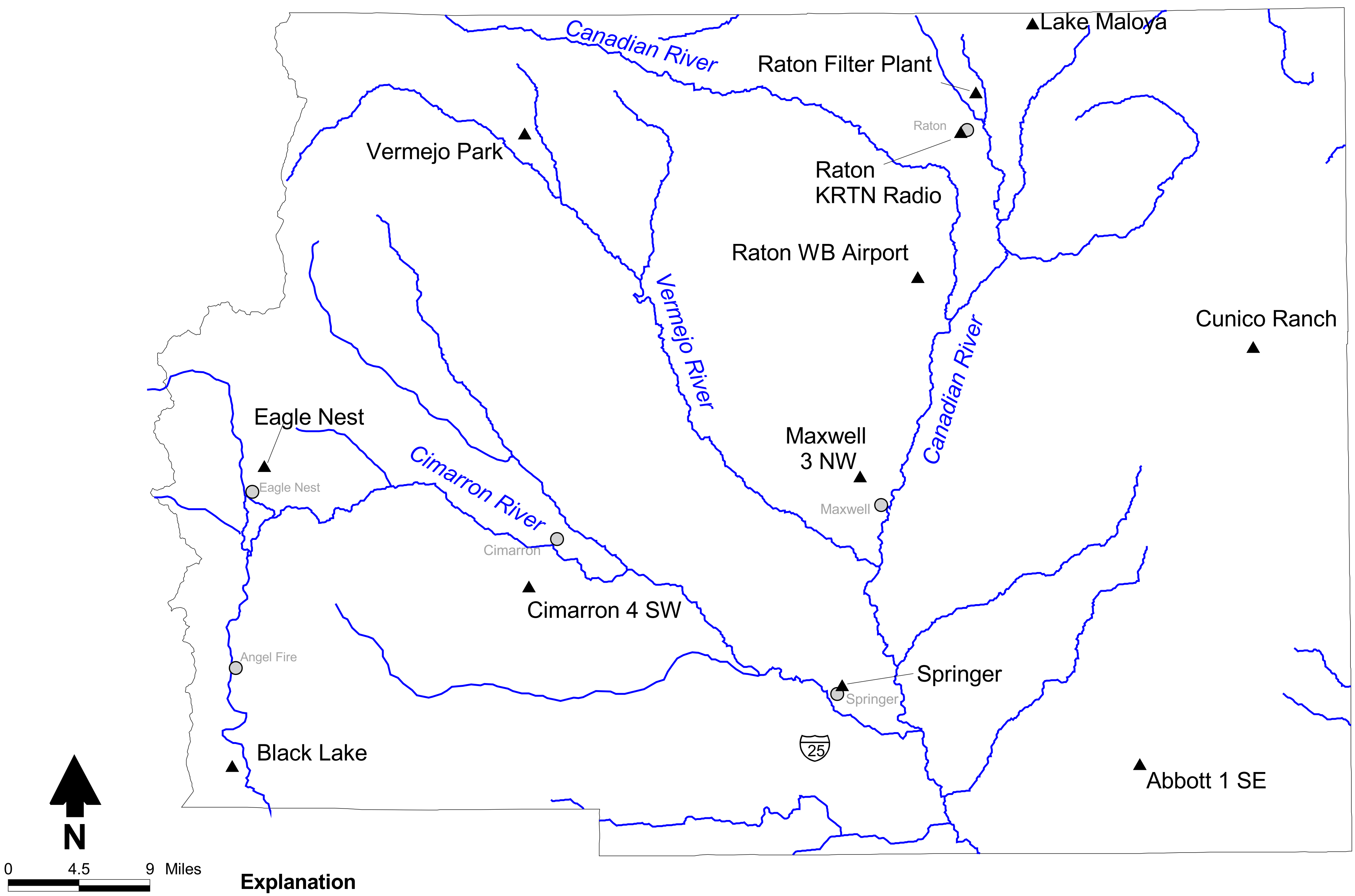

COLFAX REGIONAL WATER PLAN
Locations of Climate Stations

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Figure 5-2

Table 5-2. Climate Station Periods of Record

Station Name [a]	Period of Record				Active?
	Maximum Temp	Minimum Temp	Snowfall	Precipitation	
Abbott 1 SE	12/03/1969 to 10/31/1981	01/01/1977 to 10/31/1981	01/01/1948 to 12/31/2001	01/01/1948 to 12/31/2001	No / Yes [b]
Angel Fire Ski Course	None	None	10/01/1967 to 04/03/1968	10/01/1967 to 04/03/1968	No
Angel Fire 2 S	07/01/1990 to 10/31/1993	07/01/1990 to 10/31/1993	07/01/1990 to 10/30/1993	07/05/1990 to 10/30/1993	No
Angel Fire 4 NNW	11/01/1993 to 12/31/2001	11/10/1993 to 12/31/2001	11/09/1993 to 12/31/2001	11/09/1993 to 12/31/2001	Yes
Black Lake	None	None	01/01/1948 to 12/31/2001	01/01/1948 to 12/31/2001	Yes
Cimarron 4 SW	05/01/1904 to 12/31/2001	05/01/1904 to 12/31/2001	05/01/1904 to 12/31/2001	05/01/1904 to 12/31/2001	Yes
Cunico Ranch	None	None	01/01/1948 to 08/31/1970	01/01/1948 to 08/31/1970	No
Eagle Nest [c]	01/01/1948 to 12/31/2001	01/01/1948 to 12/31/2001	01/01/1948 to 12/31/2001	01/01/1948 to 12/31/2001	Yes
Hennigan Ranch	None	None	07/01/1971 to 11/30/1971	07/01/1971 to 11/30/1971	No
Lake Maloya	01/01/1948 to 12/31/2001	01/01/1948 to 12/31/2001	01/01/1948 to 12/31/2001	01/01/1948 to 12/31/2001	Yes
Maxwell 3 NW	01/01/1948 to 12/31/2001	01/01/1948 to 12/31/2001	01/01/1948 to 12/31/2001	01/01/1948 to 12/31/2001	Yes
Raton Filter Plant	09/08/1953 to 12/31/2001	09/08/1953 to 12/31/2001	09/01/1953 to 12/31/2001	09/08/1953 to 12/31/2001	Yes
Raton KRTN Radio	12/01/1978 to 12/31/2001	12/01/1978 to 12/31/2001	12/01/1978 to 12/31/2001	12/01/1978 to 12/31/2001	Yes
Raton WB Airport	01/01/1948 to 11/301968	01/01/1948 to 11/30/1968	01/01/1948 to 11/30/1968	01/01/1948 to 11/30/1968	No
Springer	01/01/1948 to 12/31/2001	01/01/1948 to 12/31/2001	01/01/1948 to 12/31/2001	01/01/1948 to 12/31/2001	Yes
Vermejo Park	04/01/1966 to 11/30/1981	04/01/1966 to 11/30/1981	04/01/1966 to 11/30/1981	04/01/1966 to 11/30/1981	No

[a] Stations used for the analysis of climate are in boldface type.
[b] Snowfall and precipitation are still recorded; temperature is not.
[c] Evaporation data were also tracked from May 29, 1948 until October 31, 1998.

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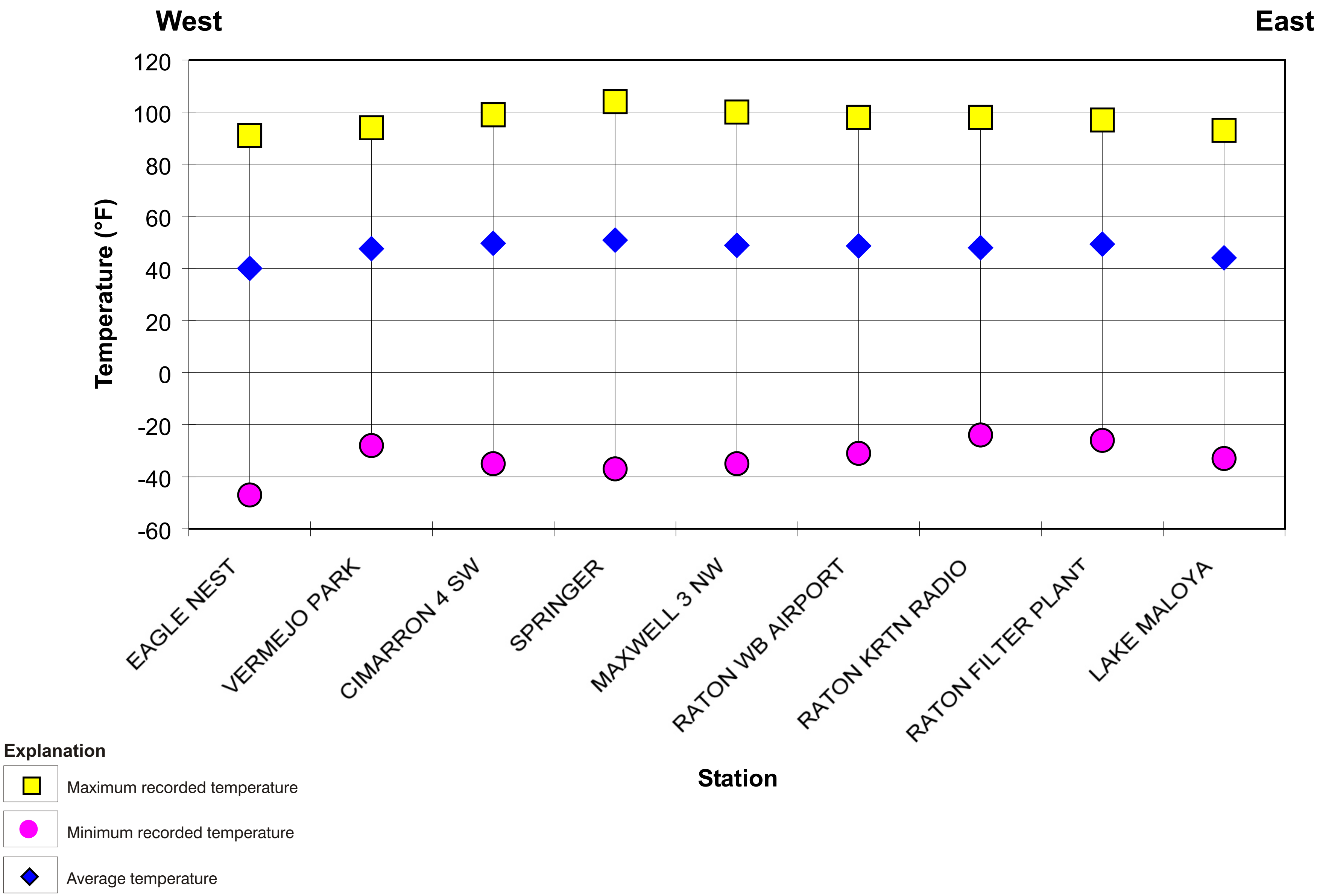

COLFAX REGIONAL WATER PLAN

Temperature Range

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Figure 5-3

Precipitation also varies across the county and is influenced by location and somewhat by elevation. Weather systems may enter the county from the west (Pacific), northeast (Arctic air masses from the plains), and southwest (Gulf of Mexico), and each of these systems brings a unique set of temperatures and moisture to the county. Figure 5-4 shows the maximum, minimum, and long-term average precipitation (rainfall and snowmelt) at the 12 stations (tabulated precipitation data are included in Appendix F3). As shown in Figure 5-4, Black Lake and Lake Maloya tend to show higher maximum (and corresponding average) amounts of precipitation. Average precipitation, including both snowmelt and rainfall, ranges from about 14 to 24 inches. Contoured precipitation throughout the county is illustrated in Appendix B, Figure B-6.

Figure 5-5 shows the average annual precipitation (for the period studied) in relation to elevation. Only the climate stations with the most complete records during the 1950 through 1999 period are shown in this figure. All of the plotted data represent stations that have been operated since 1950, except the Raton Filter Plant, which began operation in 1953.

The pattern of the plotted points suggests a reasonable correlation between average precipitation and elevation within the county, except for an outlier point representing the Eagle Nest data. A linear regression analysis of all the data on this figure yields a correlation coefficient of 0.52, but when the Eagle Nest data are excluded, the correlation coefficient improves to 0.86. The explanation for this anomaly may be demonstrated in the WRRI precipitation map (Appendix B, Figure B-6), which shows an area of reduced precipitation that corresponds with the location of the Moreno Valley. This valley sits between high mountains that bound it on both the east and west sides, with the apparent result being somewhat of an orographic rain shadow for this area. Except for the Moreno Valley area, the pattern of precipitation in the county has a fairly strong correlation with elevation.

Figure 5-6 shows the long-term trends in precipitation at three selected stations. The annual amounts have all been normalized to the average depth during that period; that is, the annual precipitation total for each year is expressed as a percentage of the long-term average annual precipitation amount for the selected period of record. With the exception of the last two years, which were below-average years, the graphs show a slight upward trend, with most years since

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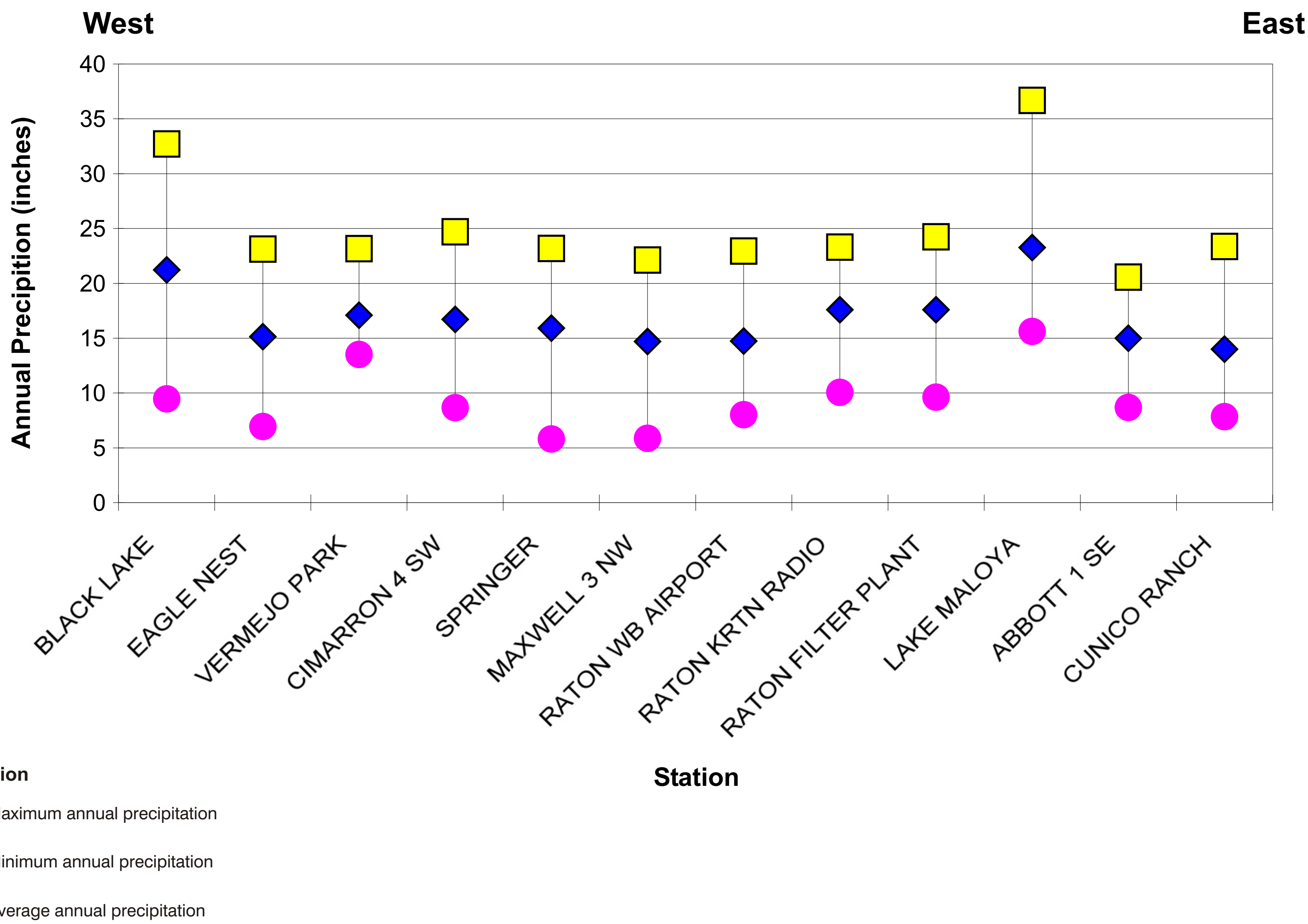

COLFAX REGIONAL WATER PLAN

Precipitation Range

Figure 5-4

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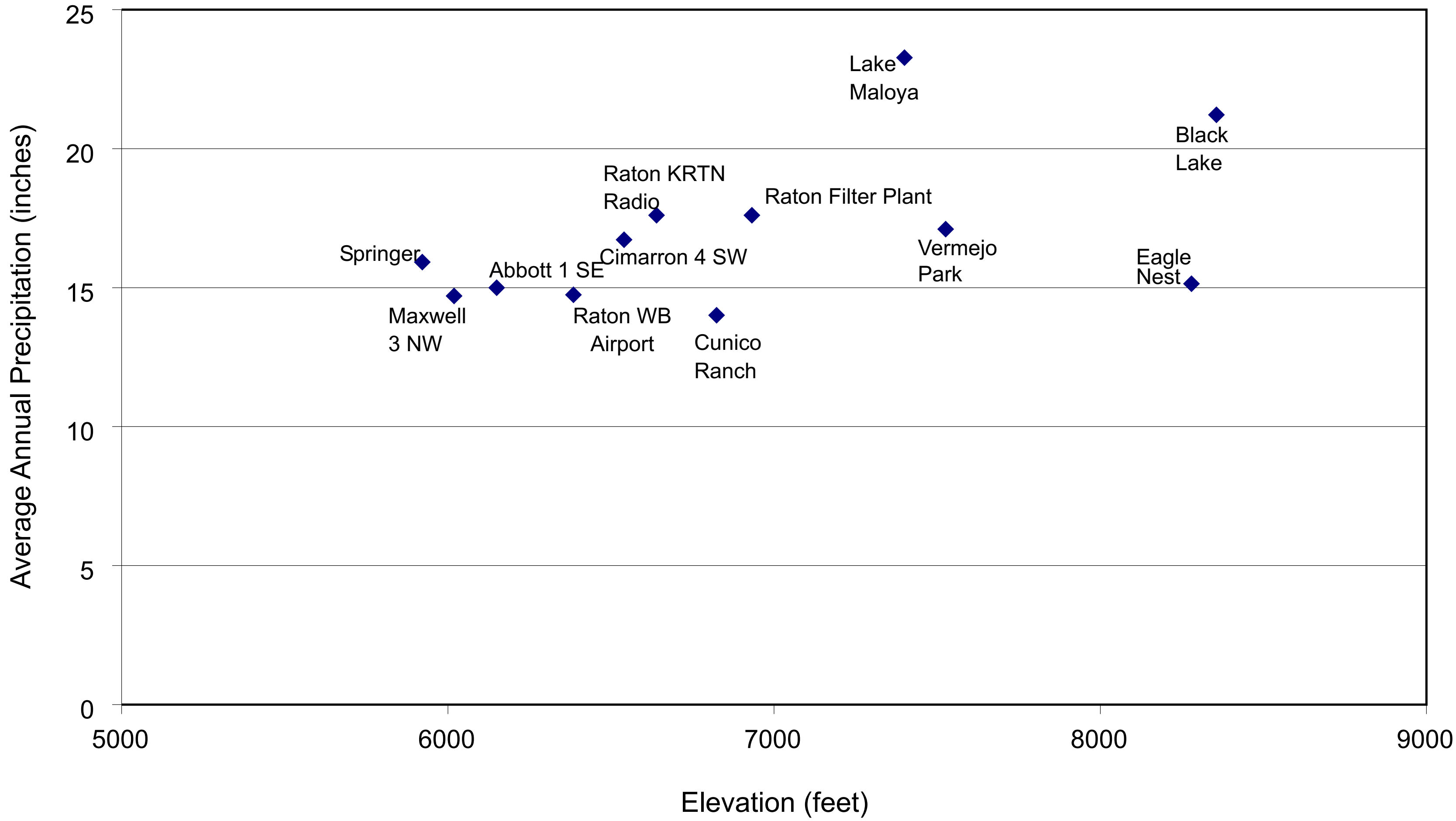

COLFAX REGIONAL WATER PLAN

Climate Station Elevation vs. Precipitation

Figure 5-5

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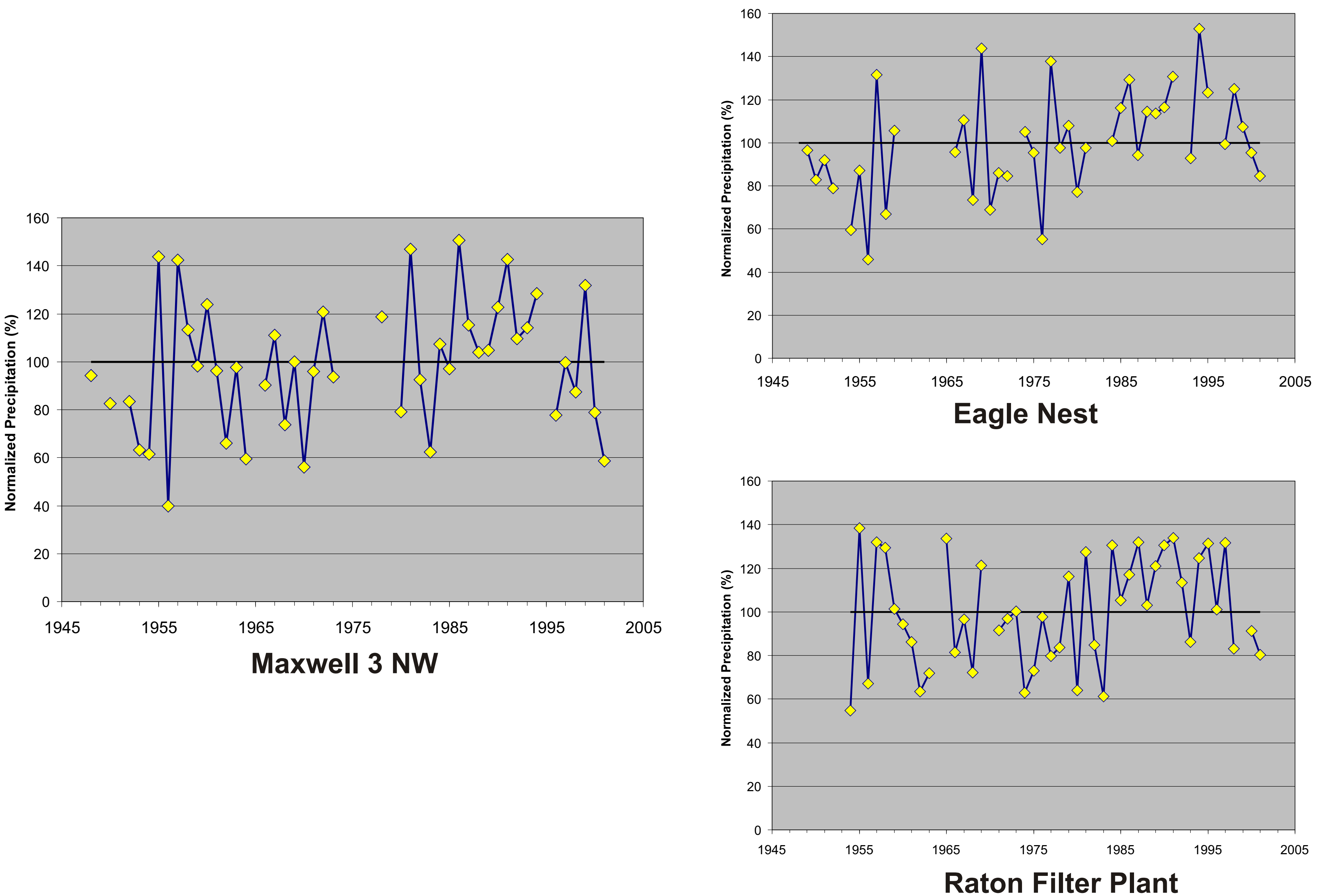

COLFAX REGIONAL WATER PLAN

Normalized Precipitation 1948 through 2001

Figure 5-6

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the early to mid-1980s showing higher than average precipitation depths. An interesting comparison between these trends can be made with the PDSI, as discussed in Sections 5.1.3.1 and 5.1.3.2.

5.1.3.1 The Palmer Drought Severity Index

A drought index consists of a ranking system derived from the assimilation of data, including rainfall, snow pack, streamflow, and other water supply indicators for a given region. Consulting drought indices can aid in water supply and agricultural planning and decision making. The PDSI was created by W.C. Palmer (1965) to measure the variations in the moisture supply and is based upon the supply-and-demand concept of the water balance equation.

Hayes (1999) provides a thorough explanation of the PDSI, which is summarized here. Additional discussion of the PDSI is included in the Drought Contingency Plan (Appendix E, Attachment E2).

The PDSI is calculated using precipitation and temperature data as well as the available water content (AWC) of the soil. These data are used to calculate all the components of the water balance equation including evapotranspiration, soil recharge, runoff, and moisture loss from the surface layer. Moisture conditions are standardized so that comparisons between different locations and between months can be made. The index is widely used because it provides an assessment of the abnormality of recent weather relative to historical conditions. The PDSI classifications for dry to wet periods are provided in Table 5-3.

There are considerable limitations when using the PDSI, as described by Alley (1984) and Karl and Knight (1985). One drawback of the PDSI is that it does not adequately represent conditions in regions that have extreme variability in rainfall, runoff, or elevation (Smith et al., 1993). The PDSI may also lag emerging droughts by several months. Yet, even with its limitations, many states incorporate the PDSI into their drought monitoring systems.

Table 5-3. Palmer Drought Severity Index Classifications

Classification	Description
4.0 or more	Extremely wet
3.0 to 3.99	Very wet
2.0 to 2.99	Moderately wet
1.0 to 1.99	Slightly wet
0.5 to 0.99	Incipient wet spell
0.49 to –0.49	Near normal
–0.5 to –0.99	Incipient dry spell
–1.0 to –1.99	Mild drought
–2.0 to –2.99	Moderate drought
–3.0 to –3.99	Severe drought
–4.0 or less	Extreme drought

The PDSI is calculated for climate divisions throughout the United States. Colfax County encompasses two climate divisions: the northern mountains and the northeastern plains, with the majority of the county, including all of the major headwaters stream systems, in the northern mountains division. Figure 5-7 shows the long-term PDSI for the northern mountains climate division. Of interest are the large variations from year to year, the high variability in the early part of the record, and the relatively lower and less variable record in the latter half of the century. These variations may be caused by different effects, including better records in recent times. Three important aspects of Figure 5-7 are that there does not seem to be a distinct trend in recent times, there is pronounced variability, and the last year (2002) is the lowest year of record.

5.1.3.2 Interpretation and Relevancy to Water Resources

Although the precipitation trend shows a slight increase for the period of analysis, that trend should not be cause for overconfidence that the water supply is increasing. In fact, in 2002 the PDSI dipped to its lowest index value in more than one hundred years (coincident with water year 2002 streamflow at the Canadian River at Taylor Springs gage, which was the second lowest in the 53-year period of record). As discussed in Section 5.1.3.1, the PDSI shows that large variations are common. Tree ring analyses conducted in various locations in the southwest have indicated that current moisture conditions in many areas are higher than the

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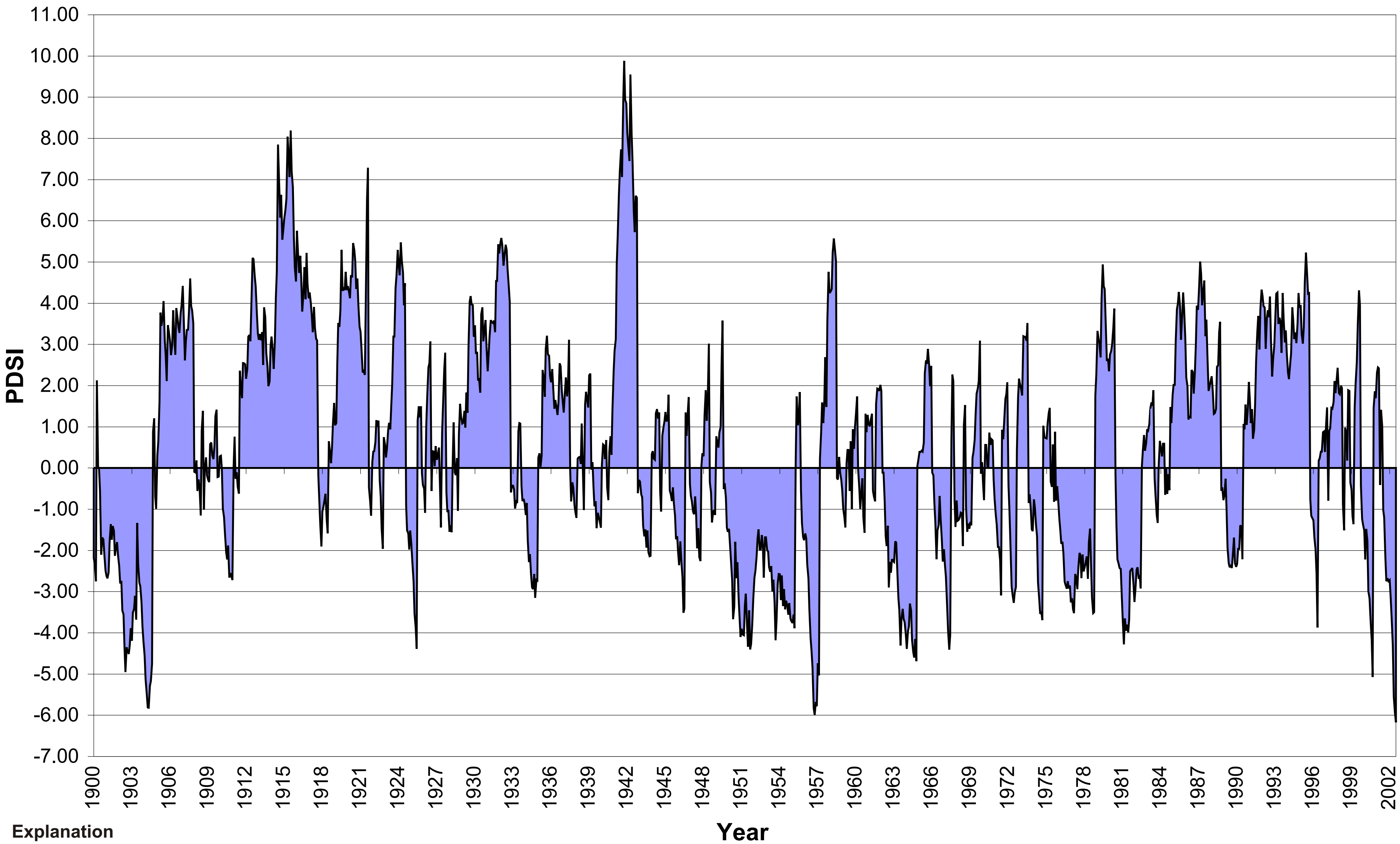

Explanation

4.0 or more = Extremely wet
3.0 to 3.99 = Very wet
2.0 to 2.99 = Moderately wet
1.0 to 1.99 = Slightly wet
0.5 to 0.99 = Incipient wet spell
0.49 to -0.49 = Near normal

-0.5 to -0.99 = Incipient dry spell
-1.0 to -1.99 = Mild drought
-2.0 to -2.99 = Moderate drought
-3.0 to -3.99 = Severe drought
-4.0 or less = Extreme drought

COLFAX REGIONAL WATER PLAN

Monthly Palmer Drought Severity Index for New Mexico Climate Division 2, 1900 Through 2002

Figure 5-7

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longer-term (500- to 1000-year) record. Even more important than evaluating past records, however, is the consideration of future climate changes that may affect the water supply for Colfax County.

Climate change has been tracked worldwide through use of temperature measurements (recent) and surrogate indicators such as tree rings, coral reefs, and ice cores. The climate change is a global phenomenon resulting from numerous causes. However, the primary driving force is the alteration of the atmosphere by the addition of greenhouse gases. These greenhouse gases are so named because they allow solar radiation to reach the earth's surface, but do not allow radiation from the earth to escape from the atmosphere, resulting in an effect similar to that which takes place in a greenhouse. Greenhouse gases include methane, nitrous oxide, and most importantly, carbon dioxide. The primary source of carbon dioxide is combustion of fossil fuels. In the last 100 years, the use of fossil fuels has increased the carbon dioxide content in the atmosphere to levels that are now creating a measurable greenhouse effect.

The climatic responses to the greenhouse effect will vary from location to location. These effects are summarized in a report prepared by the Intergovernmental Panel on Climate Change (IPCC, 2001). In this report, the IPCC states that the northern hemisphere has warmed in the 20th Century, as demonstrated by increases in nighttime minimum temperatures, a trend seen in the records from Colfax County climate stations. The report also states that precipitation has probably also increased over the middle to high latitudes of the northern hemisphere, again confirmed by the climate records in Colfax County. The report goes on to state that precipitation events will likely be more intense and that there will be an increased risk of summer droughts over mid-continental interiors. In the long- term, however, increases in precipitation may not necessarily lead to increased runoff, because the higher temperatures may create off-setting evaporation and evapotranspiration, thus raising water demand by riparian vegetation and agriculture.

These changes will affect the water supply in Colfax County over the next 40 years. At this time, there is no accurate predictor of specific climatic changes to be expected in Colfax County over the 40-year planning horizon. However, the knowledge that changes may occur should be incorporated into drought planning activities and into subsequent phases of the regional water planning process.

5.1.4 Summary of Streamflow Data

Streamflow data are collected by the USGS from several gages in Colfax County, at the locations shown in Figure 5-8. Also shown on Figure 5-8 are numerous diversions from the surface water sources in the county, along with approximate quantities as provided by the USGS. Table 5-4 lists the locations, periods of record, and types of records collected at all the stream gages in Colfax County. As indicated in Table 5-4, many of the stations only collected peak flow data or were only operational for a short period of time.

For this study, the eight stations that have the longest and most consistent period of record for daily streamflow were selected for analysis. These stations were chosen because of their locations in the hydrologic system, completeness of record, and measurement of key sources of supply. Figure 5-9 shows descriptive statistics for annual water yield at these stations in a west to east direction (generally downstream) for the period of analysis (water years 1950 through 1999).

When comparisons are made among watersheds, it is useful to base those comparisons on some type of normalized value. The most common and convenient normalization is to divide the parameter being measured by the area of the watershed. This is commonly done for runoff volume by dividing the total runoff, expressed in acre-feet, by the watershed area. The resulting value is expressed as inches of runoff, allowing comparison not only among different watersheds but also to the depth of precipitation that contributes to runoff. Figure 5-10 shows normalized annual yield statistics from Colfax County for the period of analysis (water years 1950 through 1999).

Graphs illustrating annual streamflow for the selected stations, including the monthly distribution of streamflow over a year, are presented in Appendix F1, along with monthly and daily statistics for each station. Table 5-5 provides summary statistics for each of the eight stations and for tributaries to Eagle Nest Lake, which were studied on the suggestion of the advisory committee.

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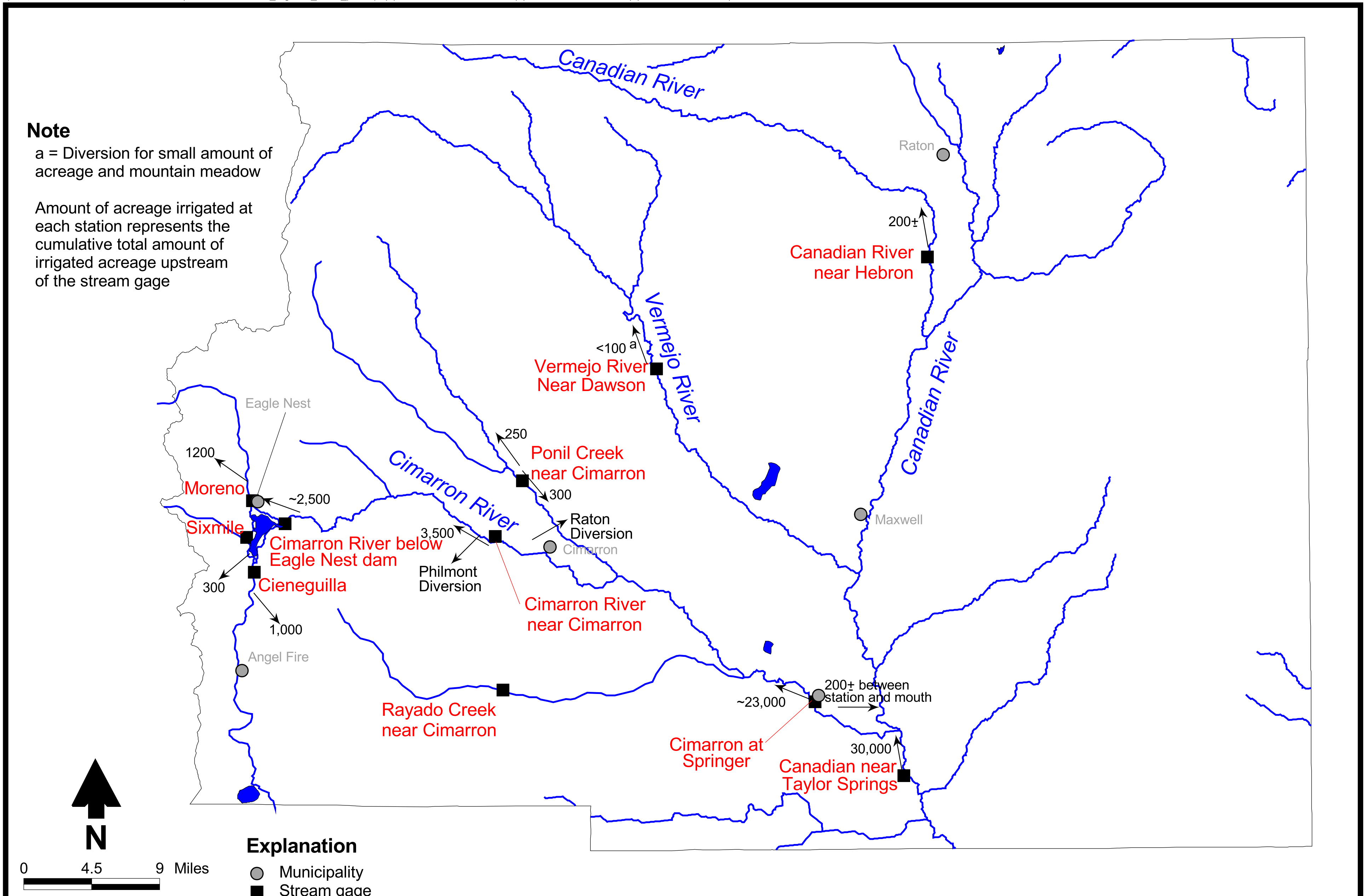

COLFAX REGIONAL WATER PLAN
Locations of Stream Gages and Irrigation Diversions

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Figure 5-8

Table 5-4. Data Available for Streamflow Gaging Stations in Colfax County
Page 1 of 4

Station Name	Station Number	Types of Records	Period of Record	Water Quality Data	
				Available?	Dates
Canadian River near Hebron, NM	07199000	Historical streamflow daily values	10/01/46-09/30/86	Yes	02/24/66-10/15/80
		Peak flows	1947-1986		
Chicorica Creek near Yankee, NM	07199600	Historical streamflow daily values	05/14/75-10/24/79	Yes	08/25/75-06/28/79
			05/17/83-09/30/87		
East Fork Chicorica Creek near Yankee, NM	07199650	Historical streamflow daily values	10/01/83-09/30/87	No	---
Chicorica below East Fork near Raton, NM	07200000	Historical streamflow daily values	10/01/45-06/30/51	No	---
Chicorica Creek near Raton, NM	07200500	Historical streamflow daily values	10/01/83-09/30/87	No	---
Raton Creek at Raton, NM	07201000	Peak flows	1953-1996	No	---
Chicorica Creek Tributary near Raton, NM	07201200	Peak flows	1971-1996	No	---
Una de Gato Creek below Throttle Dam near Raton, NM	07201420	Historical streamflow daily values	05/14/75-10/19/83	Yes	8/26/75-11/16/83
Green Mtn Arroyo near Raton, NM	07201450	Peak flows	1971-1982	No	---
Una de Gato Creek near Hebron, NM	07201500	Historical streamflow daily values	10/01/46-06/30/50	No	---
Chicorica Creek near Hebron, NM	07202000	Historical streamflow daily values	02/01/45-09/30/51	Yes	02/25/66-11/13/80
			10/01/83-09/30/87		
		Peak flows	1946-1987		
Vermejo River at Vermejo Park, NM	07202400	Historical streamflow daily values	10/01/85-09/30/93 [a]	No	---
		Peak flows	1986-1993		
Eagle Tail Ditch near Maxwell, NM	07202500	Historical streamflow daily values	01/01/45-07/31/50	Yes	09/16/75
			05/15/75-09/30/01		
Vermejo River near Dawson, NM	07203000	Current conditions (daily discharge)	31 days [b]	Yes	03/10/64-08/21/84
		Historical streamflow daily values	10/01/15-12/31/17		
			04/01/19-05/31/21		
			03/01/27-present		
		Peak flows	1929-1999		

[a] Intermittent during stated time period.
[b] Data available for previous 31 days from request date
[c] Annual maximum recorded for water years 1959-1963
[d] Short-duration water quality sampling site; continuous streamflow measurements not recorded; need to be requested from the USGS

NA = Not available
--- = Not applicable

Table 5-4. Data Available for Streamflow Gaging Stations in Colfax County
Page 2 of 4

Station Name	Station Number	Types of Records	Period of Record	Water Quality Data	
				Available?	Dates
Vermejo Ditch near Colfax, NM	07203505	Historical streamflow daily values	12/20/80-09/30/96	No	---
Vermejo River near Maxwell, NM	07203525	Historical streamflow daily values	11/25/83-09/30/94	Yes	04/05/93-09/07/93
		Peak flows	1985-1994		
Rio del Plano Tributary near Taylor Springs, NM	07203600	Peak flows	1971-1982	No	---
Moreno Creek at Eagle Nest, NM	07204000	Historical streamflow daily values	04/01/28-09/30/01 [a]	No	---
		Peak flows	1929-1999		
Cieneguilla Creek near Eagle Nest, NM	07204500	Historical streamflow daily values	04/01/28-09/30/01 [a]	No	---
		Peak flows	1929-1999		
Sixmile Creek near Eagle Nest, NM	07205000	Historical streamflow daily values	08/01/58-09/30/01 [a]	No	---
		Peak flows	1931-1999		
Cimarron River below Eagle Nest Dam, NM	07206000	Current conditions (daily discharge)	31 days [b]	Yes	08/27/75-08/07/84
		Historical streamflow daily values	05/01/50-present		
		Peak flows	1950-1999		
McEvoy Creek near Eagle Nest, NM	07206200	Historical streamflow daily values	10/01/61-09/30/62	No	---
			10/01/63-09/30/68		
		Peak flows	1962-1968		
Tolby Creek near Eagle Nest, NM	07206300	Historical streamflow daily values	10/01/61-09/30/62	No	---
			10/01/63-09/30/68		
		Peak flows	1962-1968		
Clear Creek near Ute Park, NM	07206400	Historical streamflow daily values	10/01/61-09/30/62	No	---
			10/01/63-09/30/68		
		Peak flows	1962-1996		

[a] Intermittent during stated time period.
[b] Data available for previous 31 days from request date
[c] Annual maximum recorded for water years 1959-1963

[d] Short-duration water quality sampling site; continuous streamflow measurements not recorded; need to be requested from the USGS

NA = Not available
--- = Not applicable

Table 5-4. Data Available for Streamflow Gaging Stations in Colfax County
Page 3 of 4

Station Name	Station Number	Types of Records	Period of Record	Water Quality Data Available?	Water Quality Data Dates
Cimarron River at Ute Park, NM	07206500	Historical streamflow daily values	10/01/07-12/31/17	No	---
			10/01/30-09/30/50		
		Peak flows	1910-1950		
Cimarron River near Cimarron, NM	07207000	Current conditions (daily discharge)	31 days [b]	Yes	09/18/79-05/10/96
		Historical streamflow daily values	06/01/50-present		
		Peak flows	1950-1999		
Ponil Creek near Cimarron, NM	07207500	Historical streamflow daily values	01/01/16-09/30/01 [a]	Yes	11/12/80-08/08/95
		Peak flows	1916-1999		
Rayado Creek at Sauble Ranch near Cimarron, NM	07208500	Current conditions (daily discharge)	31 days [b]	Yes	11/12/80-08/10/95
		Historical streamflow daily values	10/01/11-09/30/12		
			01/01/16-09/30/18		
			01/01/30-present		
		Peak flows	1914-1999		
Cimarron River at Springer, NM	07211000	Current conditions (daily discharge)	NA	No	---
		Historical streamflow daily values	10/01/07-09/30/28 [a]		
			04/01/30-09/30/01		
		Peak flows	1930-1999		
Canadian River near Taylor Springs, NM	07211500	Current conditions (daily discharge)	31 days [b]	Yes	06/27/66-06/04/75
		Historical streamflow daily values [c]	10/01/39-09/30/58		
			06/01/64-present		
		Peak flows	1904-1999		
Coyote Creek below Black Lake, NM	07217000	Historical streamflow daily values	01/01/53-09/30/63	No	---
		Peak flows	1953-1965		

[a] Intermittent during stated time period.
[b] Data available for previous 31 days from request date
[c] Annual maximum recorded for water years 1959-1963

[d] Short-duration water quality sampling site; continuous streamflow measurements not recorded; need to be requested from the USGS

NA = Not available
--- = Not applicable

Table 5-4. Data Available for Streamflow Gaging Stations in Colfax County
Page 4 of 4

Station Name	Station Number	Types of Records	Period of Record	Water Quality Data	
				Available?	Dates
Canadian River above Vermejo River	362912104323710	Discrete water quality samples [d]	04/05/93, 09/07/93	Yes	04/05/93, 09/07/93
South Drain Canal, Vermejo Irrigation Project	363122104330310	Discrete water quality samples [d]	04/08/93, 08/31/93	Yes	04/08/93, 08/31/93
Canadian River above Bridge at Chico Rd nr Maxwell, NM	363203104315210	Discrete water quality samples [d]	04/05/93, 08/30/93	Yes	04/05/93, 08/30/93
Middle Drain Canal, Vermejo Irrigation Canal	363252104323010	Discrete water quality samples [d]	04/07/93, 08/31/93	Yes	04/07/93, 08/31/93
Natural Playa, Maxwell Wildlife Refuge, NM	363306104360010	Discrete water quality samples [d]	04/06/93, 08/30/93	Yes	04/06/93, 08/30/93
Maxwell NWR (drain above Lake 12)	363358104350810	Discrete water quality samples [d]	06/16/92	Yes	06/16/92
North Drain Canal, Vermejo Irrigation Project	363452104323010	Discrete water quality samples [d]	04/07/93, 08/31/93	Yes	04/07/93, 08/31/93
Vermejo River above Vermejo Canal Diversion Dam	363634104451110	Discrete water quality samples [d]	04/07/93, 09/07/93	Yes	04/07/93, 09/07/93
Canadian River at road crossing near Eagle Rock, NM	363903104291510	Discrete water quality samples [d]	04/06/93, 08/30/93	Yes	04/06/93, 08/30/93
Chicorica Creek at heading of Eagle Tail Canal	364328104263910	Discrete water quality samples [d]	04/06/93, 09/08/93	Yes	04/06/93, 09/08/93

[a] Intermittent during stated time period.
[b] Data available for previous 31 days from request date
[c] Annual maximum recorded for water years 1959-1963
[d] Short-duration water quality sampling site; continuous streamflow measurements not recorded; need to be requested from the USGS

NA = Not available
--- = Not applicable

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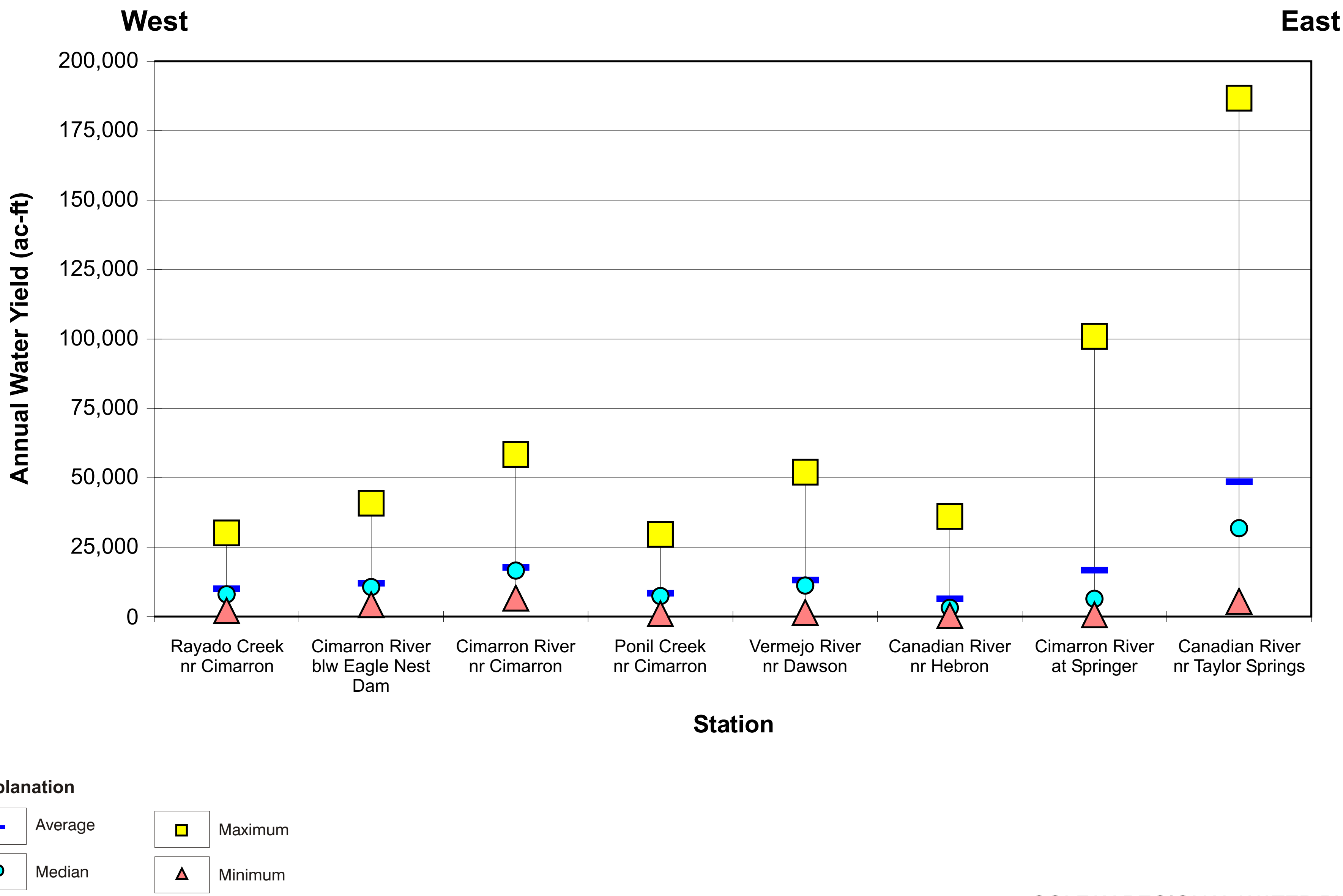

COLFAX REGIONAL WATER PLAN

Annual Water Yield

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Figure 5-9

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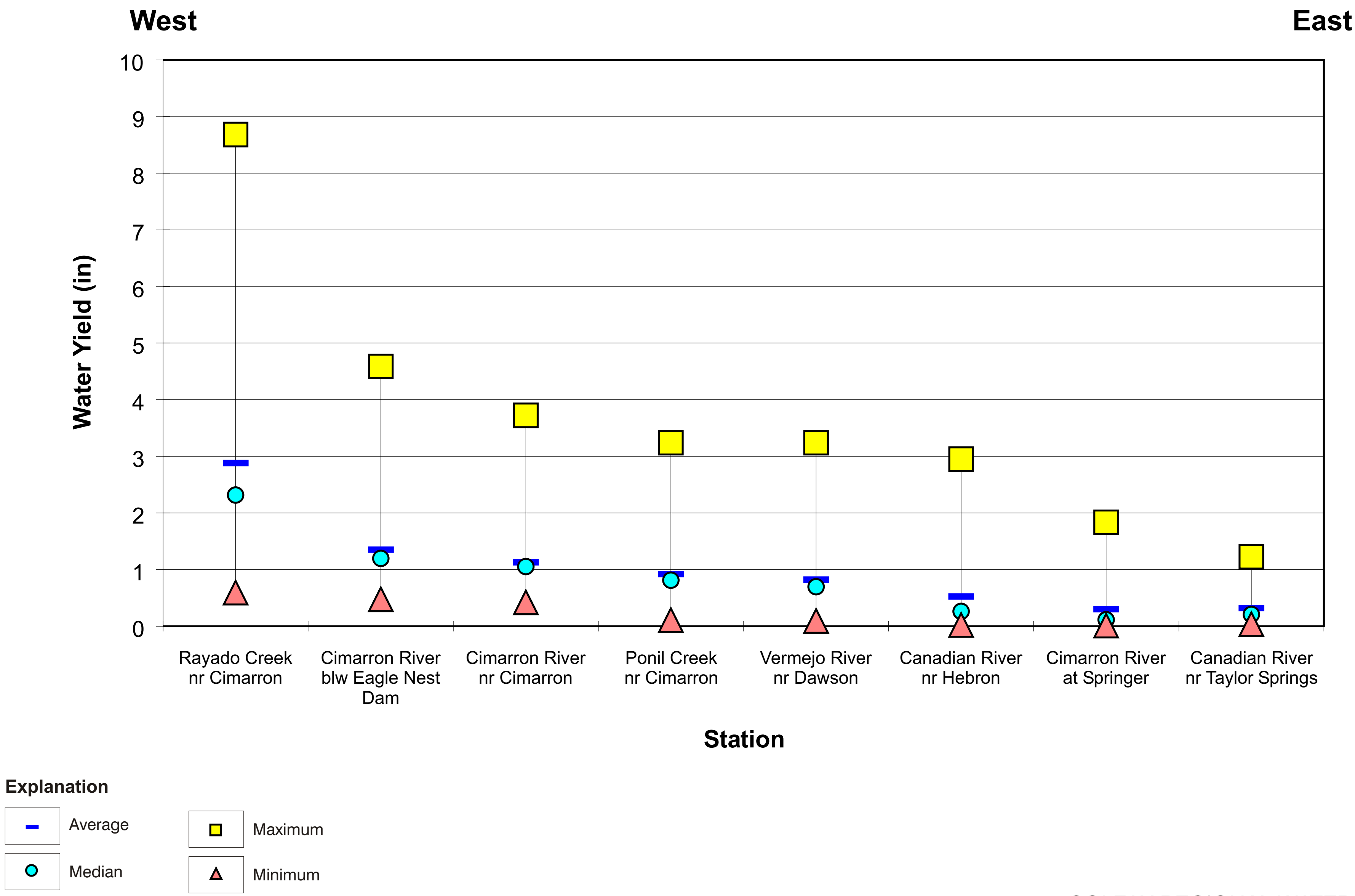

COLFAX REGIONAL WATER PLAN

Normalized Annual Water Yield

Figure 5-10

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Table 5-5. Summary of Water Yield Statistics

Station Name	Period of Record Analyzed (water years)	Average Daily Streamflow (cfs)	Annual Yield (ac-ft)				Q_{10} [a] (ac-ft)	Q_{25} [b] (ac-ft)
			Maximum	Average	Median	Minimum		
Cieneguilla Creek near Eagle Nest, NM [c]	1950-55, 1965-99	8	20,385	5,725	4,037	696	1,273	1,789
Sixmile Creek near Eagle Nest, NM [c]	1959-99	3	5,890	1,906	1,728	432	672	943
Moreno Creek at Eagle Nest, NM [c]	1950-55, 1965-99	5	13,274	3,397	2,614	208	377	616
Cimarron River below Eagle Nest, NM	1951-99	17	40,878	12,054	10,671	4,231	5,899	8,330
Cimarron River near Cimarron, NM	1951-99	24	58,397	17,728	16,538	6,600	10,458	13,072
Rayado Creek near Sauble Ranch,NM (near Cimarron)	1950-99	14	30,097	10,139	8,502	2,055	3,295	4,178
Ponil Creek near Cimarron, NM	1951-99	12	29,577	8,407	7,425	999	1,341	2,774
Vermejo River near Dawson, NM	1950-99	18	52,055	13,200	11,192	1,480	3,727	6,156
Canadian River near Hebron, NM	1950-86	9	36,048	6,428	3,189	286	617	1,578
Cimarron River at Springer, NM	1950-99	23	100,942	16,691	6,362	652	1,546	2,779
Canadian River near Taylor Springs, NM	1950-58, 1965-99	67	186,750	48,524	31,869	5,500	9,170	18,969

[a] The lowest 10 percent annual streamflow totals for the 1950 to 1999 period of record.
[b] The lowest 25 percent annual streamflow totals for the 1950 to 1999 period of record.
[c] Streamflow records are seasonal.

cfs = Cubic feet per second
ac-ft = Acre feet

Because of the large variations in the annual yields for the period of record analyzed, the data were log-transformed to remove some of the statistical skew. The original and log-transformed data sets were subjected to further review, including distributional analyses, relationships with precipitation data and trends, and inter-station relationships. These analyses are discussed in Section 5.1.5.

The hydrographs in Appendix F1 include data through water year 2002, where available. The data for water year 2002 have not been fully developed by the USGS and are therefore considered provisional. In addition, data were missing for some periods of record due to the river icing over or equipment malfunctions. In cases where these gaps were due to ice cover at the gage site, a daily value of zero was assumed, while in cases where gaps were caused by equipment malfunctioning, daily values were calculated using the following process:

- The difference between daily discharge on either side of the data gap was divided by the number of missing daily values

- The resultant value was added to the last reported value before the equipment malfunctioned

- The resultant value was then added to each subsequent estimated daily value until the data gap was filled.

5.1.5 Estimation of Surface Supply

Surface water supply can be estimated using several approaches. Two widely used approaches were determined to be unsuitable for estimating surface water supply in the Colfax water planning region, for the reasons discussed below:

- *Modeling precipitation-runoff relationships:* To determine the viability of estimating surface water supply using a model of the relationship between precipitation and runoff, this relationship in Colfax County was preliminarily investigated using (1) precipitation gages and streamflow gages that were located close to each other and (2) the northern mountain division PDSI compared to the streamflow records for several stations in Colfax County. A poor relationship between runoff and both precipitation and the PDSI was found, most likely due to the small number and sparse locations of precipitation measurement stations in the large planning area, as well as the large gap between the runoff and precipitation amounts (runoff is typically less than 10 percent of precipitation). Detailed analysis of the cause of this discrepancy and information on the long-term precipitation of the county, which is dependent on a greater density of gages than is currently available, would be required for an accurate model. Therefore, a precipitation-runoff model was not constructed for this study.

- *Inter-station relationships*. Another approach to defining the interactions of the surface water supply sources in the county is to compare the water yields among the different locations. Examination of the streamflow records at all eight gaging stations indicates that streamflow (and thus water supply) is quite variable across the county. A closer look at the relationships between a base station (the Canadian River near Hebron gage) and three other stations on the Vermejo River, Ponil Creek, and Rayado Creek indicates weak relationships (Appendix F1), but the scatter is very large, indicating that flow at the base station is not a very strong predictor of flow that will occur at the other stations (an expected result given the different elevations and locations of the stations). Because these and other comparisons indicated no strong inter-station relationships among the gage sites, this approach was rejected as a consistently reliable method of estimating the surface water supply in the planning region.

A third approach analyzes, both graphically and statistically, surface water records from key supply watersheds to determine the characteristics that define realistic scenarios (i.e., patterns of wet, average, and dry years) of surface water supply and identify the scenarios that are most likely to occur. Because it is based on measured data rather than model simulations, this technique was determined to be the best method of analyzing the available sparse and highly variable data set and was therefore used to estimate the available surface water supply over the next 40 years.

In this approach, the descriptive statistics of a water supply source are determined from the records analyzed. For the Colfax County study, the median annual yield was selected as a key variable because it represents a central value relative to which flows can be categorized (i.e., either above or below the median). The median (a value where half of the yields are above the value and half are below) is a more conservative indicator of annual yield than average yield because the data are heavily skewed to the higher values and the average is therefore larger than the median. At many gage sites, however, the median and average annual yields are close to one another (Figure 5-9).

For water supply planning, it is particularly important that the region focus on being prepared for those times when precipitation and streamflow are below normal. Table 5-5 shows the streamflow at each station that represents the amount of flow present when flows are either in the lowest 10 percent or the lowest 25 percent of all the flows. These values indicate the amount of flow that might be expected in lower flow years. In evaluating any of these flows, it is important to consider the upstream diversions (Figure 5-8), which may affect the reported streamflow.

Another important analysis is the probability of more than one drought year occurring consecutively (i.e., the probability of a series of drought years). To determine that probability, the annual yields can be categorized to represent conditions such as dry (the lowest flow years), average, and wet (the highest flow years). Once the categories for each year are defined, the "transitions" from year to year can be determined. This is done by counting the number of times a water yield at a station moves from one category to another, such as, for example, how often a year with a normal water yield at a particular station is followed by an above normal water year, or a station experiences two or more consecutive years of below normal yields. These counts can be used to estimate the probability of going from one type of category to another type. The transition probabilities are used to estimate the likelihood of various scenarios, such as a series of three drought years in a row, or one drought, one normal, then another drought year.

Although the inter-station relationships of water yields are not strong, they do exist. It is convenient to select a key station and use that station to define the water years that comprise the different categories. Then the water years of the remaining stations of interest are classified into the same categories as the key station. If each station was assigned its own classifications, then there would be widespread mismatches when compared to the others. Although not a perfect approach, it provides some consistency, and in most cases, the existing inter-station relationships of water yields are such that there is a fairly close match of categories among stations within a given year. More importantly, the resulting grouping of station yields more truly reflects the events that took place; that is the grouping does not become overly conservative by selecting the worst case at each location.

For Colfax County, the Vermejo River near Dawson gage was selected as a key station because upstream diversions are small in relation to the natural flows and the watershed area contributing to the station is relatively large. Two other data sets, the Rayado Creek near Cimarron station and the sum of the Cimarron River below Eagle Nest Dam and Ponil Creek gage stations (referred to here as Cimarron River), were also selected for evaluation. For the Cimarron River composite data, storage changes in Eagle Nest were considered in order to correct Cimarron flows either for releases from storage or additions to storage.

For all three data sets, the number of very dry, dry, average, wet, and very wet years during the 52-year period of record were determined. The threshold values chosen were:

- *Very dry:* Less than 50 percent of the median annual yield
- *Dry:* Between 50 and 20 percent less than the median
- *Average:* Within ±20 percent of the median value
- *Wet:* Between 20 and 50 percent more than the median
- *Very wet:* Greater than 50 percent more than the median annual yield.

The results of these analyses are summarized in Table 5-6.

The matches (e.g., dry-dry, average-average and wet-wet) among the three were then compared. Out of the 52 years, Vermejo and Rayado matched in 27 years, Rayado and Cimarron in 31, and Vermejo and Cimarron in 24.

Table 5-6. Water Year Categories for Selected Gaging Stations 1950 Through 2001

Water Year Category	Occurrence of Water Year Categories (number of years)		
	Vermejo River near Dawson	Rayado Creek near Cimarron	Cimarron River [a]
Very Dry	7	7	15
Dry	14	11	8
Average	13	10	8
Wet	5	4	5
Very Wet	13	20	16

[a] Sum of Cimarron River below Eagle Nest Dam and Ponil Creek gages

Using the Vermejo station as the indicator point, the category transitions (e.g., dry year to average year) from year to year were determined. The frequency of the various transitions is provided in Table 5-7.

As a more useful indicator of overall water supply than evaluating individual stations, streamflow records from the five upstream stations (Rayado Creek, Cimarron below Eagle Nest, Ponil Creek, Vermejo near Dawson, and Canadian near Hebron) were evaluated to estimate the total yield in the watershed. Total streamflow from the upstream gages represents most of the flow in the county, except for the ungaged flows north and east of Raton and the ungaged tributaries below the station; significant additional flow is not contributed below these gages except in the wettest years when ephemeral streams contribute significant flows.

In evaluating the sum of the upstream stations, yields from the Cimarron River below Eagle Nest Reservoir were corrected based on storage changes in the reservoir. Using the corrected Cimarron flows, the sum of the yields from the five watersheds indicated a median flow of approximately 45,500 acre-feet per year and minimum and maximum flows of about 11,400 and 146,800 acre-feet per year, respectively. These values represent the best overall characterization of the water supply for Colfax County.

The frequency of transitions from one category of water year to another (based on the same selection point for very dry, dry, average, wet, and very wet years) was also evaluated for the five upstream stations combined (Table 5-7). Perhaps the most important of these results for regional water planning is the high probability of having two dry or very dry years in a row.

Table 5-7. Frequency of Transitions Between Water Year Categories 1950 Through 2001

Transition		Frequency of Occurrence (% of time)	
From	To	Vermejo River near Dawson	Five Upstream Stations [a]
Very dry year	Very dry year	14	27
	Dry year	29	27
	Average year	14	18
	Wet year	14	18
	Very wet year	29	9
Dry year	Very dry year	23	11
	Dry year	46	33
	Average year	8	22
	Wet year	8	0
	Very wet year	15	33
Average year	Very dry year	8	18
	Dry year	38	9
	Average year	8	9
	Wet year	15	9
	Very wet year	31	55
Wet year	Very dry year	0	50
	Dry year	0	0
	Average year	40	13
	Wet year	20	25
	Very wet year	40	13
Very wet year	Very dry year	8	8
	Dry year	8	25
	Average year	62	33
	Wet year	0	25
	Very wet year	23	8

[a] Rayado Creek, Cimarron below Eagle Nest, Ponil Creek, Vermejo near Dawson, and Canadian near Hebron

5.2 Groundwater Supply

Though most of the water supply needs of the Colfax planning region are met through surface water resources, groundwater is also an important resource that may be useful in meeting future demands of the region. This section describes the groundwater resources of the region.

In order to actively manage groundwater resources in New Mexico, the New Mexico Office of the State Engineer (OSE) has the authority to delineate groundwater basins that require a permit for groundwater withdrawals; these basins are referred to as “declared underground water basins.” Colfax County encompasses parts of two declared underground water basins (Figure 5-11, Figure B-7): the western three-fourths of the county lies within the Canadian River Basin, while the southeastern corner of the county lies within the Tucumcari Basin. Groundwater in the northeastern part of the county is currently undeclared (Figure 5-11). Additional details regarding declaration of groundwater basins are provided in Section 4.

5.2.1 Hydrogeologic Framework

The county includes parts of two major physiographic provinces:

- The westernmost portion of the county encompasses part of the Southern Rocky Mountains Province, including the Cimarron Range and the eastern slopes of the Taos Range within the Sangre de Cristo Mountains. This province is characterized by high mountain areas with elevations ranging from 7,000 to more than 12,000 feet above mean sea level (msl).

- The remainder of the county falls within the Raton Section of the Great Plains Province. This area is characterized by pediments, plains, and high plateaus dissected by the Canadian, Vermejo, and Cimarron River systems; surface elevations range from 5,500 to 7,000 feet msl. This topography is punctuated by volcanic cindercones and mantled by basalt flows in parts of the northeast and eastern portions of the county.

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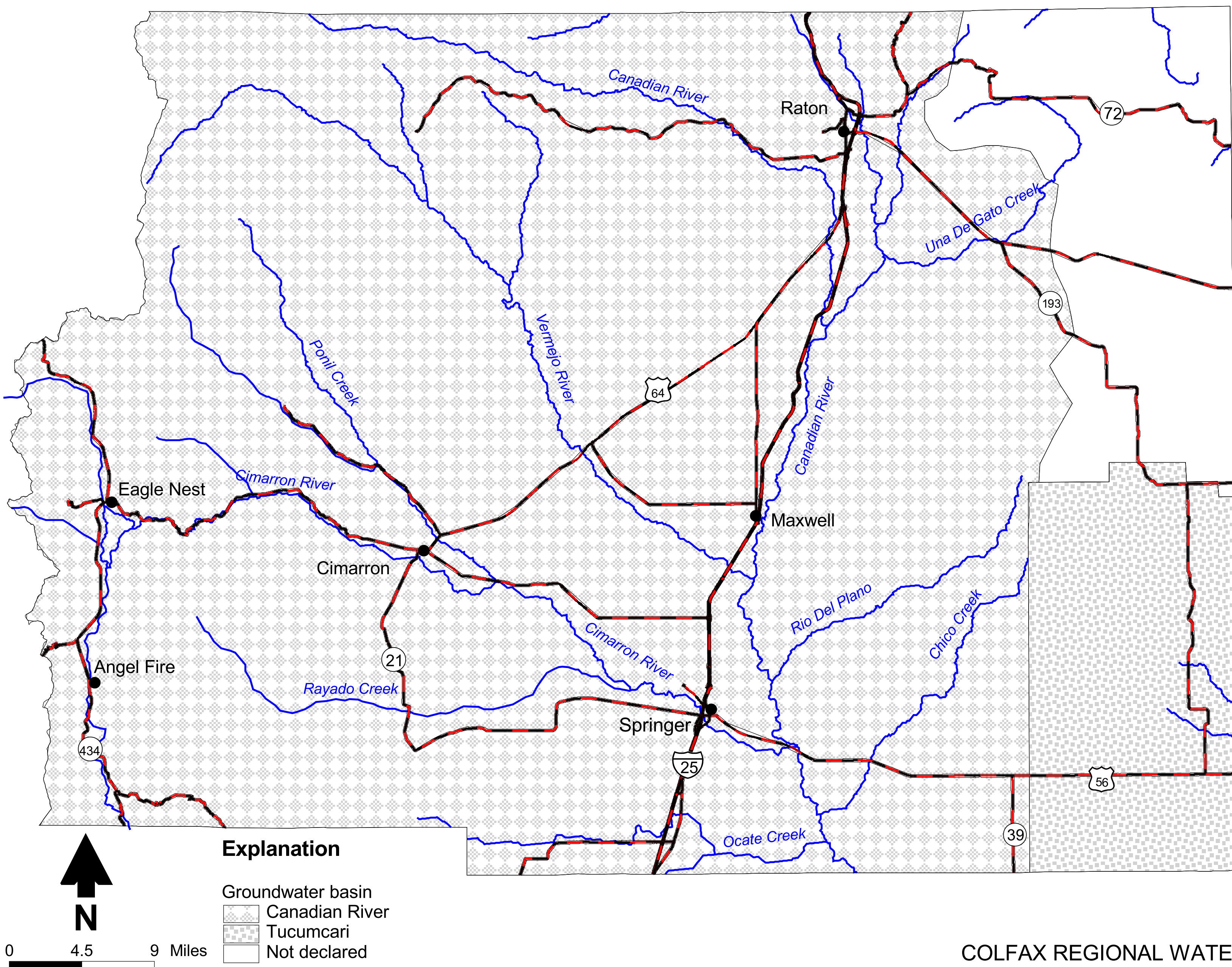

Explanation

Groundwater basin
- Canadian River
- Tucumcari
- Not declared

COLFAX REGIONAL WATER PLAN

OSE-Declared Underground Water Basins in Colfax County

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Figure 5-11

The occurrence of groundwater in each of these provinces is controlled by their varying hydrogeologic conditions, dependent upon localized geologic structures, stratigraphy, and geologic formation lithologies. A generalized stratigraphic section for the county, as derived by Ballance (1967), is provided in Table 5-8 Locations of primary water-bearing formations and groundwater resource areas are shown on Figures 5-12 and 5-13, respectively, and surface geology of the county is illustrated in Appendix B, Figure B-8.

Rock formations exposed within the county range in age from Precambrian to Quaternary. The oldest units are the Precambrian granitic, gneissic, and metasedimentary rocks, which are exposed in parts of the Cimarron Range and the eastern slopes of the Taos Range but are elsewhere overlain by thick sequences of sedimentary rocks ranging from Pennsylvanian through Tertiary in age. The total aggregate thickness of these rocks ranges from about 3,000 feet at the eastern edge of the county to about 10,000 feet in the western part (Roberts et al., 1976). Sedimentary rock types present include shale, mudstone, siltstone, fine- to coarse-grained sandstone, conglomerate, dolomite, limestone, and anhydrite. At the surface, these sequences are intermittently capped with unconsolidated alluvial, pediment, and terrace deposits of Quaternary age and Quaternary through Tertiary lava flows.

Structural geology within Colfax County is principally defined by three major tectonic features: the Sangre de Cristo Uplift in the western part, the Raton Basin in the central part, and the Sierra Grande Arch in the southeastern part.

- The Sangre de Cristo Uplift comprises a zone of structural complexity under development since Precambrian time that extends from Colorado southward to near Las Vegas, New Mexico. This zone is characterized by north-trending high- to low-angle thrust faults, high-angle normal faults, and northwest-trending transverse faults along with symmetric to asymmetric folds that have disrupted all formations to various degrees (Colpitts and Smith, 1990). The Sangre de Cristo Mountains near the western county boundary represent the surface expression of this uplift and structural deformation.

- The uplift of the Sierra Grande Arch during Pennsylvanian time resulted in the preservation of the thick continental and marginal marine sedimentary sequence in

Table 5-8. Generalized Stratigraphic Section for Colfax County, New Mexico
Page 1 of 2

System	Stratigraphic Unit	Thickness (feet)	Distribution	Physical Properties	Water-Bearing Characteristics
Quaternary	Alluvium [a]	Generally less than 100	Tributaries to Arkansas River, Tucumcari area.	Silt, sand, and gravel.	Yields small to moderate quantities of water to wells. Generally yields fresh water in most areas.
	Pediment and terrace deposits [a]	0 to 100	Cap flat-top mesas near Canadian River and large tributaries. Terraces are prominent along the large stream valleys.	Silt, sand, gravel, and boulders.	Recharge by precipitation or surface flow. May yield small to moderate quantities of water to wells; generally yields fresh water.
Quaternary and Tertiary	Volcanic complex [a]	0 to 1,000	Cap many high mesas, occur as channel deposits, dikes, sills, and interbedded with sedimentary rocks.	Basalt, cinders, and fine to coarse basaltic alluvium, scoria, pumice.	May yield small to large quantities of water to wells depending on fractures and saturated thickness. Generally is not a principal aquifer. Generally yields fresh water.
Tertiary	Ogallala Formation [a]	0 to 400	Mostly in south-central and eastern parts of Canadian River basin.	Irregularly bedded sand, grit, and local conglomerate cemented by caliche and local beds of shale, clay, and limestone.	Recharged by precipitation, varies in permeability. May yield small to medium quantities of water to wells; generally yields fresh water.
	Poison Canyon Formation	---	Underlies high mesas.	Conglomerate, arkose, sandstone, siltstone, and shale; intertongues with the Raton Formation.	Not known to yield water to wells.
	Raton Formation [a]	1,000	Generally underlies high mesas.	Conglomerate and sandstone; black shale with coal beds; intertongues with Poison Canyon Formation.	Recharged from rainfall and snowmelt; spring discharge in many places. Yields small quantities of water to wells at some places; generally yields fresh water.
Cretaceous	Vermejo Formation and Trinidad Sandstone	100±	North and east of Raton. Coal mined in this formation in Colfax County.	Interbedded sandstone and shale with coal beds.	Not known to yield water to wells.
	Pierre Shale and upper part of Niobrara Formation [a]	1,650	Outcrops in large areas in southern Colfax County and Mora County.	Compact shale with thin calcareous beds and nodules.	Yields small amounts of water to wells in the weathered zone of the formation. Generally yields slightly saline water.
	Fort Hays Limestone Member of Niobrara Formation [a]	900+	Exposed on gentle soil-covered slopes in Colfax County.	Thin-bedded marine limestone with some thin shale interbeds.	Permeability depends on interconnected fractures and bedding-plane openings. Yields small quantities of water to wells in some areas. Generally yields fresh water.
	Carlile Shale [a]	220±	San Miguel and Colfax Counties.	Sandy shale with some beds of sandstone.	Yields small quantities of water to wells. Generally yields slightly saline water.
	Greenhorn Limestone [a]	35+	Exposed along streams and ridges in Union and Colfax Counties.	Marine limestone with thin interbeds of shale.	Yields water to some stock and domestic wells; water is hard but fair quality.

Source: Ballance, 1967

--- = Information not available.

[a] Known or probable aquifer, regardless of areal extent or production potential.

Table 5-8. Generalized Stratigraphic Section for Colfax County, New Mexico
Page 2 of 2

System	Stratigraphic Unit	Thickness (feet)	Distribution	Physical Properties	Water-Bearing Characteristics
Cretaceous (cont.)	Graneros Shale [a]	215	Exposed along streams and ridges in Union and Colfax Counties.	Dark fissile shale with sandy shale and some thin sandstone beds at base.	Yields small quantities of water to wells; quality of water is generally slightly saline but suitable for livestock.
	Dakota Sandstone (also Purgatoire Formation in Union County) [a]	200±	Exposed on hillsides and streams in reach of the Arkansas River basin.	Conglomeratic sandstone, sandstone, and shale.	Best source of stock and domes-tic water in many areas. Generally yields fresh water.
Jurassic	Morrison Formation [a]	100 to 370	Colfax, San Miguel, Union, and Harding Counties.	Fine-grained shale and sandstone.	Poor source of water; yields small quantities of water to some wells. Generally yields fresh water.
	Entrada Sandstone [a]	175	Union, Harding, and Quay Counties.	Fine-grained massive sandstone.	Principal aquifer in Tucumcari area; of little importance as aquifer elsewhere; has small recharge area. Yields small quantities of water to wells locally; generally yields fresh water.
Triassic	Chinle Formation and Santa Rosa Sandstone [a]	1,000+	Exposed over small area in Colfax County and large area on plains of San Miguel County.	Interbedded red shale, siltstone, sandstone.	Santa Rosa Sandstone is an important aquifer for stock and domestic wells in San Miguel County. Chinle Formation is less important but supplies small quantities of water to some wells. Generally yields slightly to moderately saline water.
Permian	San Andres Limestone [a]	50 to 400	Union and San Miguel Counties.	Dolomite, anhydrite, and fine-grained sandstone.	Varies in permeability; yields small quantities of water to stock and domestic wells in San Miguel County. Generally yields fresh water.
	Yeso Formation	100 to 500	Southwest Union County.	Fine- to coarse-grained sandstone and mudstone.	Not known to yield water to wells.
	Glorieta Sandstone [a]	---	San Miguel County.	Quartzitic sandstone.	Yields small quantities of water to some wells. Generally yields fresh to slightly saline water.
Pennsylvanian	Sangre de Cristo Formation (locally also Magdalena Limestone)	600 to 1,000	Probably underlies all of the northern part of the Arkansas River basin.	Shale and feldspathic sandstone.	Yields small quantities to stock wells in western Colfax and San Miguel Counties.
	Sedimentary rocks	3,500 to 4,000	Western Colfax County and Cimarron Range.	Limestone, shale, arkose, and sandstone.	Not known to yield water to wells.
Precambrian	Metamorphic and igneous rocks	---	Exposed in the Cimarron Range and several places along the western boundary of Colfax County.	Granite, gneiss, schist, and quartzite.	Not known to yield water to wells.

Source: Ballance, 1967 --- = Information not available.

[a] Known or probable aquifer, regardless of areal extent or production potential.

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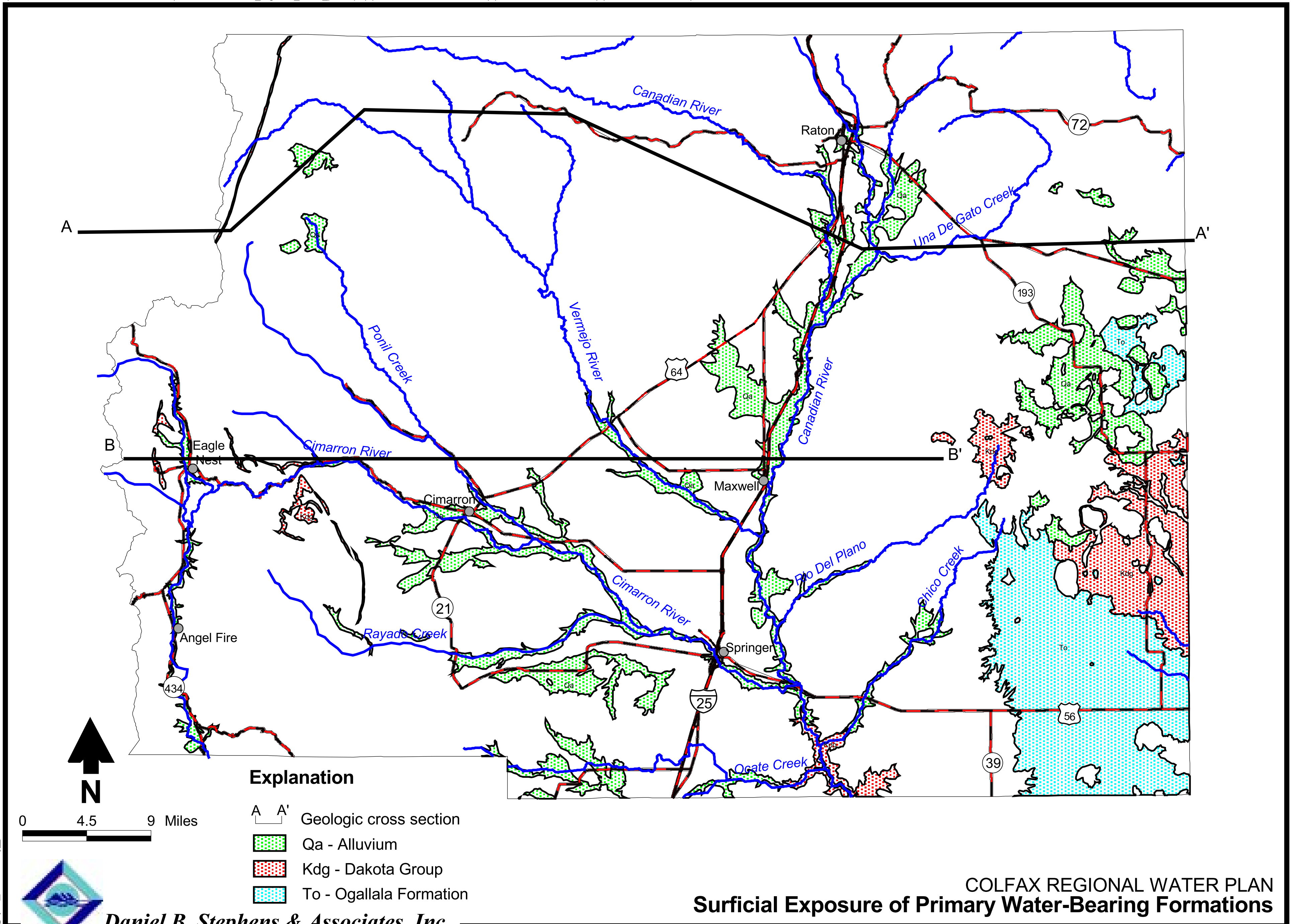

Figure 5-12

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COLFAX REGIONAL WATER PLAN
Surficial Exposure of Primary Water-Bearing Formations

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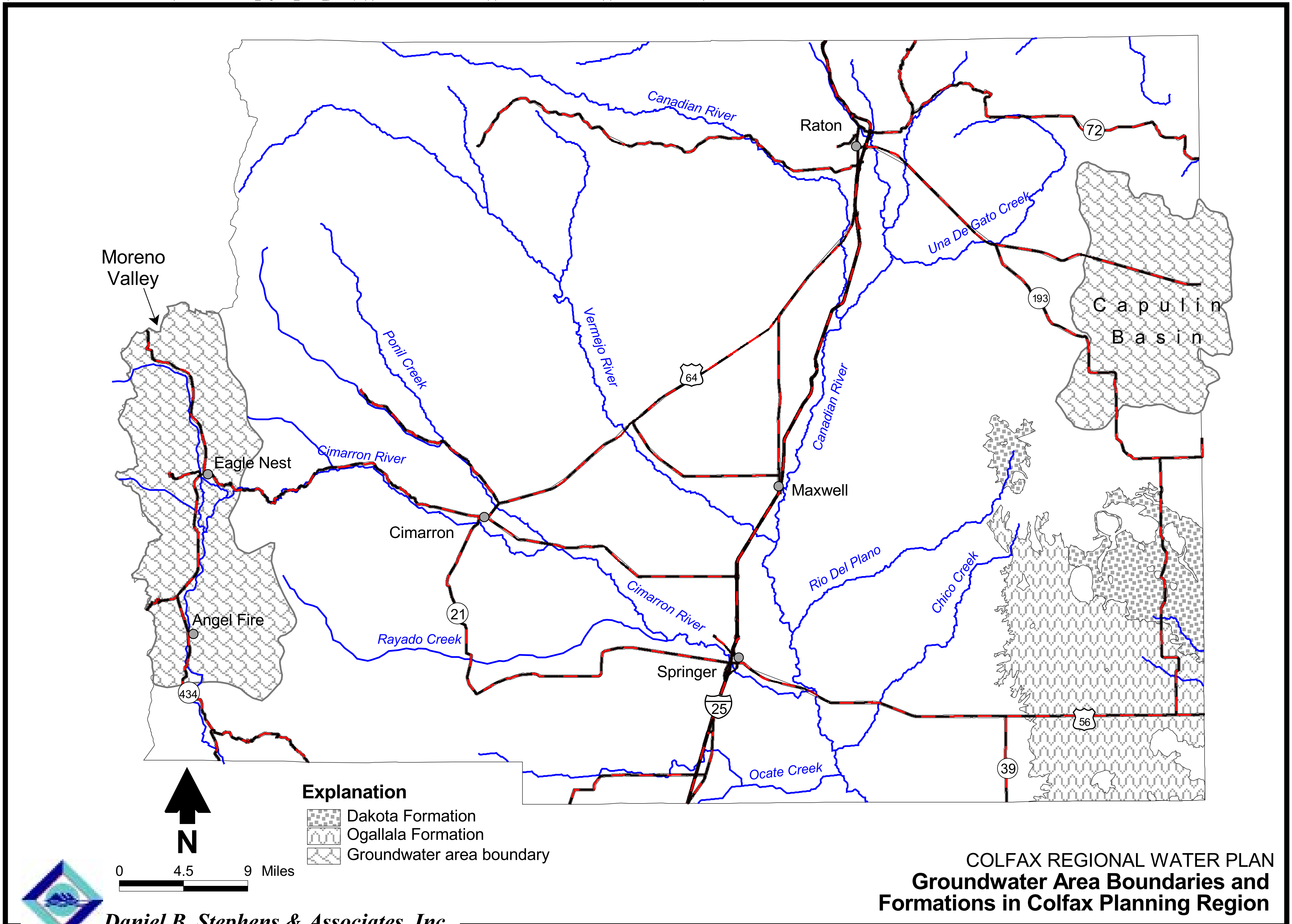

COLFAX REGIONAL WATER PLAN

Groundwater Area Boundaries and Formations in Colfax Planning Region

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Figure 5-13

upper Pennsylvanian and Permian (late Paleozoic) strata (Roberts et al., 1976). This feature is expressed in the subsurface as a northeast-trending structural high in the Precambrian rocks that is flanked by Pennsylvanian and older age units and unconformably overlapped by the Permian and Triassic age sediments.

- The intervening area between these uplifts comprises the Raton Basin, a subsurface structural low where Triassic, Jurassic, and Cretaceous sediments accumulated.

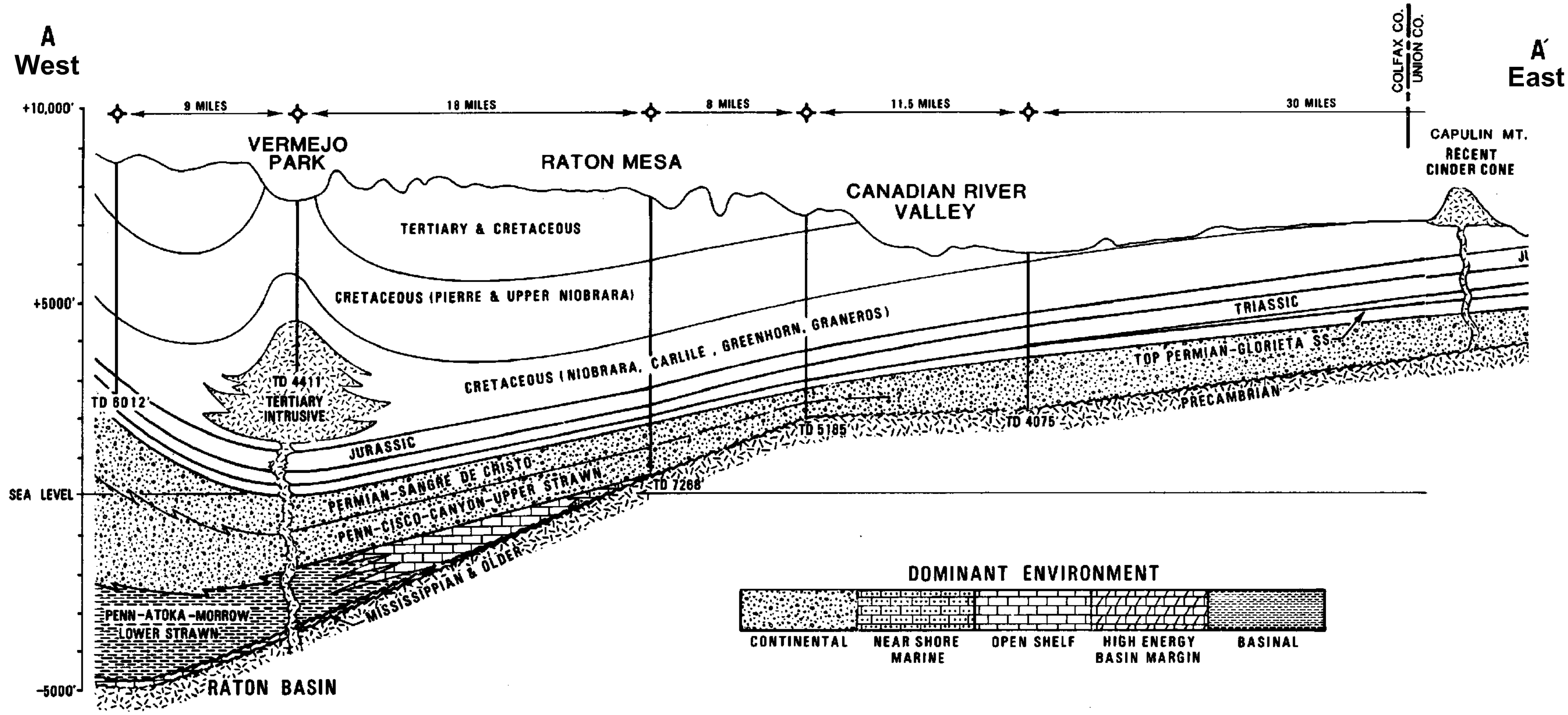
These structural features and the subsurface stratigraphy are illustrated by west to east trending cross-sections A-A’ and B-B’ (Figures 5-14 and 5-15, respectively, locations shown in Figure 5-12).

5.2.2 Primary Water Bearing Formations

Ballance (1967) identified the major geologic formations that occur in Colfax County (Table 5-8):

- Quaternary-age alluvium, pediment, and terrace deposits
- Quaternary and Tertiary age volcanics
- The Tertiary age Ogallala and Raton Formations
- The Cretaceous age Pierre Shale, Fort Hays Limestone, Carlisle Shale, Greenhorn Limestone, Graneros Shale, and Dakota Sandstone Formations
- The Jurassic age Morrison Formation.

Most of these formations have seen only very limited development and have low development potential due to a variety of reasons, including limited and sporadic occurrence, excessive depths, poor water quality, and unfavorable hydrologic conditions such as low permeability and limited saturated thickness. These formations may be able to provide some water supply in selected locations, and in areas where the quality of that water is poor, it may be possible to treat the water to bring it to an acceptable quality for some uses. A search of available literature sources identified the following formations as having the best potential for future groundwater development:



Source: Modified from Roberts et al., 1976

Explanation

⌖	Well or borehole location
TD	Total depth

COLFAX REGIONAL WATER PLAN

Geologic Cross Section A-A'

Figure 5-14

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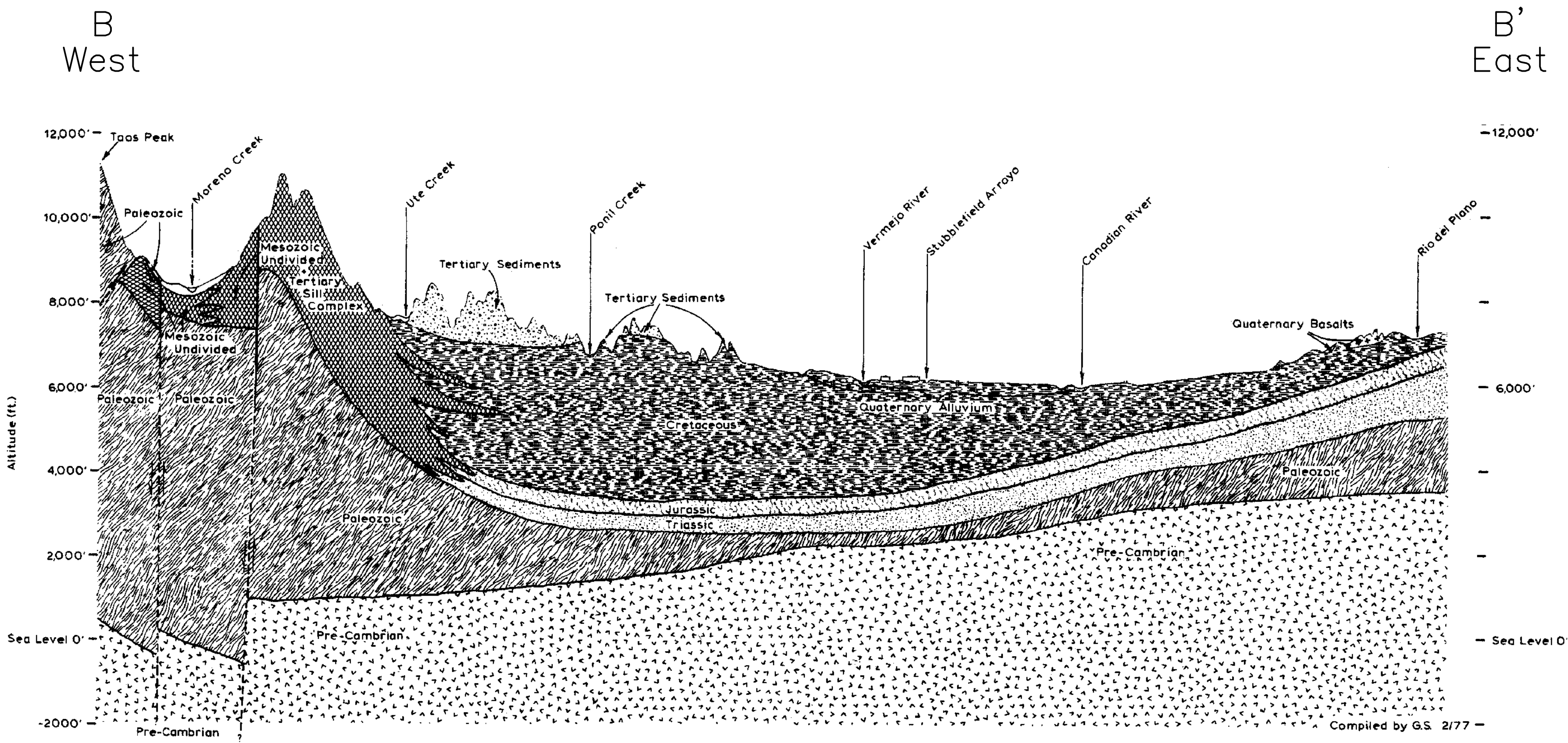

Source: Modified from Herkenhoff and Summers, 1977

COLFAX REGIONAL WATER PLAN

Geologic Cross Section B-B'

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Figure 5-15

- Alluvial deposits
- The Ogallala Formation
- The Dakota Sandstone Formation
- Sandstones and siltstones of the Moreno Valley
- Intermixed alluvial and volcanic deposits of the Capulin Basin

The locations of the surface outcrops of these formations are shown in Appendix B, Figure B-8. Sections 5.2.2.1 through 5.2.2.4 discuss the hydrologic characteristics of these formations and their groundwater supply potential and provide estimates obtained from literature sources (where such information exists) of available groundwater supplies.

5.2.2.1 Alluvium

Alluvium consists of clay, silt, sand, gravel, and cobbles that are deposited by surface water transport. Alluvial deposits in Colfax County occur in present stream channels and adjacent floodplains, as well as in an upland plain areal deposit in the Capulin Basin west of Capulin Peak near the east-central county boundary. Typical porosities for mixed sand and gravel range from 20 percent to 35 percent, while silt and clay can have porosities as high as 60 percent (Fetter, 1994). Thus, alluvial deposits often provide favorable conditions for shallow groundwater occurrence.

However, hydraulic conductivities of unconsolidated sediments are highly variable depending on the silt and clay content along with sand and gravel proportions, typically ranging from 10^{-5} to 10^{-1} cm/s (0.28 to 2800 feet per day [ft/d]) in silty sands and from 10^{-4} to as high as 100 cm/s (2.8 to 280,000 ft/d) in clean sands and gravels (Freeze and Cherry, 1979). Thus, the coarse-grained textural components and unconsolidated nature of alluvial deposits can elicit fairly high permeabilities in places. Such conditions generally allow some degree of saturation to exist in areas adjacent to perennially flowing streams; however, conditions favorable to placement of water supply wells are not consistent and are highly dependent on localized lithologies.

The thickness of the alluvium in Colfax County ranges from a feather edge to more than 50 feet along the major streams (Griggs, 1948). The lateral width of these deposits varies considerably, but in places along the Canadian River they extend more than a mile from the stream. As shown in Figure 5-12, alluvial deposits adjacent to major streams occur throughout the county and may provide a significant resource for future water supply development.

Griggs (1948) documented numerous wells completed in alluvium along the Canadian River and its tributaries in eastern Colfax County. The alluvium along the Vermejo River at Dawson and along Crow Creek at Koehler has a high permeability, and alluvial groundwater was the source of public water supply for these now abandoned mining camp communities. Alluvium thickness exceeds 30 feet with observed saturated thicknesses in the Vermejo Park Ranch headquarters area ranging up to 15.5 feet and averaging 8.7 feet (W.K. Summers & Associates, 1977).

Although the average saturated thickness for alluvial groundwater throughout the county is estimated at only about 5 feet, well records indicate that encountered alluvium thicknesses are as great as 71 feet with 42 feet of saturation (at a well 3 miles southwest of Raton) (Griggs, 1948). Pump tests of eight wells completed in the alluvium along the Canadian River at Vermejo Park Ranch yielded an average specific capacity of 41.7 gallons per minute per foot of drawdown and an average hydraulic conductivity of 2.1 x 10^{-1} cm/s (585 ft/d) (W.K. Summers & Associates, 1977). In the Capulin area, saturated thicknesses of as much as 100 feet and well yields as high as 300 gallons per minute (gpm) have been observed (Dinwiddie and Cooper, 1966); this groundwater is contained within both alluvial deposits and volcanic features of the Capulin Basin, as discussed in more detail in Section 5.2.3.2.

Because alluvial saturation along the present stream channels is dependent upon streamflow conditions, this water source will be diminished during periods of drought and low runoff. In addition, the quality of this alluvial groundwater is variable, depending on the nature of the constituent rock types of the sediments. These factors generally preclude consideration of alluvial groundwater as a major dependable water supply resource. However, it may provide adequate water supplies on a limited basis in specific local areas where conditions are favorable. Accurate determination of the magnitude of this potential water resource will require a more comprehensive and detailed analysis, including field investigations, which are not included in the regional water planning process.

5.2.2.2 The Ogallala Formation

The Ogallala Formation crops out within an area encompassing nearly five townships in the southeast corner of the county (Figure 5-12). This formation is a well known and highly developed aquifer that covers an extensive area of the Great Plains. It is an important aquifer in neighboring Harding County, where it furnishes water to municipal wells in the vicinity of Mosquero and Roy and exhibits a saturated thickness of 40 to 50 feet (Kilmer, 1987). Its occurrence in Colfax County represents only a small outlier of the formation that has been preserved there. This outlying deposit is a heterogeneous lenticular mass primarily composed of unconsolidated sand, silt, and clay with a basal gravel zone that includes boulders up to 2 feet in diameter. The Ogallala thickness in Colfax County ranges from 130 feet up to 250 feet, thickening toward the southeast corner of the county (Griggs, 1948).

In Harding County, aquifer productivity is best in areas where erosional channels exist in the pre-Ogallala paleo-surface. However, the buried channels have limited lateral extent, and wells drilled to one side or the other of the channel may find no water (Kilmer, 1987). The limited data available for the Colfax County deposit indicate discontinuous saturation in portions of the aquifer associated with low surface hummocks and a buried ridge.

Saturated thickness in the Ogallala Formation within Colfax County ranges up to 30 feet with an estimated average of 15 feet overall. Pump tests performed on two wells indicated specific capacities of 3.5 to 13 gpm per foot of drawdown. Water quality is good, with a specific conductance ranging from 315 to 375 micromhos per centimeter (μmhos/cm) (Griggs, 1948).

Griggs (1948) calculated an estimated groundwater resource of 160,000 acre-feet, assuming an average saturated thickness of 15 feet within an area of about 70,000 acres and a porosity of 15 percent. Recharge to the formation was estimated at 0.1 to 0.2 inch annually over a total surface exposure of roughly 100,000 acres, resulting in an annual recharge volume of 1,000 to 2,000 acre-feet (Griggs, 1948).

A search of the water well records of the USGS and the New Mexico OSE turned up no data specific to this area. Thus, more current public documentation of water production from the Ogallala Aquifer in Colfax County is not available to verify assumed limited withdrawal rates for agricultural or domestic use from this particular aquifer. Domestic use should be small, because this part of the county is sparsely populated. Furthermore, the OSE 2000 water use data indicate an annual total of 915 acre-feet of agricultural groundwater withdrawals for the entire county (Wilson, 2002). Therefore, it is not unreasonable to assume that Griggs' (1948) groundwater resource estimate is still valid. Because this information is so dated, however, more detailed studies are recommended to verify current conditions before any new development plans for this resource are contemplated. In particular, discussions at steering committee meetings indicated that some wells in the area are experiencing water level declines, and a current scientific study would help in evaluating this trend. Because of the relatively small saturated thickness, only limited local irrigation efforts from this aquifer are likely to be supported.

5.2.2.3 The Dakota Sandstone

The Lower Cretaceous age Dakota Sandstone underlies most of Colfax County, but is mostly buried beneath younger rocks. It crops out with limited exposures in the Sangre de Cristo and Cimarron Mountains in the western portion of the county, but its primary surface exposures occur in the eastern part due to its elevation along the rise of the Sierra Grande arch. Throughout the central part of the county, along the axis of the Raton Basin, the formation is buried at depths up to 5,000 feet.

Water can be found in the Dakota Sandstone at depths of 0 to 1,000 feet in areas of the county east of the Maxwell Grant (roughly east of the Canadian River) and at depths of approximately 500 to 2,500 feet within the Maxwell Grant. Downward vertical gradients indicate that recharge to the formation occurs in the vicinity of Capulin Peak and Laughlin Peak (in the far eastern portion of the county, approximately 20 to 35 miles east-northeast of Maxwell). The aquifer has potential for development in the area east of Laughlin Peak, where the depths to water are relatively shallow and water quality is good (Resource Technology, Inc., 1991).

Griggs (1948) documented several wells producing from the Dakota Sandstone in the southeastern part of the county, located southeast of a sinuous line extending from a few miles west of Springer to the northeast through Township 28 North, Range 27 East (T28N, R27E), near Cunico. The aquifer occurs at shallow depths throughout much of this area, with most recorded water levels between 30 and 130 feet deep (Griggs, 1948). The aquifer in this area is confined by the overlying Graneros shale except where the Dakota crops out in the southeastern corner of the county (Figure 5-12). Reported well yields vary from 16 to 100 gallons per minute (Stone, 1982).

The formation is approximately 200 feet thick and extends over an area of about 3 million acres within the county. Assuming an effective porosity of about 10 percent, an estimated 50 million acre-feet of water is contained in this aquifer (Griggs, 1948), making it by far the largest potential groundwater source in the county. However, the tightly cemented character of the sandstone leads to fairly low transmissivity over substantial areas, limiting its productivity. Griggs (1948) cited an average specific capacity of 1 gallon per minute per foot of drawdown for wells completed in the Dakota.

Most of the wells in the eastern two tiers of townships that produce from the Dakota Sandstone have fairly good water, but areas to the west in the vicinity of Springer produce poor-quality water with elevated levels of sodium chloride, sodium bicarbonate, and fluoride. The specific conductance of Dakota water in this area reportedly ranges from 40 to 910 μmhos/cm (Stone, 1982). The poor-quality water extends at least as far east as section 5 in T25N, R24E (a few miles northeast of Taylor Springs [Figure 5-8]), and the transition to better water quality is probably close to the crest of the Sierra Grande arch. The poor quality is likely related to the presence of localized igneous activity evidenced by the numerous Quaternary dikes and plugs that occur along or west of the crest of this structure, but are absent to the east (Griggs, 1948).

5.2.3 Identified Major Groundwater Resource Areas

Water well records obtained from the USGS and the New Mexico OSE WATERS database (the most complete electronic databases available) were evaluated to determine where areas with significant groundwater development activity are located and to construct potentiometric surface maps in areas where data are sufficient to delineate the water table configuration. This effort identified two major areas of groundwater development where previous well drilling has demonstrated the presence of viable groundwater resources that will likely support additional future development:

- The Moreno Valley
- The Capulin basin

By far, the most intensive groundwater development has occurred within the Moreno Valley, in the southwestern corner of the county. A substantial portion of the well records there are from wells drilled in the 1990s, representing recent water supply development efforts in support of increasing resort and residential growth in this part of the county. The Capulin Basin, located near the east-central border of the county, was defined exclusively by records from the USGS database for wells drilled prior to 1990. Descriptions of these groundwater resource areas are provided in Sections 5.2.3.1 and 5.2.3.2.

5.2.3.1 The Moreno Valley

The Moreno Valley is located in the southern Sangre de Cristo Mountains and includes the resort community of Angel Fire (Figure 5-13). Recent population growth in this area has led to the most intense groundwater development in the county, much of which occurred through the installation of domestic wells. Though the detailed studies necessary to determine the total available groundwater supply here have not been conducted, the existing data suggest that additional groundwater resources are present in the area. However, as discussed in Section 4, development of these resources is limited by water rights constraints.

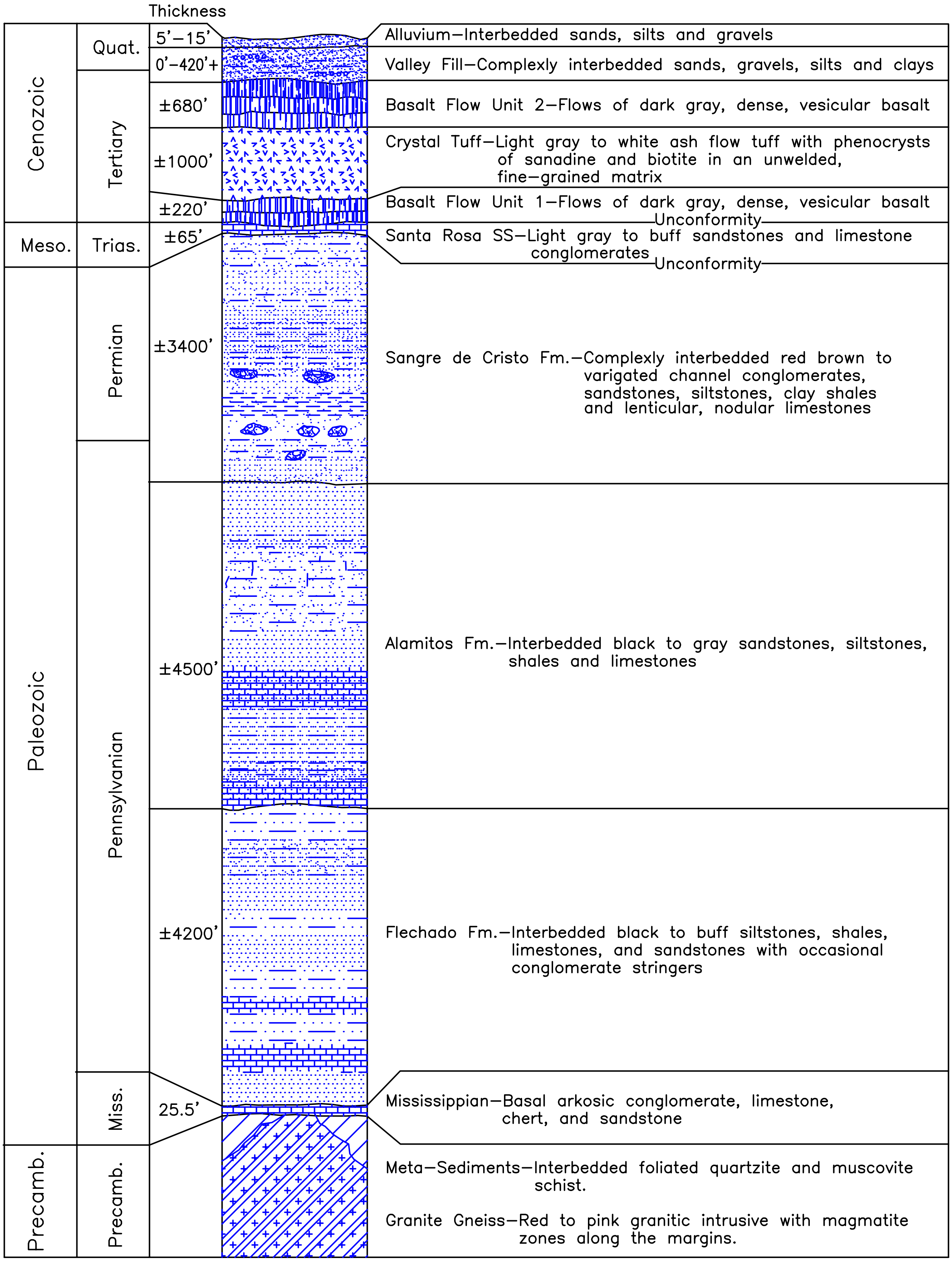
Exposed rocks range from Precambrian to Quaternary in geologic age (Colpitts and Smith, 1990). Appendix B, Figure B-8 shows the surficial geology and Figure 5-16 shows a generalized geologic sequence for the Moreno Valley. Researchers (Abbott et al., 1983; Saye, 1990) have classified four types of water-bearing zones for the Moreno Valley area:

- Unconsolidated Tertiary valley fill: Interbedded red and brown clays, sands, and gravels

- Tertiary dikes and sills: Fractured quartz diorite porphyry

- Mesozoic and Paleozoic sedimentary rocks: Sandstone, siltstone, conglomerate and limestone

- Precambrian crystalline rocks: Mainly faulted and fractured granite gneiss



Source: W. K. Summers & Associates, Inc., 1980

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COLFAX REGIONAL WATER PLAN

Generalized Stratigraphic Column
Moreno Valley

Daniel B. Stephens & Associates, Inc.
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Figure 5-16

The primary source of groundwater for the Moreno Valley is the Mesozoic and Paleozoic sandstone and siltstone water-bearing zone (Saye, 1990). In particular, the Sangre de Cristo Formation is the main source of groundwater for the Village of Angel Fire. This formation was deposited during middle Pennsylvanian to early Permian time and is described as a thick sequence of red mudstone, siltstone, sandstone, and conglomerate (Colpitts and Smith, 1990). The formation thickness ranges from about 3,300 to more than 5,200 feet in the southern and northern portions of Moreno Valley, respectively (Clark and Read, 1972; Colpitts and Smith, 1990). The Moreno Valley aquifer system is recharged by snowmelt and rainfall along the mountains that bound the valley and by return flows from pumped groundwater and surface water diversions.

According to drilling records in the Village of Angel Fire area, the Sangre de Cristo Formation is typically located below 70 to 100 feet of alluvium (Saye, 1990). Wells are generally screened over 200- to 300-foot intervals from 200 to 500 feet below ground surface (bgs) and produce sustained yields between 5 and 278 gpm (Saye, 1990). Water levels in the Village supply wells range from approximately 10 to 300 feet bgs. Pump tests of wells in the Village area indicate specific capacities of 0.1 to 8.5 gpm per foot of drawdown (Water Resource Associates, Inc., 1973). Groundwater in the unconsolidated valley fill is generally very shallow and in many areas is less than 5 feet deep (Gutowsky, 1997).

OSE data from 1990 through 2000 are provided on Plate 2, which displays the water level depths, well depths, and water level elevations for each well in the Moreno Valley with data from this period, as well as a contour map of the groundwater potentiometric surface based on these data. This map shows that groundwater along the west side of the valley generally flows to the east off the flanks of the Sangre de Cristo Uplift, with gradients ranging from about 0.1 foot per foot (ft/ft) near the southwestern boundary to about 0.02 ft/ft near Eagle Nest Lake in the middle of the valley. Groundwater flow in the north half of the valley is to the south toward Eagle Nest Lake with an average gradient of 0.01 ft/ft. Along the eastern side of the valley, flow is toward the west off the flanks of the Cimarron Range at apparent gradients of about 0.03 to 0.05 ft/ft. Groundwater in the valley appears to flow toward Eagle Nest Lake in the center of the valley, although this is not well defined in the southeastern portion, where data are sparse.

Available data were queried to examine water level changes over time and to determine if the basin is being depleted due to the current groundwater withdrawals. Unfortunately, the USGS and OSE databases do not include any monitor wells where water levels are recorded over time; thus no data are currently available to determine whether groundwater levels are declining in the area. The Village of Angel Fire has been experiencing some supply well problems that might be the result of declining water levels; again however, no monitor wells exist in the Village to assess this issue, and a specific investigation of the water supply well issue has not been conducted.

The volume of groundwater in storage in the Moreno Valley was estimated based on the observed saturated thicknesses in existing wells and conservative estimates of specific yield for unconsolidated sediments and sandstone. This estimate indicated that approximately 200,000 acre-feet or more of extractable groundwater may be present in the Moreno Valley. Additional site-specific testing and/or modeling would be required to refine this estimate. However, development of groundwater in the Moreno Valley is dependent on having a water right; the Moreno Valley is considered part of the Cimarron Decree (Section 4.4.1.1), and no new water rights in the area are likely to be issued. Nevertheless, development is occurring through the installation of domestic wells, which may be negatively impacting senior water rights users.

5.2.3.2 The Capulin Basin

The Capulin basin is located south of Johnson Mesa and southwest of Capulin National Monument in eastern Colfax County, extending into western Union County (Figure 5-13). It is a closed topographic basin that drains to its interior. It is bounded on the west by the Canadian River groundwater basin and to the south by the Tucumcari groundwater basin, but groundwater within the Capulin basin has not been declared by the OSE.

The topography in the Capulin Basin area is characterized by flat-lying to gently sloping alluvial plains, shallow closed basins, and scattered playas interrupted by numerous lava flows, volcanic cinder cones, and basalt-capped mesas. The alluvial deposits and volcanics overlie the Late Cretaceous-age Niobrara Formation, a thick sequence of shale, limestone, and fine-grained sandstone that forms an aquitard impeding downward infiltration of groundwater. Basalt flows are as much as 100 feet thick and are highly broken and jointed with rough, blocky surfaces. Slopes surrounding the various cones and vents are underlain by coarse cinders and scoria.

The combined volcanics and alluvial deposits make up the primary aquifer in the Capulin basin (Trauger and Kelly, 1987). The volcanic features in this area are highly porous and serve as recharge conduits capable of transmitting large amounts of precipitation into the subsurface, where it is trapped as groundwater within the closed basin. Where these features lie beneath the water table, they are aquifers exhibiting considerable storage capacity and high transmissivity with porosity values as high as 50 percent. The alluvium underlying most of the valley plain is composed of fine- to medium-grained sand and fine gravel, which are also highly porous and transmissive. A map of the surface geology of the county, including the Capulin Basin, is included in Appendix B, Figure B-8. Figure 5-14 shows a cross-section running west to east through the middle of the basin.

Though incompletely defined, the aquifer likely underlies an area of at least 105 square miles and varies from less than 20 feet to about 180 feet in thickness. Assuming a rather high average porosity of 40 percent, Trauger and Kelly (1987) estimated the groundwater resource to be 740,000 to 900,000 acre-feet. Using a more conservative overall average porosity of 25 percent results in an estimated resource of about 550,000 acre-feet for this aquifer.

A pump test of a production well located in section 18, T29N, R27E yielded a specific capacity of 36 gpm per foot of drawdown with a computed well yield of 2,600 gpm. Water quality is fair, with specific conductance values ranging from 86 to 808 μmhos/cm and total dissolved solids ranging from 274 to 518 milligrams per liter (mg/L) for water produced from alluvium and volcanics (Trauger and Kelly, 1987).

Well data from the USGS database, including water depths, well depths, and water elevations, are shown on Figure 5-17. These data all date prior to 1990, so any additional drawdowns in the aquifer due to groundwater withdrawals are not currently known. Annual recharge to the basin has been estimated at about 11,400 acre-feet (Trauger and Kelly, 1987). Because the recharge occurs close to the principal aquifer, substantial groundwater development over an extended period of time may be possible without significant depletion of the resource. More

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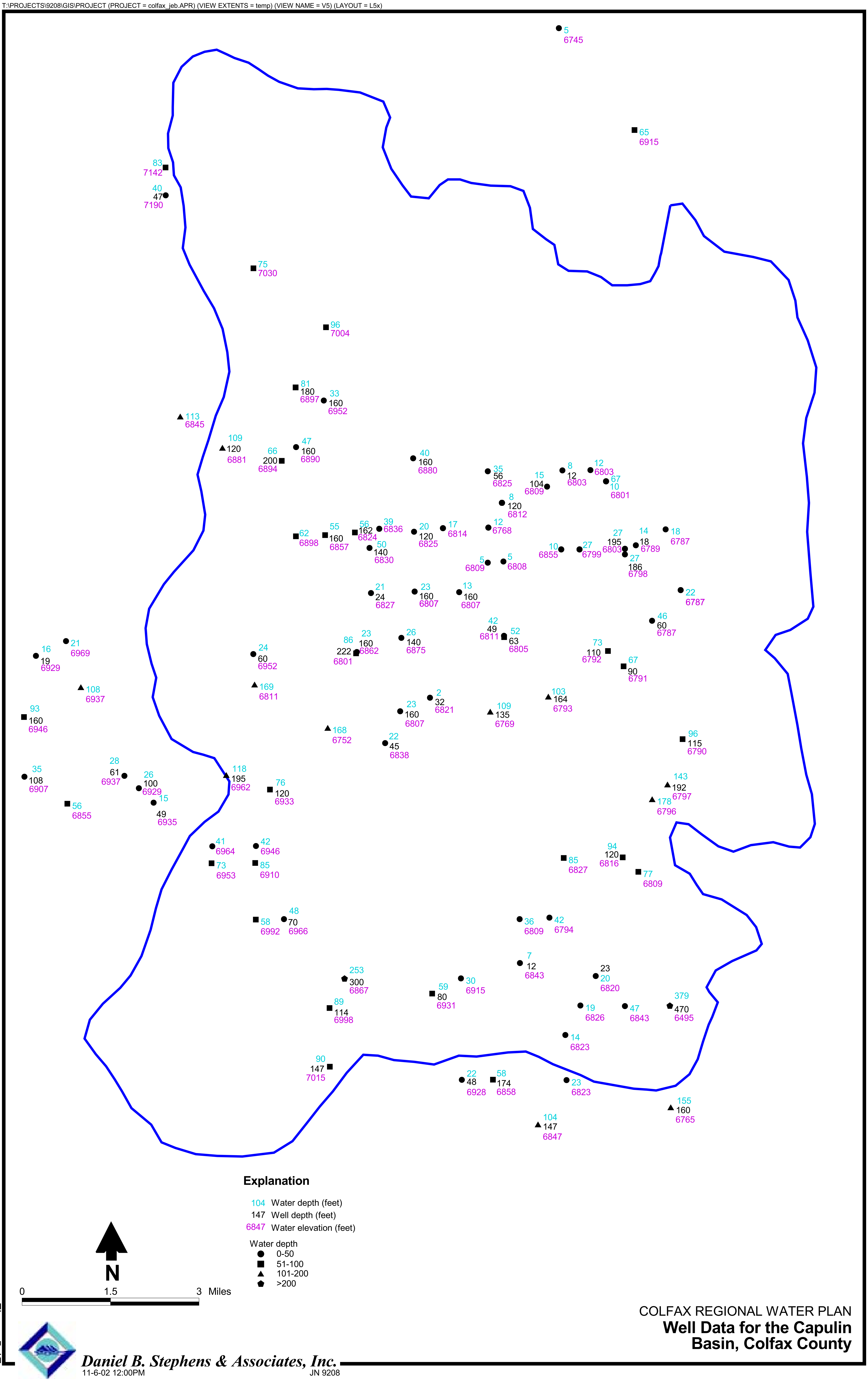

Figure 5-17

detailed studies are required to determine a sustainable yield for this aquifer or the current status of possible water level declines and resource depletion.

5.3 Water Quality Assessment

Assurance of availability to meet future water demands requires not only sufficient quantity of water, but also water that is of sufficient quality for the intended use. In order to meet drinking water quality standards, most water supplies require at least a minimal amount of treatment. Should the water quality of the drinking water supply become significantly degraded, additional and costly treatment must be provided or additional water supplies located. Where drinking water supply options are limited, water quality impairment can be a significant and expensive problem. Although standards are generally not as high for other uses (i.e., irrigation and livestock uses), water quality must nevertheless be high enough to meet these uses, or expensive treatment will be required.

Water quality for Colfax County was assessed through existing documents and databases. Surface water studies that were especially helpful were two documents prepared pursuant to Section 305(b) of the Federal Clean Water Act: (1) a list of surface waters within New Mexico that are not meeting or not expected to meet water quality standards (NMED, 2001b), as discussed in Section 5.3.1.2, and (2) *Water Quality and Water Pollution Control in New Mexico, 2000,* a report prepared by the State of New Mexico for submission to the United States Congress (NMWQCC, 2000). Information regarding groundwater quality was obtained primarily through the USGS Ground Water Sites Inventory (GWSI) database (Section 1.2).

5.3.1 Surface Water

Potential sources of contamination and measured impacts to surface waterbodies are described in Sections 5.3.1.1 and 5.3.1.2, respectively.

5.3.1.1 Potential Sources of Contamination

Sources of contamination are considered point sources if they originate from a single location or nonpoint sources if they originate over a more widespread or unspecified location. Potential point source discharges must comply with the Clean Water Act and the New Mexico Water Quality Standards by obtaining a permit to discharge. These permits are referred to as National Pollutant Discharge Elimination System (NPDES) permits. A summary of NPDES permitted discharges is included in Table 5-9 (NMED, 2001b).

Table 5-9. Colfax County Municipal and Industrial NPDES Permittees

Permit No.	Municipality/Industry
Municipalities:	
NM0020273	Raton
NM0029149	Maxwell
NM0029891	Raton Drinking Water Plant
Industries:	
NM0029459	Pittsburg & Midway, Cimarron Mine
NM0000205	Pittsburg & Midway, York Canyon Mine
NM0030180	Pittsburg & Midway, Ancho Mine
NM0030147	Pittsburg & Midway, Ancho Mine
NM0026522	Raton Public Service
NM0030295	Springer

Nonpoint sources of pollutants are a major concern for surface water in Colfax County. Among the most prevalent of these sources are the effects of historical grazing practices. Additional probable sources of pollutants or threats to surface waters are agriculture, resource extraction, recreation, hydromodification, road runoff, silvicultural activities, road construction, building sites, and septic tanks. Specific pollutants or threats to surface water quality resulting from these nonpoint sources are turbidity, stream bottom deposits, nutrients, metals, pathogens, total phosphorus, temperature extremes, total ammonia, problems with pH, habitat alteration, and overall watershed condition (NMED, 2001b).

5.3.1.2 Existing Surface Water Quality

As discussed in Section 5.1, Colfax County is mostly drained by the Canadian River and its tributaries. Water quality in the high mountain streams in the area is generally good; however, several reaches of rivers within the Canadian Basin have been listed on the 2000-2002 New Mexico 303(d) list (NMED, 2001b). This list is prepared by NMED to comply with Section 303(d) of the federal Clean Water Act, which requires each state to identify surface waters within its boundaries that are not meeting or not expected to meet water quality standards. Table 5-10 lists each of the reaches in Colfax County that are on the 303(d) list; the locations of these reaches are shown on Figure 5-18.

Section 303(d) further requires the states to prioritize their listed waters for development of total maximum daily load (TMDL) management plans. A TMDL documents the amount of a pollutant a waterbody can assimilate without violating a state water quality standard. It also allocates that load capacity to known point sources and nonpoint sources at a given flow. The Cimarron watershed was listed as a high-priority watershed, and two TMDL management plans have already been developed for streams in the Cimarron Basin.

The first TMDL management plan developed for the Cimarron Basin addresses exceedances of turbidity, stream bottom deposits, and total phosphorus along four stream segments (Figure 5-18):

- Cieneguilla Creek from the inflow to Eagle Nest Lake to the headwaters
- Sixmile Creek from the inflow to Eagle Nest Lake to the headwaters
- Moreno Creek from the inflow to Eagle Nest Lake to the headwaters
- North Ponil Creek from the confluence with South Ponil Creek to the mouth of McCrystal Creek

The main source of impairment to the above-mentioned stream segments is streambank destabilization. Along Cieneguilla Creek, for example, improper installation and maintenance of culverts has led to serious streambank destabilization and has altered the geomorphology of the stream near roads. Additionally, construction and development in the Cieneguilla Creek watershed area may contribute to erosion and sedimentation (NMED, 2000). Because phosphorus sorbs to sediment particles, a strong correlation is generally seen between turbidity and total phosphorus.

Other instances and causes of streambank destabilization include:

Table 5-10. State of New Mexico Draft 2000-2002, §303(d) List for Assessed Stream and River Reaches in Colfax County
Page 1 of 3

Water Body Name	Total Size Affected [a] (mi^2)	Probable Source(s) of Pollutant	Specific Pollutant	Date TMDL Due	Uses not Fully Supported
Black River from the mouth on the Pecos River to the headwaters	16.9	Unknown	Unknown	December 31, 2017	WWF
Raton Creek form the mouth on Chicorica Creek to the headwaters	17.3	Municipal point sources Rangeland Unknown	Plant nutrients	December 31, 2017	LWWF
Chicorica Creek from the mouth on the Canadian River to Raton Creek	9.2	Rangeland	Plant nutrients	December 31, 2017	LWWF, IRR
Cieneguilla Creek from the inflow to Eagle Nest Lake to the headwaters	13.6	Domestic point sources Rangeland Recreation	Plant nutrients [b]	December 31, 1999	HQCWF, IRR
		Rangeland Recreation	Stream bottom deposits	TMDL written and approved	
		Removal of riparian vegetation Streambank modification/destabilization	Turbidity		
		Rangeland Animal holding/management areas Wildlife impacts	Fecal coliform		
		Removal of riparian vegetation	Temperature	December 31, 2017	HQCWF
		Unknown Natural	Metals (aluminum)		
Sixmile Creek from the inflow to Eagle Nest Lake to the headwaters	6.6	On-site wastewater systems Rangeland Animal holding/management areas Wildlife impacts	Fecal coliform	TMDL written and approved	HQCWF
		Rangeland Removal of riparian vegetation Streambank modification/destabilization	Turbidity		

[a] Area within State of New Mexico jurisdiction.
[b] Proposed to be removed from the 2000-2002 §303(d) list.

TMDL = Total maximum daily load
WWF = Warmwater fishery
LWWF = Limited warmwater fishery

IRR = Irrigation
HQCWF = High quality coldwater fishery
MCWF = Marginal coldwater fishery

Table 5-10. State of New Mexico Draft 2000-2002, §303(d) List for Assessed Stream and River Reaches in Colfax County
Page 2 of 3

Water Body Name	Total Size Affected [a] (mi^2)	Probable Source(s) of Pollutant	Specific Pollutant	Date TMDL Due	Uses not Fully Supported
Moreno Creek from the inflow to Eagle Nest Lake to the headwaters	14.4	Rangeland	Fecal coliform	TMDL written and approved	HQCWF, IRR
		Rangeland Removal of riparian vegetation Streambank modification/destabilization	Turbidity		
		Recreation Removal of riparian vegetation Streambank modification/destabilization	Plant nutrients [b]	December 31, 1999	
Cimarron River from Turkey Creek to Eagle Nest Dam	17.6	Rangeland Recreation	Total phosphorous [b]	December 31, 2017	HQCWF
		Unknown Natural	Metals		
Cimarron River from the mouth on the Canadian River to Turkey Creek	35.3	Rangeland Removal of riparian vegetation Streambank modification/destabilization	Plant nutrients	December 31, 2017	LWWF
Ute Creek at its mouth on the Cimarron River [b]	4	Rangeland Removal of riparian vegetation	Turbidity	December 31, 2017	HQCWF
		Streambank modification/destabilization	Total phosphorous		
Ponil Creek from the mouth on the Cimarron River to the confluence of North Ponil and South Ponil Creeks	15.8	Removal of riparian vegetation	Temperature	December 31, 2017	HQCWF
		Rangeland Removal of riparian vegetation Streambank modification/destabilization	Turbidity Stream bottom deposits Metals		
McCrystal Creek from the confluence with North Ponil Creek to the headwaters	3	Removal of riparian vegetation	Temperature	December 31, 2017	HQCWF

[a] Area within State of New Mexico jurisdiction.
[b] Proposed to be removed from the 2000-2002 §303(d) list.

TMDL = Total maximum daily load
WWF = Warmwater fishery
LWWF = Limited warmwater fishery

IRR = Irrigation
HQCWF = High quality coldwater fishery
MCWF = Marginal coldwater fishery

Table 5-10. State of New Mexico Draft 2000-2002, §303(d) List for Assessed Stream and River Reaches in Colfax County

Water Body Name	Total Size Affected [a] (mi^2)	Probable Source(s) of Pollutant	Specific Pollutant	Date TMDL Due	Uses not Fully Supported
North Ponil Creek from the confluence with South Ponil Creek to the mouth of McCrystal Creek	17.6	Removal of riparian vegetation	Temperature	TMDL written and approved	HQCWF, IRR
		Rangeland Silviculture Removal of riparian vegetation Streambank modification/destabilization	Stream bottom deposits Turbidity		
		Rangeland Silviculture Streambank modification/destabilization	Total phosphorous		
Middle Ponil Creek from the confluence with South Ponil Creek to the headwaters	20.9	Rangeland Silviculture Removal of riparian vegetation	Total phosphorous [b]	December 31, 2017	HQCWF
		Rangeland Silviculture	Stream bottom deposits		
		Removal of riparian vegetation Streambank modification/destabilization	Turbidity		
		Removal of riparian vegetation	Temperature		
Rayado Creek from the mouth on the Cimarron River to Miami Lake diversion	16.5	Rangeland Removal of riparian vegetation Streambank modification/destabilization	Stream bottom deposits	December 31, 2017	MCWF, WWF
Coyote Creek from mouth on Mora River to Black Lake	30.1	Agriculture Road maintenance/runoff	Stream bottom deposits	December 31, 2017	HQCWF
Little Coyote Creek from inflow to Black Lake to headwaters	1	Road construction	Turbidity Stream bottom deposits Total phosphorous [b] Temperature	December 31, 2017	HQCWF

[a] Area within State of New Mexico jurisdiction.
[b] Proposed to be removed from the 2000-2002 §303(d) list.

TMDL = Total maximum daily load
WWF = Warmwater fishery
LWWF = Limited warmwater fishery

IRR = Irrigation
HQCWF = High quality coldwater fishery
MCWF = Marginal coldwater fishery

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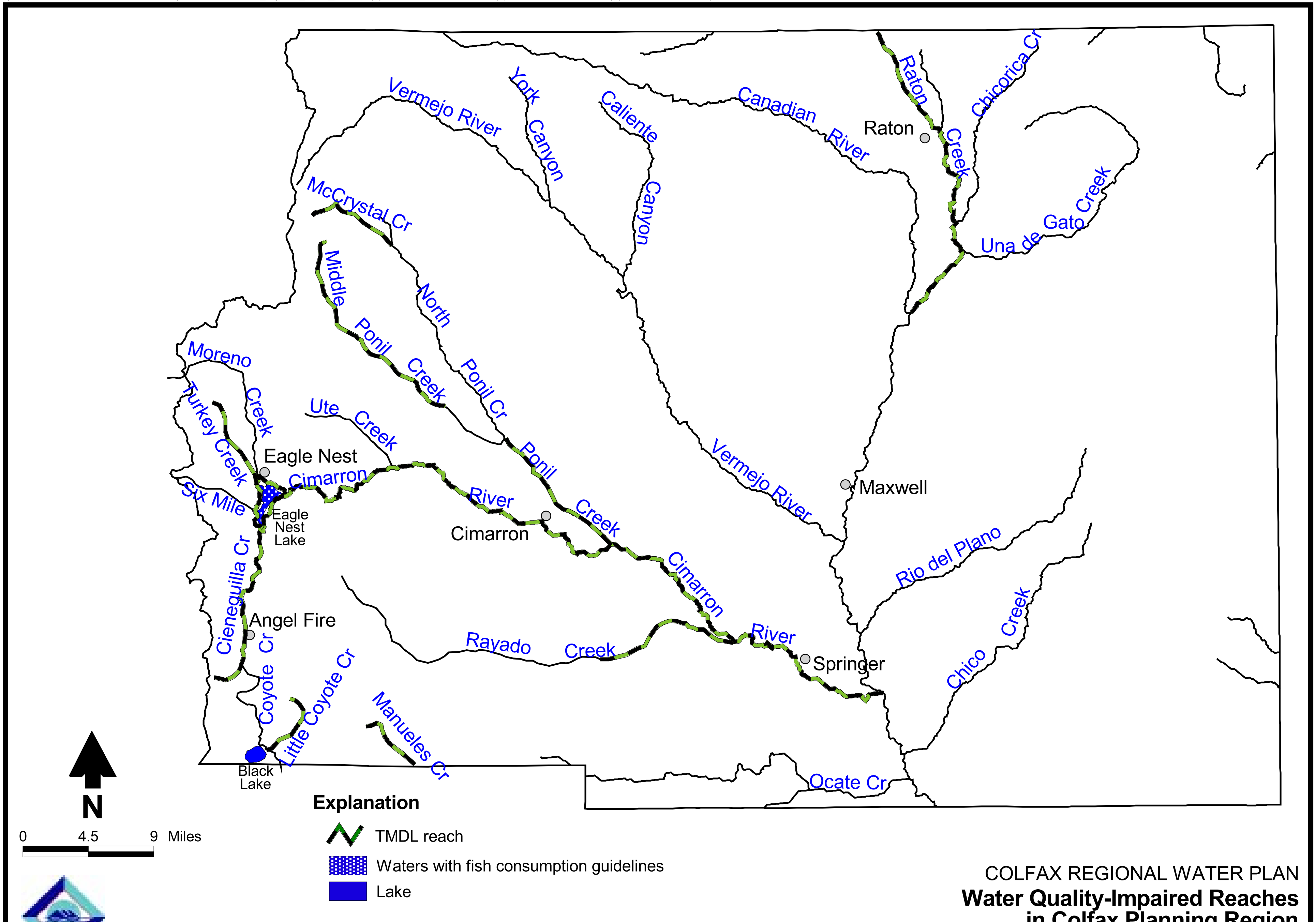

Figure 5-18

COLFAX REGIONAL WATER PLAN
Water Quality-Impaired Reaches in Colfax Planning Region

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- Along Sixmile Creek, streambank destabilization is most likely due to removal of more than 95 percent of the riparian vegetation (except for short grass) and the extensive grazing of rangeland.

- A possible source of impairment to the Moreno Creek segment is a gravel operation, which may have some inputs to the stream.

- On North Ponil Creek it appears that when the U.S. Forest Service removed a fishing pond in 1996 the stream was not restored to its natural geomorphology, thus causing serious stream bank destabilization.

The second TMDL management plan (still in draft form) addresses two areas:

- Exceedances of aluminum along the Cimarron River from its mouth on the Canadian River to Turkey Creek

- Stream bottom deposits along Rayado Creek from its mouth on the Cimarron River to the Miami Lake diversion

The Cimarron River segment has historically been impacted by agriculture, rangeland, roads, and natural aluminum sources, and the primary manifestations of impairment are streambank destabilization and removal of riparian vegetation. The aluminum exceedances in this segment of the river may be a result of surface disturbances but could also be naturally occurring background levels. The Rayado Creek segment is also impaired by streambank destabilization and removal of riparian vegetation as a result of irrigated agriculture, rangeland, and runoff from roads.

In addition to the water quality-impaired streams in the Cimarron basin, two reaches each in the Mora basin and in the Canadian Headwaters basin (Figures 5-1 and 5-18) are listed as impaired in the 303(d) list (Table 5-10):

- Coyote Creek from its mouth on Mora River to Black Lake is listed due to stream bottom deposits from agriculture and road maintenance and runoff.

- Little Coyote Creek from the inflow to Black Lake to its headwaters is listed for turbidity, stream bottom deposits, and temperature from road construction.

- Raton Creek from the mouth on the Chicorica Creek to the headwaters is listed for plant nutrients.

- Chicorica Creek from its mouth on the Canadian River to Raton Creek is listed for plant nutrients.

In evaluating the impacts of the 303(d) list on the regional water planning process, it is important to consider the nature of impairment and its effect on potential use. Problems such as stream bottom deposits and turbidity will not necessarily make the water unusable for irrigation or even for domestic water supply (if the water is treated prior to use). However, the presence of the impaired reaches illustrates the degradation that can occur in the water supply.

In addition to the 303(d) listings, the State of New Mexico has issued fish consumption advisories for four lakes and reservoirs in Colfax County: Eagle Nest Lake, Lake Maloya, Springer Lake, and Stubblefield Reservoir (Table 5-11). These advisories were issued because mercury has been found in some fish at concentrations that could lead to significant adverse human health effects. Although the levels of mercury in waters of these lakes are insignificant, very low levels of elemental mercury found in bottom sediments are passed through the food chain progressively from smaller to larger fish, resulting in elevated levels in the larger fish.

The advisories are guidelines only and no associated legal restrictions on catching or eating fish from these lakes have been issued. The State continues to recommend fishing and camping at these lakes, but urges those who fish and their families to make an informed decision as to what fish they can safely eat. While the occasional consumer of fish from these lakes is at little risk and the water quality standards for mercury are not exceeded, repeated ingestion of mercury at levels found in some of these fish over a long period could result in serious health problems.

Table 5-11. Waters with Fish Consumption Guidelines Proposed for the 2000-2002 §303(d) List

Water Body Name	Total Size Affected [a]	Probable Source(s) of Pollutant/Threat	Specific Pollutant(s) or Threat	Acute Public Health Concern
Eagle Nest Lake	2,000	Atmospheric deposition	Hg	No
Lake Maloya	150	Atmospheric deposition	Hg	No
Springer Lake	450	Atmospheric deposition	Hg	No
Stubblefield Reservoir	683	Atmospheric deposition	Hg	No

Source: NMED, 2001b. Hg = Mercury
[a] Acres within the State of New Mexico's jurisdiction.

5.3.2 Groundwater

The current or potential use of Colfax County's groundwater resources requires that groundwater be protected from contamination as much as possible. Groundwater contamination has already occurred in some areas of Colfax County from both point sources and nonpoint sources.

Point sources are a major cause of groundwater pollution in Colfax County, with leaking underground storage tanks (USTs) one of the most significant of these. As of December 2000, NMED had reported more than 50 leaking UST cases in Colfax County (Table 5-12). The majority of these groundwater contamination cases are due to oil, gasoline, jet fuel, diesel, and petroleum constituents such as benzene, toluene, ethylbenzene, and xylenes. The bulk of the sites are concentrated around municipal and industrial areas such as Raton, Springer, Cimarron, Angel Fire, and Maxwell. With the exception of Angel Fire and Maxwell, these communities rely on surface water for their municipal supplies, so the groundwater contamination has not directly affected their supplies. Approximately 50 percent of the leaking USTs in Colfax County are located in the town of Raton. Other potential point sources of groundwater contamination include landfills or other waste disposal sites.

A primary water quality concern in the Colfax planning region is shallow groundwater contamination due to septic tank failures in the Angel Fire area. Because septic systems are

Table 5-12. Leaking Underground Storage Tank Sites in Colfax County
Page 1 of 2

Site Name	Facility No.	Owner	Address	City
Chevron	1043	Colomex	Highway 434	Angel Fire
Ski Lift	26606	Angel Fire Corp	NM 434	Angel Fire
Mini-Mart	26605	Amarillo Mountain Corp	Main Street	Angel Fire
Golf Course Main Facility	28356	Angel Fire Corp	NM 434	Angel Fire
Romeros Chevron	1043	Colomex Oil & Gas	Highway 38	Angel Fire
Russells One Stop	30358	Emory Russell	Route 64	Cimarron
Western Trails Texaco	27635	Dave Heck	Highway 64 & Tenth	Cimarron
Chevron No. 70704	1044	Colomex Oil & Gas	Highway 58 & US 64	Cimarron
Chevron	1044	Bill Hickman	Highway 58 & 64	Cimarron
Kit Carson Texaco	27573	Internatl Bank	Highway 64	Cimarron
NMSHTD Cimarron	29873	NMSHTD	SR 21	Cimarron
Pittsburg & Midway	29988	Pittsburg/Midway	35 miles west of Raton	Cimarron
Eagle Nest Conoco	27817	CK&K Evans	Highway 285	Eagle Nest
Golden Eagle RV	28352	Jay Martin	Highway 64	Eagle Nest
NMSHTD Eagle Nest	27819	NMSHTD	US 64	Eagle Nest
Maxwell Gulf	1510	Keith Martin	Third Street	Maxwell
Old Conoco Station	27042	Goldie Bragg	218 Second Street	Maxwell
Interstate/Phillips	28669	Pendleton Oil	US 87 & I-25	Raton
Sav-O-Mat No. 9	30490	Lavern Gaylord	745 S. Second	Raton
NMSHTD Raton	29872	NMSHTD	S. Second Street	Raton
La Mesa Chevron	1453	Gary Wilson	1550 S. Second Street	Raton
Colfax Cty Road Department	27457	Colfax County	W. Troy Avenue	Raton
Value-Mat	1982	NA	713 S. Second Street	Raton
B&W Auto/Truck Stop	943	Gary Wilson	931 Clayton Road	Raton
Adams Conoco	26391	Don Adams	409 Clayton Road	Raton
Art's Chevron Service	26662	NA	1101 Second Street	Raton
AT&SF Keota	26685	AT&SF	Keota Siding	Raton
B&J Conoco	26818	Pat Webster	815 S. Second Street	Raton
B&W Truck Stop	943	Wilson Corp	901 Clayton Road	Raton
B&W Truck Stop	1871	NA	901 Clayton Road	Raton
Chevron 75703	26290	Chevron USA	10001 Clayton Road	Raton
Conoco Raton	26391	Don Adams	Clayton Highway & I-25	Raton
D&D Muffler	30863	Ernest Carlini	500 S. Second Street	Raton

Source: NMED, 2001a.

NMSHTD = New Mexico State Highway Department   NA = Not available   AT&SF = Atchison Topeka and Santa Fe

Table 5-12. Leaking Underground Storage Tank Sites in Colfax County
Page 2 of 2

Site Name	Facility No.	Owner	Address	City
Downtown Gulf	1201	NA	312 N. Second Street	Raton
Former Mobil Station	NA	NA	430 N. Second Street	Raton
Former Phillips 66	NA	NA	600 S. Second Street	Raton
K&G Food Store	31022	Duane Vanhorn	236 S. Second Street	Raton
K-Mart 9238	28964	K-Mart	1235 S. Second Street	Raton
Mr. M's Upholstery	27455	Monty Colangelo	100 Canyon Drive	Raton
Pendleton Truckstop	29908	Pendleton Oil & Gas	South Highway 85	Raton
Texaco Raton	26303	Rick Kolb	I-25 & Highway 87	Raton
United Chevrolet	31284	John Lackey	345 S. Second Street	Raton
Upholstery By Tony	NA	NA	400 N. Second Street	Raton
Vermejo Park	31478	Pennzoil Corp	Southwest of Raton	Raton
Springer Auto	30735	Joe Montoya	824 Fourth Street	Springer
Lemat Distribution	29080	Gary Munden	Maxwell Street & Second	Springer
Sky Chief Texaco	917	Loy Ross	723 Maxwell Avenue	Springer
Texaco Bulk Plant	1747	Loy Ross	Railroad Avenue	Springer
Cactus Corral	27195	Zeke Trujillo	810 Fourth Street	Springer
AT&SF French	26684	NA	French Siding	Springer
NMSHTD New Patrol Yard	29613	NMSHTD	Miami Road	Springer
NMSHTD Old Patrol Yard	29759	NMSHTD	Frontage Road	Springer
Springer Fina	29457	M. Montoya Trust	100 Maxwell Avenue	Springer

Source: NMED, 2001a.

NMSHTD = New Mexico State Highway Department NA = Not available AT&SF = Atchison Topeka and Santa Fe generally spread out over rural areas, they are considered a nonpoint source. Reports from NMED list a total of 50 septic failures between 1993 and 1997, and nitrate levels in groundwater along New Mexico Highway 434 have been increasing (Gutowsky, 1997). Most of the septic failures have occurred where groundwater is shallow.

Another primary water quality concern in Colfax County is the naturally (background) poor water quality of the groundwater resources. High levels of salinity or total dissolved solids make many sources of groundwater in the county unsuitable for use without treatment. Additional discussion of background water quality is provided in Section 5.2.

5.4 Summary of Water Supply Considering Legal Constraints

As discussed in Section 4, federal and state laws and water rights issues raise no obstacles to pursuing the alternatives and objectives of the *Colfax County Regional Water Plan,* although water managers and local governments implementing various aspects of the plan will be required to follow legal requirements, such as permitting. The primary issues regarding legal access to the water supply in Colfax County are the Canadian Compact and the New Mexico system of water appropriations (water rights):

- The Canadian Compact allows for “free and unrestricted use” of the Canadian River in Colfax County and therefore does not limit the region’s access to the primary surface water supply in the county (Section 4.2.2).

- The OSE has adjudicated the majority of the region, except for a small portion of the Canadian River near the southern boundary of the county, and the amount of water that can be withdrawn in the county is limited by the adjudicated quantities of water rights in each decree, as presented in Section 4.4. However, in most years the amount of adjudicated water rights exceeds the available surface water supply; consequently, the supply is mostly limited by the physical availability of surface water, rather than by water rights or other legal constraints. Additional discussion of the ability of the supply to meet adjudicated water rights is provided in Section 7.

Section 6

Water Demand

6. Water Demand

Sections 6.1 through 6.3 addresses present water demands, projected future water uses, and water conservation measures that can be used to help reduce future demands.

6.1 Present Uses

Present and historical water use was determined primarily based on information from the OSE, which tracks water used in New Mexico in several categories: public water supply and self-supplied domestic, irrigated agriculture, self-supplied livestock, self-supplied commercial, industrial, mining, power, and reservoir evaporation. Table 6-1 shows water use in each category for the years 1975, 1980, 1985, 1990, 1995, and 2000 based on the OSE inventories for those years (Sorensen, 1976; Sorensen, 1981; Wilson, 1986; Wilson, 1992; Wilson and Lucero, 1997, Wilson, 2002). Over the years, the OSE has made a few changes in the way that water demand is categorized and reported, including:

- Fish and wildlife and recreation were previously (1975 through 1985) reported as separate categories but are now included in the commercial category.

- Rural, urban, and military uses were separate categories until 1990, when they were replaced with the public water supply and self-supplied domestic categories.

- The OSE stopped reporting stock pond evaporation (which was previously a separate category) after 1985.

Annual water use data are shown on Table 6-1 by the earlier categories originally reported, but were combined into the current categories for the graphical illustrations of OSE water data in Figures 6-1and 6-2. Figure 6-1 shows the total amount of water withdrawn in each category, while Figure 6-2 shows the total amount of water depleted, or consumptively used, in each category, that is, the amount of withdrawal minus any return flow.

Table 6-1. Colfax County Water Use, 1975 Through 2000
Page 1 of 4

Use Category	Withdrawal (acre-feet)		Depletion (acre-feet)		Return Flow [a] (acre-feet)		Withdrawal (acre-feet)	Total Depletion (acre-feet)	Total Return Flow (acre-feet)
	Surface Water	Ground-water	Surface Water	Ground-water	Surface Water	Ground-water			
2000 Water Year									
Public water supply	2,453	788	1,554	374	899	414	3,241	1,928	1,313
Domestic (self-supplied)	0	89	0	89	0	0	89	89	0
Irrigated agriculture [b]	48,400	915	19,912	595	28,488	320	49,315	20,507	28,808
Livestock (self-supplied)	309	316	309	316	0	0	625	625	0
Commercial (self-supplied)	76	93	34	74	42	19	169	108	61
Industrial (self-supplied)	0	0	0	0	0	0	0	0	0
Mining (self-supplied)	570	0	308	0	262	0	570	308	262
Power (self-supplied)	0	0	0	0	0	0	0	0	0
Reservoir evaporation [b]	7,204	0	7,204	0	0	0	7,204	7,204	0
Totals	59,012	2,201	29,321	1,448	29,691	753	61,213	30,769	30,444
1995 Water Year									
Public water supply	2,092	630	1,136	296	956	334	2,722	1,432	1,290
Domestic (self-supplied)	0	121	0	54	0	66	121	54	66
Irrigated agriculture	47,496	828	19,636	453	27,860	375	48,324	20,089	28,235
Livestock (self-supplied)	365	372	365	372	0	0	737	737	0
Commercial (self-supplied)	93	69	42	34	51	34	162	76	85
Industrial (self-supplied)	0	0	0	0	0	0	0	0	0
Mining (self-supplied)	616	10	419	2	197	8	626	421	205
Power (self-supplied)	0	0	0	0	0	0	0	0	0
Reservoir evaporation	7,204	0	7,204	0	0	0	7,204	7,204	0
Totals	57,866	2,030	28,802	1,211	29,064	817	59,896	30,013	29,881

Source: New Mexico Office of the State Engineer (OSE).

[a] For water years 1985, 1980, and 1975, no return flow was reported by the OSE. The number shown here for these years is the potential return flow, calculated by subtracting the depletion from the withdrawal.

[b] Data are from water year 1999 because data for water year 2000 were determined to not be representative of typical conditions due to the drought that occurred in that year.

Table 6-1. Colfax County Water Use, 1975 Through 2000
Page 2 of 4

Use Category	Withdrawal (acre-feet)		Depletion (acre-feet)		Return Flow [a] (acre-feet)		Withdrawal (acre-feet)	Total Depletion (acre-feet)	Total Return Flow (acre-feet)
	Surface Water	Ground-water	Surface Water	Ground-water	Surface Water	Ground-water			
1990 Water Year									
Public water supply	2,675	108	1,772	49	903	59	2,783	1,820	963
Domestic (self-supplied)	0	58	0	26	0	32	58	26	32
Irrigated agriculture	57,898	91	23,662	74	34,236	17	57,989	23,736	34,253
Livestock (self-supplied)	337	355	337	354	0	1	692	690	1
Commercial (self-supplied)	105	363	53	221	52	142	467	274	194
Industrial (self-supplied)	0	0	0	0	0	0	0	0	0
Mining (self-supplied)	0	278	0	144	0	134	278	144	134
Power (self-supplied)	0	0	0	0	0	0	0	0	0
Reservoir evaporation	6,829	0	6,829	0	0	0	6,829	6,829	0
Totals	67,844	1,253	32,653	868	35,191	385	69,096	33,519	35,577
1985 Water Year									
Urban (public water supply)	1,484	0	668	0	816	0	1,484	668	816
Rural (domestic self-supplied)	546	246	246	111	300	135	792	357	435
Irrigated agriculture	54,827	242	19,691	157	35,136	85	55,069	19,848	35,221
Livestock	350	356	350	355	0	1	706	705	1
Stockpond evaporation	2,124	0	2,124	0	0	0	2,124	2,124	0
Commercial	0	1	0	1	0	0	1	1	0
Industrial	0	0	0	0	0	0	0	0	0
Minerals (mining)	475	21	333	3	142	18	496	336	160
Military (public water supply)	0	0	0	0	0	0	0	0	0
Power	74	0	74	0	0	0	74	74	0
Fish and wildlife (commercial)	732	0	234	0	498	0	732	234	498
Recreation (commercial)	0	190	0	116	0	74	190	116	74
Reservoir evaporation	12,824	0	12,824	0	0	0	12,824	12,824	0
Totals	73,436	1,056	36,544	743	36,892	313	74,492	37,287	37,205

Source: New Mexico Office of the State Engineer (OSE).

[a] For water years 1985, 1980, and 1975, no return flow was reported by the OSE. The number shown here for these years is the potential return flow, calculated by subtracting the depletion from the withdrawal.

[c] Land-based only

Table 6-1. Colfax County Water Use, 1975 Through 2000

Use Category	Withdrawal (acre-feet)		Depletion (acre-feet)		Return Flow [a] (acre-feet)		Withdrawal (acre-feet)	Total Depletion (acre-feet)	Total Return Flow (acre-feet)
	Surface Water	Ground-water	Surface Water	Ground-water	Surface Water	Ground-water			
1980 Water Year									
Urban (public water supply)	1,350	0	608	0	742	0	1,350	608	742
Rural (domestic self-supplied)	469	211	211	95	258	116	680	306	374
Irrigated agriculture	51,680	0	32,610	0	19,070	0	51,680	32,610	19,070
Livestock	371	376	371	375	0	1	747	746	1
Stockpond evaporation	2,124	0	2,124	0	0	0	2,124	2,124	0
Commercial	0	0	0	0	0	0	0	0	0
Industrial	0	0	0	0	0	0	0	0	0
Minerals (mining)	313	15	114	2	199	13	328	116	212
Military (public water supply)	0	0	0	0	0	0	0	0	0
Power	151	0	151	0	0	0	151	151	0
Fish and wildlife (commercial)	596	0	372	0	224	0	596	372	224
Recreation [c] (commercial)	0	184	0	71	0	113	184	71	113
Reservoir evaporation	11,463	0	11,463	0	0	0	11,463	11,463	0
Totals	68,517	786	48,024	543	29,493	243	69,303	48,567	20,736
1975 Water Year									
Urban (public water supply)	1,604	0	722	0	882	0	1,604	722	882
Rural (domestic self-supplied)	763	265	344	119	419	146	1,028	463	565
Irrigated agriculture	54,700	0	28,710	0	25,990	0	54,700	28,710	25,990
Manufacturing (industrial)	0	92	0	55	0	37	92	55	37
Minerals (mining)	337	15	169	2	168	13	352	171	181
Military(public water supply)	0	0	0	0	0	0	0	0	0
Livestock	362	363	362	363	0	0	725	725	0
Stockpond evaporation	2,119	0	2,119	0	0	0	2,119	2,119	0
Power	0	74	0	74	0	0	74	74	0

Source: New Mexico Office of the State Engineer (OSE).

[a] For water years 1985, 1980, and 1975, no return flow was reported by the OSE. The number shown here for these years is the potential return flow, calculated by subtracting the depletion from the withdrawal.

[c] Land-based only

Table 6-1. Colfax County Water Use, 1975 Through 2000

Use Category	Withdrawal (acre-feet)		Depletion (acre-feet)		Return Flow[a] (acre-feet)		Withdrawal (acre-feet)	Total Depletion (acre-feet)	Total Return Flow (acre-feet)
	Surface Water	Ground-water	Surface Water	Ground-water	Surface Water	Ground-water			
1975 Water Year (continued)									
Fish and wildlife (commercial)	626	0	626	0	0	0	626	626	0
Recreation[c] (commercial)	0	0	0	0	0	0	0	0	0
Reservoir evaporation	10,200	0	10,200	0	0	0	10,200	10,200	0
Playa lake evaporation	0	0	0	0	0	0	0	0	0
Totals	70,711	809	43,252	613	27,459	196	71,520	43,865	27,655
Average for 6 Years	66,231	1,356	36,433	904	31,298	451	67,587	37,337	30,250

Source: New Mexico Office of the State Engineer (OSE).

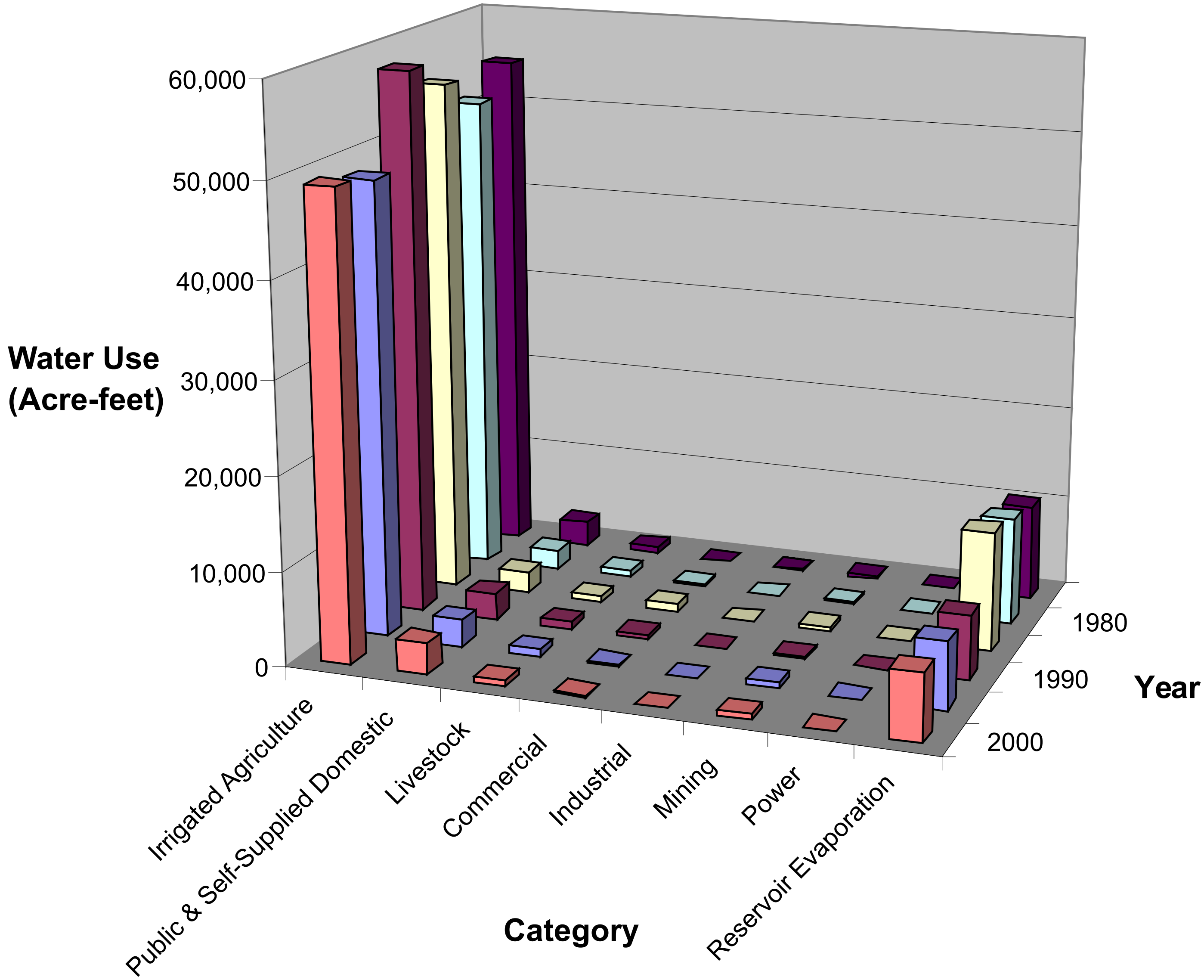
[a] For water years 1985, 1980, and 1975, no return flow was reported by the OSE. The number shown here for these years is the potential return flow, calculated by subtracting the depletion from the withdrawal.

[c] Land-based only

Source: New Mexico Office of the State Engineer (OSE).

[a] For water years 1985, 1980, and 1975, no return flow was reported by the OSE. The number shown here for these years is the potential return flow, calculated by subtracting the depletion from the withdrawal.

[c] Land-based only



COLFAX REGIONAL WATER PLAN

Total Withdrawals by Category in Colfax Planning Region

Daniel B. Stephens & Associates, Inc.
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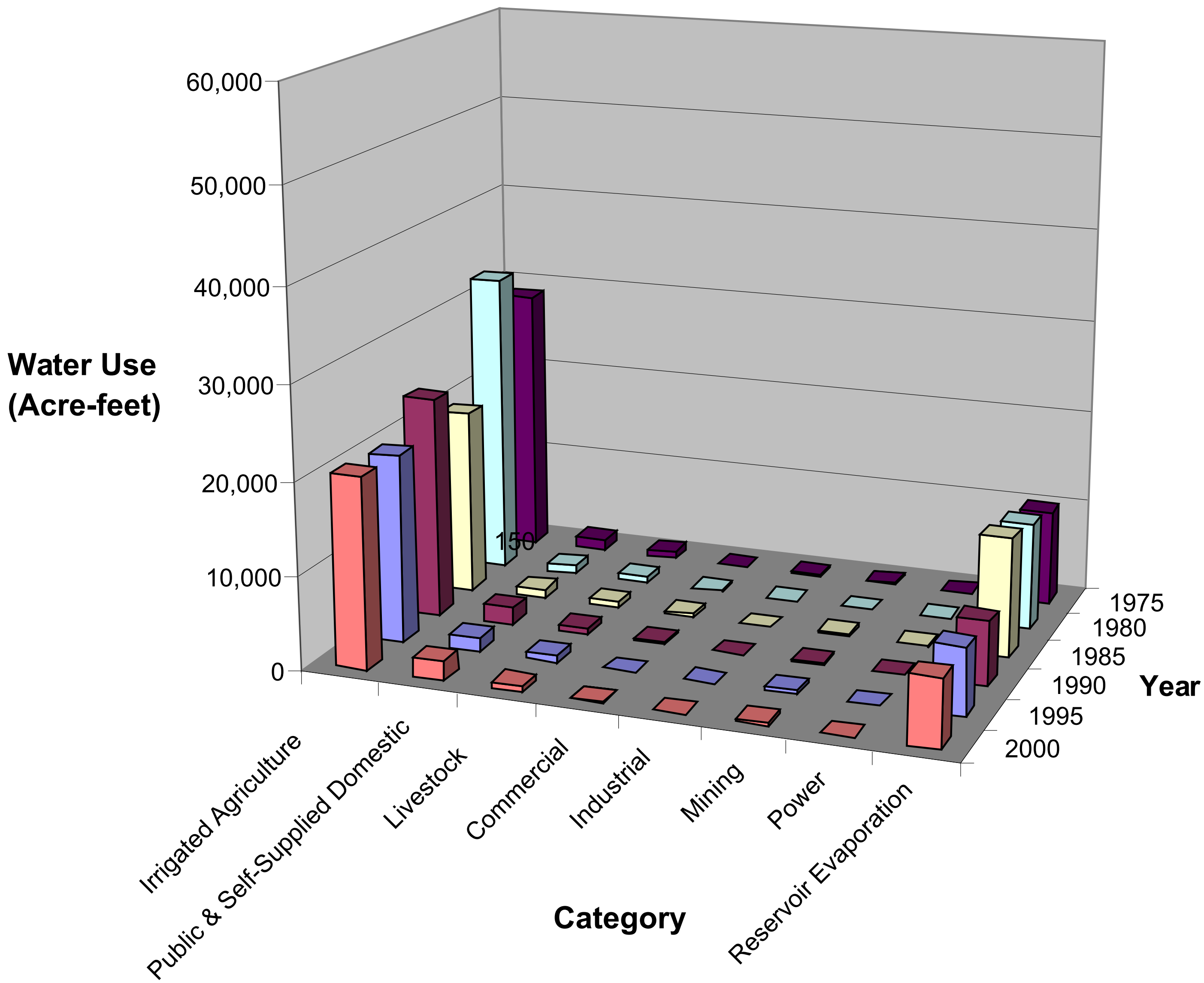

COLFAX REGIONAL WATER PLAN

Total Depletions by Category in Colfax Planning Region

Figure 6-2

Daniel B. Stephens & Associates, Inc.

11-04-02

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The OSE water use data include only the amount of water that is used by people or is indirectly used through a man-made structure (i.e., reservoir evaporation) and thus do not include natural riparian consumption. Estimates for riparian consumption are provided in Section 7. Information for each of the current OSE categories is summarized and discussed in Sections 6.1.1 through 6.1.7.

6.1.1 Public Water Supply and Self-Supplied Domestic

These two OSE categories include domestic use from both public water supplies that serve whole communities and private domestic wells that serve only one or a few residences. These two types of domestic use are discussed in Sections 6.1.1.1 and 6.1.1.2.

6.1.1.1 Public Water Supply

This category includes community water systems that rely upon surface water and/or groundwater diversions other than private domestic wells and that consist of common collection, treatment, storage, and distribution facilities operated for the delivery of water to multiple service connections (Wilson and Lucero, 1997). Water used for the irrigation of self-supplied golf courses, playing fields, and parks, or water used to maintain the water level in ponds and lakes owned and operated by a municipality or water utility is also included in this category. Inclusion of these uses allows comparison of the total amount of water used by the system to the water rights owned by these public water suppliers.

Information on Colfax County public water systems was compiled from the New Mexico Environment Department records and is summarized in Appendix G, Table G-1. As indicated on this table, there are 65 public water systems in Colfax County producing a total of about 3 million gallons per day (mgd). The public water systems listed include both incorporated municipalities and smaller campground and recreation systems.

A summary of water use in recent years by county municipalities only is presented in Table G-2. Information on monthly water use by each municipality, which aids in preparing for seasonal variability, is shown on Figures G-1 and G-2. These figures illustrate that most of the municipalities show increased use in the summer months, corresponding to increased outdoor watering as well as increased tourism in some locations. Angel Fire also shows increased water use in the winter months, corresponding to ski resort operations.

6.1.1.2 Self-Supplied Domestic Wells

This category includes self-supplied residences, which may be single family dwellings or multi-family dwellings, with wells permitted by the OSE under NMSA Section 72-12-1 (Appendix D).

The OSE Water Administration Technical Engineering Resource System (WATERS) database lists 1,079 domestic wells in Colfax County. However, the WATERS database is incomplete at present. According to OSE records, there are approximately 3,500 domestic wells in the county (Jim Hollis, Cimarron Water Master, personal communication with Joanne Hilton, February 2001).

The OSE indicates total withdrawals of 89 acre-feet for the self-supplied domestic well category in 2000 (Table 6-1). This estimate was based on the procedure defined by Wilson and Lucero (1997), which is to subtract the population served by public water supply systems from the total county population. However, since domestic wells are not metered, this is only an estimate of domestic well use. An alternative estimate can be developed by assuming that each of the 3500 domestic wells in the county uses 0.5 ac-ft/yr, resulting in a total annual withdrawal of 1750 acre-feet. Since it is unclear whether the 3500 domestic wells supply other uses (such as livestock watering) as well, there is some uncertainty in this estimate. A more detailed accounting of domestic wells is necessary to accurately quantify their impact.

6.1.2 Irrigated Agriculture

Irrigated agriculture is the largest water use in Colfax County. Wilson and Lucero (1997) define irrigated agriculture as including all diversions of water for the irrigation of crops grown on farms, ranches, and wildlife refuges. In the Colfax planning region, irrigated agriculture relies primarily on surface water supplies (Table 6-1). The distribution of irrigated agricultural land in the region is shown in Appendix B (Figure B-3), and a more detailed discussion of agriculture in Colfax County, including consumptive use calculations and all pertinent references, is provided in the *Agricultural Water Conservation Plan* (Appendix H and Attachment H2).

Agricultural demand for both withdrawals and consumptive use are not directly measured, but are instead estimated based on a model of crop water needs. Agricultural consumptive use and withdrawal estimates reported by the OSE (Sorenson, 1976, 1981; Wilson, 1986, 1992; Wilson and Lucero, 1997) are summarized in Tables 6-1 and G-3 and shown on Figure G-3. As indicated by this figure, withdrawals exceed consumptive use, roughly by a factor of 2.2.

For the Colfax regional water planning study, independent estimates of irrigated agriculture water use were developed and compared to estimates provided by the OSE in their water use reports (Sorenson, 1976, 1981; Wilson, 1986, 1992; Wilson and Lucero, 1997). The independent estimates were based on OSE crop use information (Blaney and Hanson, 1965), NMDA irrigated acreage figures (NMDA, 1962-1998), and the 1997 USDA Census of Agriculture (USDA, 1999). The latter two sources are derived from information provided by the producers themselves (farmers, ranchers, livestock feeders, slaughterhouse managers, grain elevator operators, etc.). However, irrigators present at Colfax County Steering Committee meetings have repeatedly indicated that they believe the USDA figures to be undercounts, possibly because busy farmers and ranchers do not return surveys. The USDA information is thus presented here only to show approximate crop distributions, rather than to indicate the total demand for agricultural water.

Consumptive use requirements vary from crop to crop (Blaney and Hanson, 1965). Table G-4 and Figure G-4 present irrigated acreage values for each crop as obtained from NMDA and USDA data. The primary crops grown in the planning region are alfalfa, other hay, and wheat. New Mexico agricultural statistics (NMDA, 1962-1998) indicate that irrigated acreages and cropping quantities vary from year to year. The USDA data show similar variability, although they differ from the NMDA data. For the irrigated agriculture demand estimate, the variability among the NMDA and USDA figures was resolved in the following manner:

- When the USDA and NMDA values were not consistent, the larger of the two acreage values was used.

- When the total acres for all crops did not equal the total acres of irrigated land presented in the reports, an “other” category was added to account for the difference. For the “other” category, a consumptive use requirement equivalent to alfalfa was assumed.

Consumptive use of crops was then evaluated on an annual basis by multiplying the crop consumptive use requirements less average growing season precipitation (based on a 70-year record at the Springer station) (Blaney and Hanson, 1965) by the acreage for each crop (NMDA, 1962-1998; USDA, 1999). The consumptive use of a crop varies dependent on the growing season. A longer growing season will result in greater consumptive use. The length of the growing season given in Blaney and Hanson (1965) was used to define the appropriate growing season by crop for the geographic area encompassing Colfax County. Irrigation demand in Colfax County since 1959 estimated in this manner is presented in Figure G-5. The NMDA and USDA estimates of total crop acreage are lower than a survey of acreage conducted by the State Engineer Office in 1978 (Appendix H, Attachment H1, Table H-1).

This independent estimate was compared to the agricultural consumptive use and withdrawals reported by the OSE (Sorenson, 1976, 1981; Wilson, 1986, 1992; Wilson and Lucero, 1997) and shown in Figure G-3. Colfax County demand estimated using the independent approach described above is on the order of 10,000 acre-feet per year higher than the long-term average of the OSE published values.

6.1.3 Self-Supplied Livestock

This category includes water used to raise livestock, maintain self-supplied livestock facilities, and provide for on-farm processing of poultry and dairy products (Wilson and Lucero, 1997). In 2000, self-supplied livestock represented approximately 2 percent of the total water use in the county.

For the Colfax regional water planning study, livestock water use was estimated based on information from the OSE water use reports (Sorenson, 1976, 1981; Wilson, 1986, 1992; Wilson and Lucero, 1997), the NMDA statistics (NMDA, 1962-1998), and the 1997 USDA Census of

Agriculture (USDA, 1999). The OSE reports provide a direct estimate of water depletion and withdrawal within the livestock category.

Prior to 1990 the OSE estimates included average total stock pond evaporative depletion (the OSE stopped reporting stock pond evaporation after 1985). To provide consistent estimates over time, especially given that the reported stock pond depletions in the planning region were relatively large (2,122 acre-feet per year [Sorenson, 1976, 1981; Wilson, 1986]), stock pond evaporation water demands after 1985 were incorporated into the Colfax County independent estimate by adding average stock pond evaporation to the direct livestock consumptive use listed in the OSE water use reports. The historical livestock demand profiles determined in this manner are presented in Figure G-6; Table G-4 summarizes the withdrawal and consumptive use estimates.

To provide a comparison to the OSE estimate, the NMDA and USDA statistics, which provide estimated numbers of livestock (dairy and beef cattle, sheep, hogs, and poultry) on a county-by-county basis (Figure G-7), were used to evaluate livestock consumptive use for the time period from 1960 through 1999. To estimate water depletion by the livestock, the livestock numbers were multiplied by species-specific per capita water consumption (Wilson and Lucero, 1997). In cases where the NMDA and USDA values were not consistent, the higher of the two values was used.

Livestock demand in Colfax County since 1960, estimated using the procedure described above, is presented in Figure G-8. The total livestock demand in Figure G-8 includes all of the species use plus the average stock pond evaporation. This independent Colfax County demand estimate (Figure G-8) is on the order of 300 acre-feet per year higher than the long-term average of the OSE published values (Figure G-6, Table G-4).

6.1.4 Self-Supplied Commercial, Industrial, Mining, and Power

The self-supplied commercial, industrial, mining, and power categories make up a relatively small proportion of the total water use in Colfax County. Wilson and Lucero (1997) define these categories as follows:

- Commercial includes self-supplied businesses (e.g., motels, restaurants, recreational resorts, and campgrounds) and institutions. Self-supplied golf courses that are not watered by a public water supply are also included, as are off-stream fish hatcheries engaged in the production of fish for release.

- Industrial includes self-supplied enterprises engaged in the processing of raw materials or the manufacturing of durable or nondurable goods. Water used for the construction of highways, subdivisions, and other construction projects is also included.

- Mining includes self-supplied enterprises engaged in the extraction of minerals occurring naturally in the earth's crust, including (1) solids, such as coal and smelting ores, (2) liquids, such as crude petroleum, and (3) gases, such as natural gas. Water used for drilling and/or processing at a mine site is also included.

- Power includes all self-supplied power generating facilities. Water used in conjunction with coal mining operations that are contiguous with a power generating facility that owns and/or operates the mines is also included.

As shown in Table 6-1 and Figures 6-1 and 6-2, the self-supplied commercial, industrial, mining, and power categories are a relatively small part of the county water demand. The published OSE records were used to represent historical demand in these sectors.

6.1.5 Reservoir Evaporation

As indicated in Table 6-1 and Figures 6-1 and 6-2, reservoir evaporation represents a significant portion of the water demand and is the second highest use category in the county. The monthly evaporation rate is directly measured only at Eagle Nest Reservoir; for the other reservoirs it is estimated. OSE combines these measured or estimated monthly evaporation rates with monthly rainfall to compute a net evaporation rate. This evaporation rate is then used to compute the volume of evaporation (in acre-feet) based on the surface area of the reservoir and the depth of water in storage. The computed water use from reservoir evaporation is shown in

Table 6-1. All reservoir evaporation is a consumptive use; there is no return flow in this category.

6.2 Future Water Uses

To determine the future demand for water in the region, it is necessary to not only evaluate historical water use as presented in Section 6.1, but to understand the demographics and economics of the region as well. Accordingly, Southwest Planning & Marketing (SPM) completed a detailed analysis of population and economic growth in Colfax County (Appendix I). The SPM study projected population growth for a 40-year planning horizon, ending in 2040. In order to project future water demand for each of the water use categories discussed in Section 6.1, growth was projected in the following sectors:

- Public water supply, domestic, and commercial
- Industrial, power, and mining
- Irrigated agriculture and livestock

Factors affecting potential growth were presented for each category. Since assumptions regarding one of these factors, economic growth, are somewhat uncertain, both high and low growth rates were established to bracket the range of future conditions that are likely to occur.

Table 6-2 shows the projected future water demand for each water use category under high and low use scenarios, with a third, moderate use scenario added for irrigated agriculture. The proportion of water withdrawn from either surface water or groundwater resources in the future depends on the alternatives that are implemented (Section 8). Initially it is anticipated that the proportion of surface water and groundwater will be similar to that historically experienced (greater than 95 percent surface water). However, if alternatives for appropriating and developing additional groundwater supplies are implemented, a greater proportion of groundwater may be used in the future. Due to the inability of surface water supplies to meet demands in drier years, significant additional storage and/or groundwater development will be required to meet projected demands. Nevertheless, groundwater use is anticipated to remain less than surface water use over the planning period. The methods and assumptions used in

Table 6-2. Colfax County Water Use Projections by Sector

Sector	2000	2010	2020	2030	2040
Low Use Scenario [a]					
Irrigated agriculture	62,475	59,421	56,516	53,753	51,125
Public and self-supplied domestic	3,607	3,923	4,293	4,564	4,763
Livestock	3,182	3,026	2,878	2,738	2,604
Commercial	169	169	169	169	169
Industrial	0	0	0	0	0
Mining	570	570	570	570	570
Power	0	0	0	0	0
Reservoir evaporation	9,287	9,287	9,287	9,287	9,287
Totals	79,290	76,396	73,713	71,081	68,518
Moderate Use Scenario [b]					
Irrigated agriculture	70,840	70,840	70,840	70,840	70,840
High Use Scenario [c]					
Irrigated agriculture	120,000	120,000	120,000	120,000	120,000
Public and self-supplied domestic	3,607	5,040	7,158	9,835	13,153
Livestock	3,397	3,397	3,397	3,397	3,397
Commercial	169	169	169	169	169
Industrial	0	0	0	0	0
Mining	570	570	570	570	570
Power	0	0	0	0	0
Reservoir evaporation	12,824	12,824	12,824	12,824	12,824
Totals	140,567	142,000	144,118	146,795	150,113

Note: The amount of water use in 2000 for surface water and groundwater is shown in Table 6-1. In the future, the amount of water use with surface water or groundwater will depend on the alternatives implemented.

[a] Sources for Low Use Scenario:

Irrigated agriculture	Based on average consumptive use from 1959 to 1998 ∗ 2.2. Then declining at 0.5% per year
Public and self-supplied domestic	Based on projected population growth (Appendix F).
Livestock	Based on average consumptive use from 1960 to 1999. Then declining at 0.5% per year
Commercial	Based on 2000 total withdrawal, held constant
Industrial	Based on 2000 total withdrawal, held constant
Mining	Based on 2000 total withdrawal, held constant
Power	Based on 2000 total withdrawal, held constant
Reservoir evaporation	Average evaporation withdrawal from 1975, 1980, 1985, 1990, 1995, 2000

[b] Sources for Moderate Use Scenario:

Irrigated agriculture	Based on top 75% consumptive use from 1959 to 1998 ∗ 2.2. Then holding at that use.

[c] Sources for High Use Scenario:

Irrigated agriculture	Based on assumption that full water right duty (Section 4.4.1) is fulfilled.
Public and self-supplied domestic	Based on projected population growth (Appendix F).
Livestock	Based on maximum consumptive use from 1960 to 1999. Then holding at that use.
Commercial	Based on 2000 total withdrawal, held constant
Industrial	Based on 2000 total withdrawal, held constant
Mining	Based on 2000 total withdrawal, held constant
Power	Based on 2000 total withdrawal, held constant
Reservoir evaporation	Maximum evaporation withdrawal from 1975, 1980, 1985, 1990, 1995, 2000

developing estimates of future water demand in each sector for the period 2000 to 2040 are described in Sections 6.2.1 through 6.2.5.

6.2.1 Public Water Supply and Self Supplied Domestic

In order to translate the SPM projections (Appendix I) into future water use, the municipal historical water use data presented in Section 6.1.1 were divided by the population of each municipality to determine an average water use rate in gallons per capita per day (gpcd) for that community (Table G-2). In general, the municipal water use data were based on the amount of water pumped or diverted, rather than the amount of water sold (i.e., system losses were included) in order to provide a higher per capita use rate that will be more realistic in evaluating future demands. In Angel Fire the per capita use rate is particularly high, because it includes significant commercial and outdoor use that is supplied by the municipal system; domestic use rates are lower. The per capita use rate was then multiplied by the projected population (Appendix I, Exhibits 4 through 9) to estimate a range of future projected water demands (both high and low projections). To estimate future demand by self-supplied domestic wells, the rural population outside the incorporated areas was multiplied by the average water use rate for the county. Projected future demand under each growth scenario is presented in Table 6-2. Additionally, projections of future water supply needs for each incorporated community are shown in Table G-5 and Figures G-9 and G-10.

This method of projecting future water use assumes that average rates of use will be steady during the projection period. If water conservation measures are implemented to reduce the average use rate, water demand should be adjusted accordingly. Strategies for reducing demand are discussed in Sections 6.3 and 7.1.

6.2.2 Irrigated Agriculture

As discussed in Appendix I, irrigated agriculture is expected to remain stable or experience a moderate decline of approximately 2 percent. Even if crop acreage remains stable, however, the amount of water used by the agriculture sector varies from year to year depending on climatic conditions. In order to bracket the change, the following scenarios were selected:

- *Low water use:* Though agricultural land may decline at a rate of 2 percent per year, it is expected that as land goes out of production, much of the water will be transferred to other agricultural land. This scenario thus assumed that agricultural acreage and water use declined at a more moderate rate of 0.5 percent per year and that long-term average water use rates are representative of future conditions. For this scenario, the average water use (withdrawal) based on the NMDA and USDA data (Section 6.1) was calculated. This amount was then decreased by 0.5 percent per year.

- *Moderate water use:* This scenario assumed that agricultural acreage will remain constant, and dryer conditions will be prevalent for the next 40 years. To represent the drier conditions or higher consumptive use needs, the maximum consumptive use based on the NMDA and USDA data was used and was converted to a total withdrawal.

- *High water use:* Historically, many of the agricultural water rights holders in Colfax County have not received enough water to fulfill their legal rights (Appendix H). Consequently, relying on projections that are based on historical water use may undercount the true demand for water. Under this scenario, it was assumed that the demand for agricultural water is based on fulfillment of all adjudicated water rights, as discussed in Section 4. The amount of water decreed in each basin is as follows:

  – *Cimarron Decree:* Approximately 40,000 acre feet, assuming a duty of 1.5 acre-feet per acre on all irrigated land

  – *Rayado Decree:* 12,169.5 acre feet (as described in the 1935 hydrographic survey [Bliss, 1935])

  – *Dry Cimarron Decree:* 778 acre-feet in Colfax County

  – *Sugarite/Chico Rico Decree:* More than 40,000 acre-feet per year, almost all of which were for irrigation purposes, with some reservoir storage and stock watering rights

  – *Vermejo Decree:* Approximately 27,000 acre feet

All these decreed rights total about 120,000 acre-feet of water rights in the county. The vast majority of these rights are for irrigation, but some of these have been transferred in recent years to other uses. This number is slightly higher than the projected water use under the high use scenario and possibly provides a better upper bound on the amount of water that will be required for future use in the county.

6.2.3 Self-Supplied Livestock

Again, two scenarios were selected to bracket the possible climatic conditions:

- *Low water use:* The average livestock water use reported in the NMDA and USDA data (Section 7.3) was used to represent year 2000 water use. This amount was decreased by 0.5 percent per year to represent future water use.

- *Moderate to high water use:* The maximum livestock water use reported in the NMDA and USDA data was used to represent year 2000 water use. This rate was held constant for future scenarios.

6.2.4 Self-Supplied Commercial, Industrial, Mining, and Power

While growth in the commercial, industrial, mining, and power categories is expected to increase proportionally with residential growth, it is expected that most of these demands will be met through municipal water supplies. Because of the relatively small amount of water use apportioned to these sectors, combined with the lack of substantial changes in the projections for these categories (some changes that could either increase or decrease water use may be expected) (Appendix I), water use for these sectors was held constant for both the low and high water use scenarios.

6.2.5 Reservoir Evaporation

As with irrigated agriculture, reservoir evaporation is dependent on climatic conditions, and two scenarios were again used to bracket the possible conditions:

- *Low water use:* This scenario assumed that reservoir evaporation over the planning period is equal to the average category use, based on the six years of OSE data (1975, 1980, 1985, 1990, 1995, and 2000).

- *High water use.* This scenario assumed that reservoir evaporation over the planning period is equal to the maximum category use, based on the six years of OSE data (1975, 1980, 1985, 1990, 1995, and 2000).

6.2.6 Summary

The projections in Table 6-2 represent withdrawal requirements, which are greater than consumptive use requirements and are thus more conservative for use in planning. Because considerable uncertainty exists regarding future conditions and needs for water, the amount of water use projected will not necessarily be accurate for any given year. The low and high scenarios for future water use are intended to identify the range of future water demand that can reasonably be expected in Colfax County. As regional water planning continues, estimates of future projected water use can be refined.

In addition to the projections by water use category, 40-year water usage projections for Colfax County were calculated for the six major metropolitan areas, the rural area, and the county as a whole, based on high and low population growth scenarios provided by SPM. Average daily per capita data for Eagle Nest, Cimarron, Raton, Maxwell, and Springer are the averages of the daily per capita data in Table G-2, which were calculated from records of water usage divided by the population of each community as shown in Appendix I. Angel Fire and rural daily per capita data are from the 2000 OSE water use report (Wilson, 2002). County daily per capita data were calculated by dividing the total county daily water use in each water year by the 2000 population.

6.3 Water Conservation

As discussed in Section 6.1, more than 80 percent of the water used in the Colfax planning region is applied to irrigated agriculture. Consequently, the greatest potential for savings due to water conservation measures is in the agricultural sector. Applicable water conservation measures and estimates of potential water savings are discussed in the agricultural water conservation plan, provided in Appendix H. Though municipal users represent a much smaller proportion of the total water use in the region, it is nonetheless important to consider implementation of water conservation measures to optimize the use of the available water resources. A discussion of municipal water conservation is included in Section 8.2.

Section 7

Ability of Water Supply To Meet Demand

7. Ability of Water Supply to Meet Demand

In order to understand how the water supply in the region (Section 5) compares to the current and projected demands for water (Section 6), this section integrates the supply and demand information. First, water budgets showing the amount of water available and where it is used are presented in Section 7.1. These are followed by an analysis of the probability that water supplies (based on historical records) will be sufficient to meet projected demands in the region (Section 7.2).

7.1 Water Budget

A water budget is an accounting of the input and output components of the hydrologic cycle for a specified hydrologic system. The hydrologic cycle is a continuous process in which water moves from the oceans to the atmosphere, then to the land, and eventually back to the oceans using the energy of the sun. Components of the cycle include:

- The primary input is precipitation, part of which is intercepted by vegetation or structures and returned to the atmosphere by evaporation and part of which becomes runoff.
  - Some precipitation seeps into the ground to become soil moisture, part of which is taken up by plant roots and returned to the atmosphere through the process of transpiration. It is difficult to separate these quantities, so they are typically combined into a single term known as evapotranspiration (ET).
  - Runoff that is not intercepted or infiltrated flows through surface channels, from which it may be removed for various consumptive uses, or it may fill reservoirs where it sits in storage until used or evaporated.
- When soil moisture storage capacity is exceeded, recharge to groundwater occurs. Groundwater may reside in storage until withdrawn from a well, or where physical conditions allow, it may discharge into streams or lakes.

The hydrologic cycle is thus a complex movement of water through several subsystems. A hydrologic budget is a quantification of the amounts of water moving in and out of a specified subsystem of the overall hydrologic cycle.

For a given region, the overall hydrologic budget can be expressed by the equation (Veissman et al., 1989):

$$P - R - G - ET = \Delta S$$

where P = precipitation
R = runoff
G = groundwater flow
ET = evapotranspiration
ΔS = change in storage.

Except for precipitation, subsets of these parameters apply differently to budgets computed above or below the surface. For example, losses to infiltration from the surface are realized as an input to the subsurface system, and losses from subsurface discharges are realized as an input to the surface system. It is therefore convenient to view surface water systems and groundwater systems as separate subsystems of the hydrologic cycle. Sections 7.2.1 and 7.2.2 discuss the analysis of surface water and groundwater budgets performed for the Colfax County region.

7.1.1 Surface Water Budget

Two annual surface water budgets for Colfax County were prepared: one representing an average climate year and one for a representative drought year. Data for the water budgets were obtained from the following sources:

- Water usage data are from New Mexico OSE reports (Sorensen, 1976, 1981; Wilson, 1986, 1992, 2002; Wilson and Lucero, 1997).

- Streamflow data are from the USGS (2001, 2002).

- Data on reservoir releases were provided by Jim Hollis, Cimarron River Basin Water Master.

7.1.1.1 Average Surface Water Budget

The average annual surface water budget results are presented in Table 7-1 and Figure 7-1. Inflows are comprised of (1) gaged stream discharges from the five main drainages in the county and (2) documented reservoir releases:

- The stream discharges are average values for the period 1975 through 1995, computed from the annual total discharge volumes recorded at each gage. Since the Cimarron River near Cimarron gage records flows that include releases from Eagle Nest Lake, the discharge for this gage was adjusted to exclude the Eagle Nest releases.

- The average volume of Eagle Nest releases was computed from the annual discharge volumes recorded at the Cimarron River below Eagle Nest Dam gage from 1975 through 1995. Release volumes for Miami Lake, Antelope Valley Lakes No. 2 and No. 3, and Springer Lake are based on 1995 data.

Outflows are comprised of surface water depletions and downstream discharge outflow measured at the Canadian River near Taylor Springs gage. With the exception of reservoir evaporation, depletions are the average of Colfax County water use figures reported by the OSE for the years 1975, 1980, 1985, 1990, and 1995. Due to a change in OSE reporting, reservoir evaporation is based on the OSE master database for all reservoirs in the county. Since 1985, the OSE has reported evaporation only for reservoirs with 5,000 or more acre-feet of storage. However, the volume of storage represented by the large reservoirs is only about 54 percent of the total storage volume of all reservoirs in the county. Therefore, the master database figures were used instead.

Table 7-1 shows an accounting of measured inflows minus reported depletions and compares this value to downstream discharge outflow. This comparison shows that total measured inflows minus reported depletions is only 2.2 per cent less than the measured downstream discharge outflow. This indicates that, on average, surface water usage in the county is well balanced with reservoir releases, and primary stream through-flow is generally well maintained.

Table 7-1. Colfax County Average Annual Surface Water Budget

Line Item	Inflow / Depletion [a] (ac-ft)
Surface Water Inflows	
Gaged Stream Inflows:	
Canadian River near Hebron	8,868
Vermejo River near Dawson	15,046
Ponil Creek near Cimarron	10,108
Cimarron River near Cimarron [b]	6,343
Rayado Creek near Cimarron	11,213
Stream inflows subtotal	51,578
Reservoir Releases: [c]	
Miami Lake	7,296
Antelope Valley No. 2 and No. 3	8,222
Springer Lake	7,039
Eagle Nest Lake [d]	14,650
Reservoir releases subtotal	37,207
Total inflows	88,785
Surface Water Depletions [e] and Outflow	
Public Water Supply	981
Domestic Water Supply	160
Irrigated Agriculture	24,862
Livestock	357
Commercial	47
Mining	207
Power	45
Reservoir Evaporation [f]	12,569
Total depletions	39,228
Total Inflows minus depletions	49,557
Downstream discharge outflow [g]	50,663
In minus out	–1,106
In minus out percentage	–2.2%

ac-ft = Acre-feet

[a] Data from 1975 to 1995 unless otherwise noted.

[b] Gage data corrected to exclude Eagle Nest Lake releases.

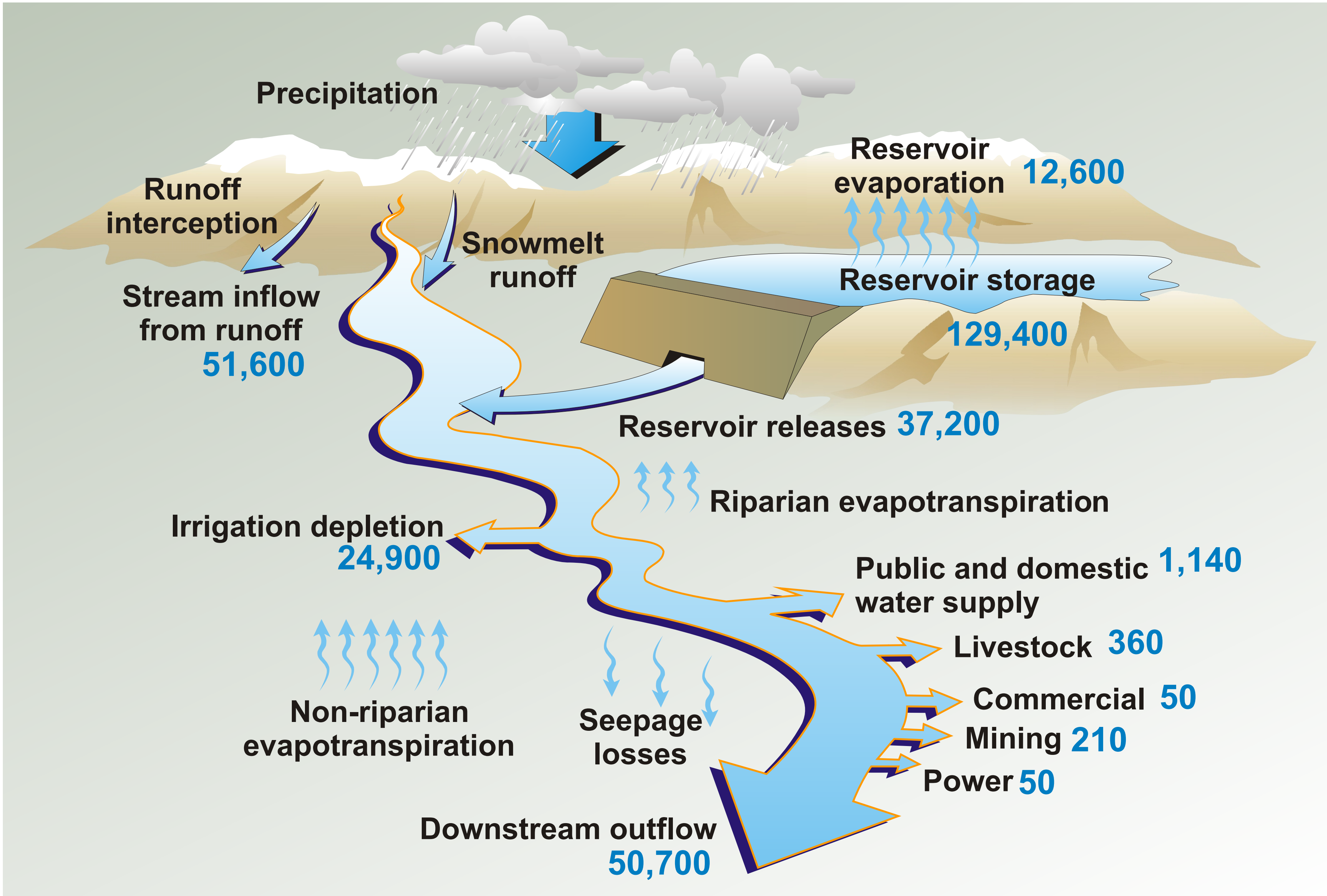
[c] Documented 1995 releases for reservoirs located downstream of streamflow gages used in water budget analysis unless otherwise noted. Reservoir discharge data provided by Jim Hollis, Cimarron River Basin Water Master.

[d] Average 1975-1995 discharge from the Cimarron River below Eagle Nest Dam gage.

[e] Average of Office of the State Engineer (OSE) water use reports for 1975, 1980, 1985, 1990, and 1995 unless otherwise noted.

[f] Based on OSE long-term average data for all reservoirs in county.

[g] Average 1975-1995 discharge at Canadian River near Taylor Springs gage.



Note: Numbers are volumes in acre-feet based on year 1975 - 1995 data.

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COLFAX REGIONAL WATER PLAN
Colfax County Average Annual Surface Water Budget

Figure 7-1

Figure 7-1 portrays these data in a schematic format. In addition to the data discussed above, the riparian ET and precipitation volumes were estimated to be 354,000 and 4,057,000 acre-feet per year, respectively. This is approximately 1 to 2 orders of magnitude greater, respectively, than the other major quantified components of the surface water budget. The method of quantifying these components is outlined in the following discussion.

The average total precipitation volume for the county was derived using 1975 through 1995 data from the Abbott 1 SE, Black Lake, Cimarron 4 SW, Eagle Nest, Lake Maloya, Maxwell 3 NW, Raton Filter Plant, and Springer climate stations. Polygonal areas determined by drawing perpendicular bisectors between station locations were multiplied by the average annual precipitation rates at each station to estimate representative volumes of precipitation throughout the county. Since the representative polygons included large areas within which some precipitation variability occurs, the representative station volumes were adjusted by applying the methodology described below:

- The areas between isopleth contours from the map of 1931 through 1960 average annual precipitation (Appendix B, Figure B-6) were measured within each climate station polygon, and a weighted average precipitation amount was determined within each polygon.

- The weighted average precipitation amounts were then compared to the average precipitation amounts recorded at each station during the period of 1931 through 1960 using the available records for each climate station.

- The percentage differences were then applied to the 1975 through 1995 average volumes determined for each polygon.

In this manner, the relation between the documented precipitation variability within each representative polygon and its climate station records was maintained.

Through a query of the GIS files for the WRRI map of riparian areas (Appendix B, Figure B-9), riparian areas in the county were determined to total 118,812 acres. A representative average annual ET rate for riparian areas was developed by averaging data collected along the Rio Grande by Thorn (1995) and Hong et al. (2000) (ET data specific to Colfax County were not available). The Rio Grande studies showed that ET from grass-covered areas ranged between 0.15 and 4.70 millimeters per day (mm/d) over a 19-month period and averaged 2.43 mm/d (Thorn, 1995). ET from areas with cottonwood vegetation ranged from 4.5 to 5.7 mm/d during a single day in September 2000 (Hong et al., 2000) and averaged 5.1 mm/d. The annual average ET for cottonwood vegetation was assumed to be 50 percent of the September measurements, or 2.55 mm/d. Finally, an average ET rate of 2.49 mm/d for riparian areas was estimated based on the assumption that riparian areas in the planning region are made up of 50 percent grass and 50 percent cottonwood vegetation. This daily rate is equivalent to an average annual rate of 2.98 feet per year, which was multiplied by the riparian acreage to generate the total volume of riparian ET.

Figure 7-1 also depicts unquantified components of the surface water budget such as runoff interception, non-riparian ET, snowmelt, and seepage losses:

- Interception is that part of precipitation input that wets and adheres to aboveground objects (generally vegetation) and is subsequently returned to the atmosphere through evaporation. Generally, about 10 to 20 percent of precipitation that falls during the growing season is intercepted in this manner. However, interception for areas with dense forests may be as much as 25 percent of total annual precipitation (Viessman et al., 1989).

- Non-riparian ET is likely the largest output component of the surface water budget, since total ET can exceed 90 percent of precipitation in some watersheds (Brooks et al., 1991). Measurements of non-riparian ET in the Los Alamos, New Mexico area showed that ET losses were between 75 and 87 percent of total precipitation (Gray, 1997).

- Snowmelt volume is not well defined since there is only one snow monitoring station in the county.

- Data on seepage losses have not been developed for this region.

The total of the unquantified components of runoff interception, non-riparian ET, and seepage losses should be nearly the same magnitude as the total precipitation input minus riparian ET. However, data are not available to make reliable estimates of these quantities. Therefore, these additional components of the surface water budget are not included in the quantitative water balance reconciliation (Table 7-1).

7.1.1.2 Representative Drought Year Surface Water Budget

Annual surface water budget results for the year 2000, selected as a representative drought year, are presented in Table 7-2 and Figure 7-2. Inflows are comprised of gaged stream discharges from the five main drainages in the county and documented reservoir releases during the year 2000. Again, the discharge for the Cimarron River near Cimarron gage was adjusted to exclude documented Eagle Nest Lake releases during the year 2000.

Outflows are comprised of surface water depletions reported by the OSE for the year 2000 and downstream discharge outflow measured at the Canadian River near Taylor Springs gage. As was done for the average surface water budget, reservoir evaporation is based on the OSE master database for all reservoirs in the county. The OSE reported irrigation depletion for the year 2000 is based on 1999 data because 2000 was a drought year and their water use reports are meant to represent average conditions. For the purpose of this water budget, therefore, irrigation depletion for the year 2000 was estimated by adjusting the OSE-reported 1995 irrigation depletion by the percentage difference between documented 1995 and 2000 reservoir releases, excluding Eagle Nest Lake. This amount reflects the estimated amount of surface water available during the 2000 drought year, and depletions reflect those that occur during a drought year. The actual demand, however, is greater than the supply (i.e., if more water were available, there would be demand for it). The ability of the supply to meet demand is discussed further in Section 7.2.

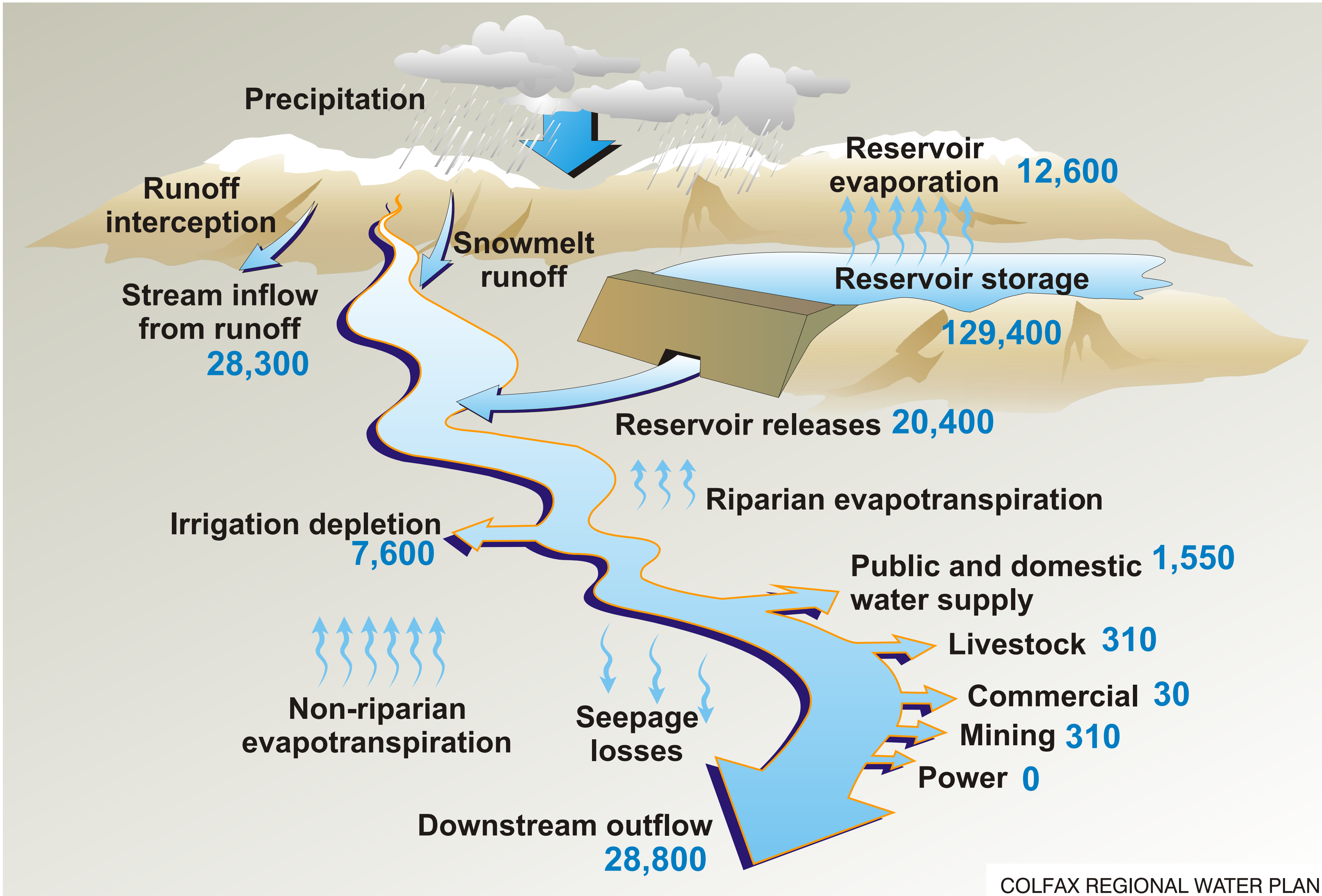
Table 7-2 shows an accounting of measured inflows minus reported depletions and compares this value to downstream discharge outflow. This comparison shows that total measured inflows minus reported depletions is 8.7 percent less than the measured downstream discharge outflow. The larger discrepancy in the inflow/outflow reconciliation than was seen in the average surface water budget results may stem from the use of the OSE master database

Table 7-2. Colfax County Surface Water Budget Representative Drought Year

Line Item	Inflow / Depletion [a] (ac-ft)
Surface Water Inflows	
Gaged Stream Inflows:	
Canadian River near Hebron	6,453
Vermejo River near Dawson	11,100
Ponil Creek near Cimarron	3,800
Cimarron River near Cimarron [b]	868
Rayado Creek near Cimarron	6,050
Stream inflows subtotal	28,271
Reservoir Releases: [c]	
Miami Lake	2,307
Antelope Valley No. 2 and No. 3	1,738
Springer Lake	2,816
Eagle Nest Lake [d]	13,535
Reservoir releases subtotal	20,396
Total inflows	48,667
Surface Water Depletions [d] and Outflow	
Public Water Supply	1,554
Domestic Water Supply	0
Irrigated Agriculture [e]	7,562 [f]
Livestock	309
Commercial	34
Mining	308
Power	0
Reservoir Evaporation [g]	12,569
Total depletions	22,336
Total Inflows minus depletions	26,331
Downstream discharge outflow [h]	28,830
In minus out	–2,499
In minus out percentage	–8.7%

ac-ft = Acre-feet

[a] Data from 2000 unless otherwise noted.
[b] Gage data corrected to exclude Eagle Nest Lake releases.
[c] Reservoir discharge data provided by Jim Hollis, Cimarron River Basin Water Master.
[d] Based on Office of the State Engineer (OSE) water use figures reported for the year 2000 unless otherwise noted.
[e] SEO 2000 water use figures reported 1999 data for irrigation; 2000 irrigation depletion estimated by multiplying 1995 irrigation depletion by percentage difference between 1995 and 2000 reservoir releases (excluding Eagle Nest Lake).
[f] Depletions shown here for irrigated agriculture are based on the available surface water supply in a drought year. Actual demand exceeds the available supply.
[g] Based on OSE long term average data for all reservoirs in county.
[h] 2000 discharge at Canadian River near Taylor Springs gage.



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Colfax County Representative Drought Year Annual Surface Water Budget

Note: Numbers are volumes in acre-feet based on year 2000 data.

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Figure 7-2

reservoir evaporation figures rather than actual 2000 data. That is, depletions from reservoir evaporation are likely overstated for drought conditions, when reservoir storage is lower than average.

Figure 7-2 portrays these data in a schematic format. In addition to the components shown in Figure 7-2, estimated precipitation input and riparian evapotranspiration (ET) volumes, along with depictions of the unquantified surface water budget components, were described in Section 6.3.1. The major quantified components were determined as follows:

- The total precipitation volume was derived from year 2000 data in a manner similar to that performed for the average budget calculations.

- Riparian ET was estimated by applying the percentage difference between the 1975 through 1995 average precipitation volume and the year 2000 precipitation volume to the previously estimated average riparian ET volume.

Based on this method, estimates of precipitation and riparian ET were 3,594,000 and 308,000 acre-feet per year, respectively. As before, the additional, unquantified surface water budget components are not included in the quantitative water balance reconciliation (Table 7-2), due to the lack of available data to accurately balance these components against the magnitude of overall precipitation input.

7.1.2 Groundwater Budget

The output components of the groundwater budget are withdrawals from pumping wells for a variety of beneficial purposes, as detailed in Table 6-3. Though it currently represents only about 5 percent of all water use in the county, consumptive use of groundwater in the county has consistently grown since 1975 (Table 6-3). Therefore, recent data are most pertinent to a groundwater budget analysis.

As shown in Table 6-3, for the year 2000, irrigated agriculture was the largest single use of groundwater in the county, accounting for 41 percent of all groundwater depletions. As noted in

Section 7.2.1.2, however, the OSE reported 1999 rates for irrigation in the 2000 report, since 2000 was a drought year and not representative of average conditions.

The next largest component of groundwater use was for public water supplies, which accounted for 26 percent of the total reported groundwater depletions in the county during 2000. By far, the largest public water supply groundwater usage was in the Moreno Valley area. Total groundwater withdrawals of 731 acre-feet were made by the Angel Fire and Eagle Nest water systems during 2000. The OSE assumes an average depletion factor of 47 percent for these systems, resulting in a total depletion of 345 acre-feet, which accounted for about 24 percent of all groundwater depletions in the county during 2000.

The other major component of groundwater usage was for livestock, which accounted for 22 percent of depletions, while domestic and commercial usage accounted for the remaining 11 percent of groundwater depletions. The volume of all groundwater depletions reported by the OSE during the year 2000 totaled 1,448 acre-feet.

The input component of the groundwater budget is recharge. The main source of groundwater recharge in Colfax County is likely from mountain-front recharge. This type of recharge is derived largely from the melting of the snowpack that forms in the higher elevations of a mountainous region bordering on an adjacent groundwater basin and runoff from rainfall on the mountain highlands. The recharge occurs through two mechanisms: (1) subsurface flow of groundwater from the mountainous areas to the adjacent groundwater basin, and (2) infiltration of streamflow from the channels that carry runoff from the mountain highlands to the adjacent basin.

A calculation of mountain-front recharge for Colfax County was made based on the results of recent studies in New Mexico on this topic:

- Anderholm (1998, 2000) used the chloride-balance method to generate several estimates of mountain-front recharge for the east side of the middle Rio Grande Basin.

- In the Manzano Mountains, mountain-front recharge was estimated to total approximately 6 percent of the mean annual precipitation (Anderholm, 1998).

- Later studies yielded recharge estimates that ranged from 0.7 to 15 percent of mean annual precipitation within different subareas, with the largest rates seen at the higher elevations and the lowest rates in the lower, more arid elevations (Anderholm, 2000).

- An average annual recharge rate of 22 millimeters was estimated for the entire middle Rio Grande Basin mountain front, which amounts to 4.3 percent of the mean annual precipitation of 20.1 inches (Anderholm, 2000).

• Guan and Wilson (2002) used numerical modeling to estimate a mean annual percolation rate of 26 millimeters for the west slope of the Sandia Mountains, which represents 5.1 percent of mean annual precipitation.

Based on these studies, a recharge rate of 5 percent of mean annual mountain-front precipitation was assumed for the Colfax region. To determine the total mean annual mountain-front precipitation, the areas between isopleths on a map of average annual precipitation (Appendix B, Figure B-6) for the areas of the county that lie above the 2,600-meter (8,530 feet msl) elevation contour were measured. Using this definition, a total of 32,871 acres of mountain front area were delineated, within which a weighted (by area) average annual precipitation rate of 21.4 inches for the evaluated area was determined. Assuming a 5 percent recharge rate yields a mean annual mountain-front recharge rate of about 27 millimeters (1.06 inches), which agrees closely with the earlier research (Anderholm, 1998, 2000; Guan and Wilson, 2002). The mean annual precipitation volume for the mountain-front region was calculated to total about 58,650 acre-feet; based on this amount, the assumed 5 percent recharge rate yields a total mean annual mountain-front recharge volume of about 2,930 acre-feet for the county.

This magnitude of groundwater recharge is approximately 2.5 times greater than the current rate of groundwater depletion reported for the county. Total groundwater withdrawals during 2000, not accounting for return flows, amounted to 2,201 acre-feet, which is about 75 percent of the estimated mean annual groundwater recharge volume. This analysis suggests that perhaps about 700 to 1,500 acre-feet per year of additional groundwater usage could be developed without depleting the total resource, assuming that average precipitation conditions prevail. However, more detailed groundwater monitoring and modeling would be required to fully evaluate sustainable yields for local resource areas.

This quantified recharge amount is distributed along the entire mountain front and feeds aquifers throughout the entire north to south length of the county. Therefore, growth of groundwater withdrawals focused within a relatively small segment of that area, such as the Moreno Valley region, will likely result in future groundwater declines in that area. Also, mountain-front recharge rates will be reduced during drought years, when lower snowpack yields produce reduced amounts of runoff available for recharge. If drought conditions were to persist over a prolonged period, the current rate of groundwater use in the county will likely result in mining of the groundwater resource.

7.2 Probability of Supply Meeting Demand

As discussed in Section 5, more than 95 percent of the water demands in Colfax County are supplied by surface water sources, the volume of which is highly variable. In order to understand the ability of the surface water supplies to meet demands, the probability that surface water flows are large enough to meet demands is evaluated.

One of the primary purposes of regional planning is to assess the available water supply in the region and to compare available supplies to projected demands. Based on the results of the water supply and demand analyses, decisions can be made regarding whether excess supplies are available in the region or whether additional supplies are necessary. For Colfax County, it would be inappropriate to consider that there is available water as long as there are adjudicated water rights that are not fulfilled. Consequently, to determine how often the available surface water supply was able to meet demand, streamflow was compared to the corresponding decreed water rights. This analysis is similar to that presented in Section 5.1.5, except that the comparison was to demand instead of median flow (i.e., the demand was assumed to be equal to the total of the adjudicated water rights). This analysis was conducted for the Cimarron, Rayado, and Vermejo Decrees (Section 4.4.1):

- For the Cimarron Decree the demand of 40,000 acre-feet was compared to sum of the streamflow at the Cimarron River below Eagle Nest and Ponil Creek gages. In summing these two stations, storage changes in Eagle Nest were considered in order to correct Cimarron flows either for releases from storage or additions to storage.

- For the Rayado Decree the demand of 12,170 acre-feet was compared to streamflow at the Rayado near Cimarron gage station.

- For the Vermejo decree the demand of 27,000 acre feet was compared to the Vermejo River near Dawson station.

The results of these analyses are summarized in Table 7-3. As noted in Table 7-3, the majority of years show an inability to meet demands for all three decrees.

Table 7-3. Ability of Supply to Meet Demand for Selected Decrees 1950 Through 2001

Amount of Demand Met	Occurrence (Number of years)		
	Vermejo Decree [a]	Rayado Decree [b]	Cimarron Decree [c]
Less than 50% of demand	34	19	30
Between 20 and 50% less than demand	10	13	10
Within ± 20% of demand	7	8	9
Between 20 and 50% greater than demand	0	7	2
50% more than demand	1	5	1

[a] Streamflow from Vermejo River near Dawson gaging station
[b] Streamflow from Rayado Creek near Cimarron gaging station
[c] Streamflow from Cimarron River below Eagle Nest gaging station (corrected for Eagle Nest Reservoir) and Ponil Creek gaging station combined

Next, the transition from year to year for the ability of streamflow to meet demand was examined for these decreed areas. The frequency of these transitions is shown in Table 7-4.

Table 7-4. Frequency of Demand Transitions for Selected Decrees 1950 Through 2001

Transition		Frequency of Occurrence (percentage of time)		
From	To	Vermejo River near Dawson	Rayado Creek near Cimarron	Cimarron River [a]
Less than 50% of demand	Less than 50% of demand	64	32	59
	Between 20% and 50% less than demand	21	47	14
	Within +/– 20% of demand	12	11	21
	Between 20% and 50% greater than demand	0	11	7
	50% more than demand	3	0	0
Between 20% and 50% less than demand	Less than 50% of demand	50	25	60
	Between 20% and 50% less than demand	30	0	20
	Within +/– 20% of demand	20	25	10
	Between 20% and 50% greater than demand	0	33	0
	50% more than demand	0	17	10
Within +/– 20% of demand	Less than 50% of demand	86	50	67
	Between 20% and 50% less than demand	0	25	33
	Within +/– 20% of demand	14	0	0
	Between 20% and 50% greater than demand	0	0	0
	50% more than demand	0	25	0
Between 20% and 50% greater than demand	Less than 50% of demand	0	29	50
	Between 20% and 50% less than demand	0	14	50
	Within +/– 20% of demand	0	43	0
	Between 20% and 50% greater than demand	0	14	0
	50% more than demand	0	0	0
50% more than demand	Less than 50% of demand	100	60	0
	Between 20% and 50% less than demand	0	20	0
	Within +/– 20% of demand	0	0	100
	Between 20% and 50% greater than demand	0	0	0
	50% more than demand	0	20	0

[a] Streamflow from Cimarron River below Eagle Nest gaging station (corrected for Eagle Nest) and Ponil Creek gaging station combined.

The same analysis shown above was repeated the entire region's demand using two different approaches.

- The first approach was to use the sum of the five tributary stations (Rayado, Ponil, Cimarron below Eagle Nest, Vermejo at Dawson, and Canadian at Hebron) and compare this value to the corresponding demand of approximately 80,000 acre feet (sum of the Cimarron, Rayado and Vermejo Decrees). In summing the five stations, storage changes in Eagle Nest were considered in order to correct Cimarron flows either for releases from storage or additions to storage.

- The second approach was to use streamflow from the Canadian River at Taylor Springs gage plus an estimated surface water depletion amount. The surface water depletion amount was assumed to be the average of the amounts reported by the OSE (Table 6-1). This value was then compared to the estimated 120,000-acre-foot demand for the entire region. Table 7-5 summarizes the number of years the supply was able to meet region's demand, and Table 7-6 contains the frequency of these transitions. Again the analyses show an inability to meet demands for the majority of years.

Table 7-5. Ability of Supply to Meet Demand for the Region 1950 Through 2001

Amount of Demand Met	Occurrence (Number of years)	
	Five Upstream Stations [a]	Canadian River at Taylor Springs [b]
Less than 50% of demand	23	18
Between 20 and 50% less than demand	14	23
Within ± 20% of demand	9	4
Between 20 and 50% greater than demand	2	4
50% more than demand	4	3

[a] Streamflow from the sum of the five tributary stations (Rayado, Ponil, Cimarron below Eagle Nest, Vermejo at Dawson, and Canadian at Hebron).
[b] Streamflow from the Canadian River at Taylor Springs gage station plus an average surface water depletion amount (36,433 acre-feet).

As shown on Table 7-5, the supply is greater than or equal to 80 percent of the demand only 15 out of 52 years (29 percent of the time) for the five upstream stations or 11 out of 52 years (21 percent of the time) for the Canadian River at Taylor Springs gage.

Table 7-6. Frequency of Demand Transitions for the Region 1950 Through 2001

Transition		Frequency of Occurrence (percentage of time)	
From	To	Five Upstream Stations [a]	Canadian River at Taylor Springs [b]
Less than 50% of demand	Less than 50% of demand	50	53
	Between 20% and 50% less than demand	14	12
	Within +/– 20% of demand	27	18
	Between 20% and 50% greater than demand	0	12
	50% more than demand	9	6
Between 20% and 50% less than demand	Less than 50% of demand	36	26
	Between 20% and 50% less than demand	29	61
	Within +/– 20% of demand	14	4
	Between 20% and 50% greater than demand	7	4
	50% more than demand	14	4
Within +/– 20% of demand	Less than 50% of demand	33	0
	Between 20% and 50% less than demand	56	75
	Within +/– 20% of demand	11	0
	Between 20% and 50% greater than demand	0	25
	50% more than demand	0	0
Between 20% and 50% greater than demand	Less than 50% of demand	100	50
	Between 20% and 50% less than demand	0	25
	Within +/– 20% of demand	0	0
	Between 20% and 50% greater than demand	0	0
	50% more than demand	0	25
50% more than demand	Less than 50% of demand	50	33
	Between 20% and 50% less than demand	25	67
	Within +/– 20% of demand	0	0
	Between 20% and 50% greater than demand	25	0
	50% more than demand	0	0

[a] Streamflow from the sum of the five tributary stations (Rayado, Ponil, Cimarron below Eagle Nest, Vermejo at Dawson, and Canadian at Hebron).

[b] Streamflow from the Canadian River at Taylor Springs gage station plus an average surface water depletion amount (36,433 acre-feet).

Section 8

Analysis of Alternatives

8. Analysis of Alternatives for Meeting Future Demand

Once the region has studied their water supply and projected future demand for water, the next key component of the regional water plan is to develop alternatives for meeting the projected water demand. Alternatives are actions that the region can take to increase supply, reduce demand, protect or improve water quality, or better manage water resources so that the water supply of the region continues to be viable. This section provides information on the process used to identify and screen alternatives and also provides a feasibility analysis of priority alternatives selected by the steering committee.

8.1 Identification and Selection of Alternatives

After the initial water supply and demand study was completed, the steering committee identified three key alternatives and requested additional funding for analyzing these three alternatives in detail:

- Agricultural water conservation
- Drought planning
- Watershed management, including establishment of watershed groups on the Canadian Headwaters and Cimarron watersheds

A detailed drought contingency plan and an agricultural water conservation plan were prepared and are included herein (Appendices E and H). Watershed management is addressed in Section 8.2.

In addition to the three alternatives that were selected early in the process for more detailed study, a complete list of potential alternatives for addressing water supply needs was developed at a steering committee meeting held in 2000. Additional alternatives were added to the list and revisions were made at subsequent steering committee meetings and at public meetings held in 2001.

The steering committee also identified criteria to help determine which of the alternatives were the most important to identify and analyze in the regional water plan. These criteria included:

- Economic feasibility
  - Local capital costs
  - Local O&M costs
  - Feasibility of state/federal funding

- Technical feasibility
  - Physical feasibility
  - Local operational challenge
  - Availability of technical assistance

- Legal/regulatory
  - Permitting
  - Impact on water rights
  - Conflicting laws

- Benefits
  - Regional benefits
  - Ability to address multiple goals
  - Efficient use of water
  - Protection/enhancement of water quality
  - Ability to increase supply/reduce demand
  - Reduction of vulnerability to drought

- Political feasibility
  - Local public acceptance
  - Support by political leaders
  - Need for and likelihood of legislation
  - Equitability to stakeholders

- Other
  - Speed of implementation
  - Environmental impact
  - Sociocultural impact

These criteria were used to score all of the alternatives as an initial evaluation of the technical, legal, financial, and political feasibility, and the social and environmental impacts of the alternatives. Technical and legal scores were prepared by DBS&A and were reviewed and revised by the steering committee. Scores for the social and environmental impacts and political feasibility were prepared by the steering committee. The top ranked alternatives were then presented to several focus groups (attendance at the groups is described in Section 2).

The focus group and steering committee discussions resulted in a refined list of alternatives (Table 8-1). In accordance with the ISC template, the alternatives defined by the steering committee fall into the categories of water resource management, water conservation, water and infrastructure development, and water quality management (Table 8-1). A subset of these alternatives was identified by the steering committee for analysis within this *Regional Water Plan;* these alternatives include:

- Implementing dredging projects to improve storage in reservoirs and ponds
- Developing county and city ordinances for conservation
- Pursuing water rights transfers or leases to help supply projected demand
- Appropriating and reserving groundwater for the region
- Developing 40-year water plans and securing water to meet future demands (municipalities and other local entities)
- Developing and implementing county-wide septic tank and other water quality control ordinances
- Recycling municipal wastewater for agricultural and recreational use
- Implementing growth management and land use planning
- Providing public outreach and educational activities

Table 8-1. Alternatives for Meeting Future Water Supply Needs

	Priority Alternatives	Other Alternatives
Water Supply Conservation	• Implement voluntary agricultural water conservation measures, including lining ditches and encasing delivery systems to reduce losses • Develop county and city water conservation ordinances – Increase water rates – Implement efficiencies in industrial uses such as mining	• Implement efficiencies in municipal water supply management (e.g., leak detection) • Remove invasive vegetation; revegetate to reduce riparian evapotranspiration • Xeriscape to conserve (municipal) water
Water Supply Development and Infrastructure	• Implement dredging projects to improve storage in reservoirs and ponds • Recycle municipal wastewater for agricultural and recreational use	• Build additional water storage capacity (aboveground and underground) • Build a regional delivery system to tie in municipal systems (Cimarron, Springer, Maxwell, Miami, and Raton) • Maintain treatment plant in municipalities and upgrade mains and other infrastructure • Implement cloud seeding projects
Water Quality Protection	• Develop and implement county septic tank and other water quality control ordinances	• Construct wastewater treatment systems to replace septic tanks in the Moreno Valley and other areas • Implement nonpoint source management projects • Draft and implement source water and wellhead protection plans for key water supplies • Monitor methane gas extraction activities for potential impacts to groundwater quality/quantity and consider potential reuse of water
Water Resources Management	• Implement drought contingency plan • Manage watersheds to improve yield, implement watershed groups to undertake projects, and obtain funding and adopt watershed management plans that address private and public lands • Develop 40-year water plans and appropriate water to meet future demand (municipalities and other entities) • Pursue water rights transfers or leases that could supply projected demand • Implement growth management and land use planning – Develop a county-wide comprehensive land use plan. – Develop and implement city and county ordinances to control domestic wells • Appropriate and reserve groundwater for the region	• Establish regional water banking (accounting) source for drought periods • Actively manage existing storage facilities to make most efficient use of water/storage • Establish a mechanism to better manage water delivery throughout Colfax County • Establish a Canadian River Water Master • Declare Capulin Basin
General Actions	• Public education and outreach (materials, events, brochures, hire coordinator) • Seek funding for continued planning and implementation projects • Interact with political leaders to develop support (state and federal legislators)	

In accordance with the ISC template, these priority alternatives were evaluated with regard to their technical feasibility, political feasibility, social and cultural impacts, financial feasibility, and hydrologic and environmental impacts (Sections 8.2 through 8.10). Physical impacts, if relevant to the alternative, are discussed in the hydrologic impacts subsections of Sections 8.2 through 8.10. An implementation schedule for the alternatives is provided in Section 8.14.

Scores for legal feasibility were provided for all alternatives and reflect varying degrees of legal complexity in implementing the alternatives. No legal issues that would prohibit implementation of any of the alternatives were identified, though in some cases permits or other legal concerns would need to be addressed. Legal issues affecting the water supply in the region are discussed in Section 4.

In addition to the priority alternatives that are analyzed in this document, the steering committee identified several other alternatives to be included as part of the long-term water plan (Table 8-1). The steering committee also identified actions that would support most of the other alternatives, including educating the public, obtaining funding, and gaining support of political leaders. These actions are discussed in Sections 8.11 through 8.13.

8.2 Watershed Management

Early on, the steering committee identified watershed management as a key alternative. When additional funding was received from the ISC, part of it was directed toward establishing two watershed groups: one for the Cimarron watershed and one for the Canadian Headwaters watershed (Figure 5-1). In the meantime, however, the NMED independently formed a Cimarron watershed group. To avoid duplication, the Colfax regional water planning steering committee decided not to form a separate watershed group, but to join the NMED group. Technical support was provided to the NMED Cimarron watershed group, and additional effort was directed toward the formation of a Canadian watershed group.

Two meetings were held regarding formation of the Canadian group. Stakeholders from the watershed were invited to attend and the meetings were publicized. The group expressed interest in continuing to meet. In September 2002, the Colfax SWCD submitted a grant application to the New Mexico Water Trust Board in hopes of obtaining funding to continue the Canadian watershed group and to support watershed projects.

The focus of the watershed groups is to develop watershed management plans and to identify projects that can improve or protect the water quality in the area. In addition to these efforts, the remainder of this section focuses on an analysis of conducting watershed management activities to potentially affect the yield of the watersheds.

8.2.1 Summary of the Alternative

This section discusses the management of three distinct ecosystems: forests, piñon-juniper woodlands, and riparian systems. For the purpose of this plan, these ecosystems are defined as follows:

- Forests are the areas dominated by conifers and aspens. In general, the forest zone can be broken up into three main vegetation types: (1) the lower-elevation ponderosa pine zone, (2) the middle-elevation mixed conifer zone, and (3) the upper-elevation zone grading from fir to spruce.

- Piñon-juniper woodlands are those areas where the overstory is dominated by piñon pine, juniper, or both.

- Riparian zones technically occur along all streams and rivers, but for the purpose of this discussion the term "riparian systems" will only refer to the areas along lower-elevation intermittent or perennial streams below the forest zone. Riparian zones within the forest are explicitly or implicitly included in the discussion of the management options in forested areas.

The focus of this alternative is assumed to be the potential to increase water yields through vegetation management. However, the potential for increasing water yields cannot be separated from the effects of management on runoff processes, erosion, and water quality.

Hence the discussion of management alternatives includes an assessment of the potential positive and negative effects on water quality.

In the past couple of decades forest density has generally increased due to the suppression of fire and the limited amount of timber harvest. This has almost certainly resulted in a decrease in water yields, particularly in the Cimarron River watershed. Management activities such as forest harvest or thinning could potentially increase water yields. In addition, reducing vegetation density can help lower the risk of severe wildfires. As seen in the case of the Cerro Grande and numerous other fires (Robichaud et al., 2000; Moody and Martin, 2001), high-severity fires can greatly increase the size of peak flows and surface erosion rates, thus increasing channel erosion, causing downstream sedimentation, and adversely affecting water quality.

In the piñon-juniper zone there also has been a general increase in tree density, as well as a corresponding reduction in the abundance of forbs and grasses. Past management practices have focused on reducing woody vegetation and increasing the amount of forbs and grasses, but increases in herbaceous vegetation have generally been short-lived. Efforts to reduce the amount of woody vegetation will have a negligible effect on water yields, as the annual precipitation is simply too low; any reduction in transpiration will be lost to a corresponding increase in evaporation (e.g., Bosch and Hewlett, 1982). Changes in grazing management practices could potentially affect the partitioning of rainfall between surface runoff and infiltration and, hence, the amount of hillslope and riparian erosion, as well as water quality, channel morphology, and aquatic habitat.

In the riparian zones the primary management issue is grazing and the resultant effects on water quality.

8.2.2 Technical Feasibility

8.2.2.1 Restore and Manage Forests

The management activity with the greatest potential to increase water yields is to reduce forest density. In general, water yield increases are proportional to annual precipitation and the proportion of the forest canopy that is removed (Bosch and Hewlett, 1982; Troendle and

Kaufmann, 1987). Little or no water yield increases can be expected in areas where annual precipitation is less than about 450 to 500 millimeters (mm) (18 to 20 inches) (Ffolliott and Thorud, 1975; Bosch and Hewlett, 1982; Stednick, 1996) or in areas at or near timberline, where there is insufficient vegetation to make transpiration a dominant source of water “loss.” In the case of the study area, only the weather stations at Lake Maloya and Black Lake average more than 500 mm (20 inches) of annual precipitation (Section 5.1.3, Figure 5-4).

Research in Colorado has shown that water yield increases in the higher elevation lodgepole and spruce-fir forests are directly proportional to the amount of basal area that is removed (Troendle and King, 1987). However, limitations in the accuracy of streamflow measurements and the regressions between paired basins means that at least 20 to 25 percent of the basal area within a watershed must be removed in order to detect a statistically significant change in runoff (Troendle and King, 1987; Troendle et al., 2001). Smaller reductions in basal area should proportionally increase streamflow, but the magnitude of increases from small changes in forest density cannot be predicted with any confidence.

The large variability in annual precipitation is another important limitation to managing forests for water yield. Data from the Fool Creek study in central Colorado showed that water yield increases in dry years were only about one-quarter of the increases in wet years (Troendle and King, 1985). This means that water yield increases from forest harvest would be least in the dry years, when they are most needed, and greatest in the wet years, when they are least needed. Since the relative variability of annual precipitation increases as annual precipitation decreases, the increase in water yield with forest management becomes increasingly variable, and therefore increasingly uncertain, as annual precipitation drops near the threshold of 450 to 500 mm (18 to 20 inches). Additional storage capacity, either through dredging (Section 8.3.1) or through new storage projects, will be needed to carry over excess water from wet years if forest management is to be a viable option for increasing water yields.

It also is important to recognize that most of the increase in water yield in snow-dominated areas comes on the rising limb of the snowmelt hydrograph. At Fool Creek in Colorado, May was the only month with a statistically significant increase in monthly water yields (Troendle and King, 1985). Paired watershed experiments in areas with more substantial amounts of summer rainfall have sometimes yielded large increases in summer runoff in percentage terms, but the amounts are very small in absolute terms (e.g., less than 0.1 cubic feet per second [cfs] per square mile) (Austin, 1999). Again this suggests that more storage will be required if most of the harvest-generated increases in runoff are to be used between the beginning of July and approximately mid-April.

Another technical limitation for increasing water yields is the fact that the increased water yields diminish as the forest regrows. Long-term data from the Fool Creek study suggest that approximately 60 to 70 years are required for water yields in the subalpine zone to return to pre-harvest levels (Troendle and King, 1985). The recovery rate for aspen, however, is substantially shorter, and a shorter recovery rate would also be expected for lower-elevation areas where less regrowth is needed before water yields return to their pre-harvest levels. In the Wagon Wheel Gap paired watershed study, the increase in water yield disappeared within a few years due to a series of dry years and rapid regrowth of aspens (Bates and Henry, 1928; Troendle, 1983; U.S. Forest Service, personal communication with Lee MacDonald, Colorado State University, 2000). More recent modeling efforts have assumed that aspen reaches full hydrologic recovery in 30 years, although the potential range is from 15 to 45 years (Troendle and Nankervis, 2000). The hydrologic recovery associated with forest regrowth means that the long-term average increase in water yield is much less than the water yield increase observed in the first few years after treatment (Rector and MacDonald, 1987).

In summary, the average long-term increase in water yield depends on the annual precipitation, the species being treated, the proportion of the canopy that is removed, the regrowth rate, and the length of time between treatments. Based on these factors, the relative potential for increasing water yields is as follows:

- The greatest potential for increasing water yields is in the higher-elevation fir and spruce forests.

- The aspen and mixed conifer forests have a more limited potential for increasing water yields because of the lower annual precipitation and the more rapid hydrologic recovery of aspen sites.

- The smallest potential for increasing water yields is in the ponderosa pine forests. In these drier sites the remaining vegetation and soil evaporation will take up more of the water that is “saved” by the reductions in interception and transpiration, and less regrowth will be needed before the site has hydrologically recovered. Observed increases in flow from the harvest of ponderosa pine stands in other areas have ranged from zero to a maximum of 2 inches per unit area (Rich, 1972; Brown et al., 1974; Ffolliott and Thorud, 1975; Gary, 1975; Troendle, 1983). A recent study of the potential for increasing water yields in north-central Colorado assumed that harvesting ponderosa pine would result in no net increase in water yield (Troendle and Nankervis, 2000).

In any case, the timing of the increase in runoff may not match up well with the timing of peak demand, so storage capacity will be required to obtain the full benefits of any projected increase in streamflow.

An extensive program of forest harvest or thinning could increase erosion rates and adversely affect water quality as a result of increased turbidity and sediment loads. The magnitude of these effects will depend more on the methods used to yard and remove the woody material than on the harvest itself, as roads and skid trails are the primary sources of sediment from well designed and carefully executed forest management programs. The increase in erosion from harvested areas and the accompanying adverse impacts on water quality can usually be minimized by applying best management practices. The careful design and construction of the road and skid trail system is critical to minimizing overland flow and reducing erosion, while the use of buffer strips along ephemeral and perennial streams is needed to minimize sediment delivery into the stream network. Maintaining riparian vegetation is the best means to minimize increases in water temperatures.

A reduction in forest density by prescribed burning generally would not increase water yields because most prescribed burns are designed primarily to remove brush and suppressed trees and therefore do not extend into the crowns and kill a significant proportion of the larger overstory trees. In some cases small patches of higher-intensity crown fires may occur, but an increase in water yields would not be expected unless the basal area is substantially reduced. Because prescribed fires typically do not burn all of the protective litter and humus layer and do not result in large patches of water-repellent soils, prescribed fires are not expected to cause a significant increase in runoff or to adversely affect water quality (Tiedeman et al., 1979; Robichaud and Waldrop, 1994).

Two key limitations to the increased use of prescribed fire are the limited meteorologic windows for conducting prescribed burns and the amount of smoke and particulates generated from prescribed fires. Prescribed fires require conditions that are dry enough to burn, but sufficiently wet so that the fire has relatively little risk of escaping and causing unwanted damage. Only a few days each year may be suitable for igniting a controlled burn, and the limited number of trained personnel constrains the amount of area that can be treated at one time. The production of particulates is a concern for both public health and visual air quality. Both of these issues may pose serious constraints to the initiation of larger-scale prescribed burning programs.

In the absence of any efforts to reduce forest density, a continuing high risk, or a gradual increase in risk, of high-severity wildfires can be expected. High-severity fires are of considerable concern because of the potential to destroy property and greatly increase runoff and erosion rates (Robichaud et al., 2000; Moody and Martin, 2001). These increases can then have severe effects on downstream channels, aquatic habitat, and reservoir sedimentation rates.

8.2.2.2 Restore and Manage Piñon-Juniper

Though there may be some benefits to ecosystem health, the opportunities for management actions to affect water yields and water quality in the piñon-juniper zone are much more limited than in the forested areas. There is virtually no opportunity to increase water yields through removal or reductions in the tree canopy, as the annual precipitation in this zone is less than 450 mm. The critical issue with respect to runoff and erosion is the amount of cover and surface roughness in the intercanopy areas. Hence the effect of increasing tree density on water quality can vary, but runoff and erosion rates are generally less under the tree canopy than in the intercanopy areas (e.g., Reid et al., 1999). Increased fuelwood harvests would probably have minimal effects on runoff, but the corresponding increase in herbaceous vegetation could improve water quality. A decrease in water quality could occur if there is substantial ground disturbance associated with tree cutting and increased vehicle traffic.

In some cases the timing and quality of streamflow can change substantially after removing piñon-juniper, even though annual water yields remain unchanged. If the removal of the woody vegetation results in a much denser vegetation cover, there can be a shift from overland flow and high surface erosion rates during high-intensity rainstorms to more subsurface flow and lower surface erosion rates. The greater infiltration may reduce peak flows and cause some streams to flow on a more regular basis. Thus while total annual runoff may be less, the nature of the runoff is drastically changed. Such changes will be highly site-specific and will depend on a variety of factors, such as soil depth, soil texture, slope, bedrock type, changes in percentage of ground cover, and precipitation amounts and intensities.

With respect to runoff and water quality, the most significant management issue in this zone is the intensity, timing, type, and location of grazing activities. Although the effects of grazing can be highly variable, the scientific literature generally indicates that continuous high-intensity grazing causes a significant reduction in plant cover and infiltration rates, potentially leading to increased runoff, an increase in surface erosion, a decrease in site productivity, and a decline in water quality (Blackburn et al., 1982; Trimble and Mendel, 1995; Belsky et al., 1999).

Cattle tend to concentrate in riparian areas within the piñon-juniper zone because of the better forage, water for drinking, and shade. The concentration of cattle or other large animals in riparian areas usually causes more direct and largely adverse effects on aquatic resources than high-intensity grazing outside the riparian area, as the delivery of sediment and animal wastes into the stream channel is much more direct. If cattle or other animals concentrate in the riparian areas, the resultant trampling and reduction of riparian vegetation can destabilize the streambanks and further increase the amount of sediment being delivered to the stream. The large number of studies on grazing have reached varying conclusions, but the general consensus is that heavy grazing can have relatively severe effects on runoff, erosion, water quality, and stream channel characteristics, while time-controlled and well managed grazing has much less effect in terms of soil compaction, surface erosion, the degradation of riparian areas, and adverse changes in water quality and stream channel characteristics.

Some of the adverse effects of grazing can be alleviated by better managing the amount of time animals are in a given area, as the total number of animals is often not as much of a problem as the distribution of animals within the areas being grazed. A combination of fencing, herding, and the provision of salt and watering points away from the stream can help ensure a more even distribution of grazing pressure and reduce the concentration of animals in the riparian zone. The use of such management techniques could be expected to have a beneficial effect on riparian health and water quality. However, the likely impact of a given change in management is extremely difficult to quantitatively estimate.

An important limitation to a better match between site productivity and the number of grazing animals is the interannual variability in the amount and quality of forage. Although a given parcel of land can support fewer animals in dry years than in wet years, it is very difficult for landowners to rapidly adjust the size of their herds in response to short-term changes in range productivity. The social and economic issues associated with changes in grazing management are discussed in Sections 8.2.3 and 8.2.4.

8.2.2.3 Restore and Manage Riparian Zones

The primary issue with respect to the restoration and management of riparian zones is the control of grazing. The issues of grazing, as discussed in Section 8.2.2, apply to the lower-elevation riparian zones as well.

Efforts to restore the native vegetation and the natural geomorphic processes in riparian zones will often be constrained by the existing alterations of the flow regime and channel morphology. In many (if not nearly all) cases, the restoration of the natural flow regime cannot be achieved given the existing water needs and infrastructure of impoundments, diversions, and water rights. Extensive negotiations will be needed to balance human needs with ecological restoration.

8.2.3 Political Feasibility and Social/Cultural Impacts

The impediments to initiating an active program to manage or restore forests, piñon-juniper woodlands, and riparian zones are many and difficult. Foremost among these are public concerns, which stem from a variety of different issues and perceptions. Efforts to harvest or thin public forest lands often elicit opposition, even though these actions might substantially reduce the risk of high-severity wildfires while having minimal effect on water quality. Efforts to alter the management of piñon-juniper woodlands and riparian zones can be viewed as a threat to local or private controls on land and resource use. However, private landowners participating in watershed groups in the planning region have indicated strong local support for this option.

Given the general enhancement of environmental conditions and watershed productivity possible with the management options discussed herein, local rural residents are likely to be allies in these efforts. However, some of the management actions discussed herein may encounter local opposition. Piñon and juniper have long been the preferred fuelwood in New Mexico, and any program or action that would reduce or strictly limit access or supply might encounter local opposition. Grazing of sheep and cattle is also a tradition and a source of livelihood for local people in the planning region, and efforts to restrict or control the number of animals and the intensity of use in piñon-juniper lands and riparian areas could meet with local opposition. Involvement of the local community in project design and implementation should help alleviate potential conflicts and possible opposition.

Additionally, the steering committee identified the following political and social issues:

- Thinning may be controversial in urban areas, but local acceptance is high.
- Watershed management enhances forest health, wildlife habitat, and water yields.
- Increased yield is only a secondary benefit relative to the primary benefits of rangeland health, habitat improvement, and fire suppression.
- Watershed groups can support applications for thinning to increase chances for funding.
- There could be social impacts in the Cimarron watershed from restrictions on development aimed at protecting the watershed.
- Removing exotics may not increase yield if they are replaced by willows and cottonwoods.
- Willows provide cattle feed in dry years and lead to beaver ponds.

- Watershed groups will help with fire suppression and protect water quality, to the benefit of municipalities.

Prescribed burning programs often encounter considerable public resistance due to the adverse effect of smoke from the fire on visibility and visual esthetics. An extended period of prescribed fire could also raise issues such as the potential effect on tourism.

Designing restoration and management plans in collaborative consultation with affected local communities would help enlist local support and involvement and would integrate valuable knowledge about local resources. Direct socioeconomic and cultural benefits would flow from contracting with local communities and small-scale local enterprises for forest thinning and fire management, riparian system enhancement, erosion control, and/or other stewardship work.

8.2.4 Financial Feasibility

Larger-scale efforts to reduce vegetation density and increase water yields in the forested zones will require the cooperation of multiple landowners, and timber harvesting will either need to be made a commercially viable operation or some public funding will need to be provided. Commercial timber sales on public lands in Colfax County may be limited by environmental concerns and public opposition, which are often raised in such cases.

The commercial harvest or thinning of forest lands is economically more feasible in flatter areas (e.g., less than 30 percent slope) with an existing road network. In steeper areas, thinning is much more difficult unless it also includes some harvest of the larger trees that have more economic value. In areas with road access, costs for non-commercial thinning may be approximately $60 to $70 per acre; in steeper areas and areas without an existing road network, the costs would be considerably higher.

Development of markets for the small-diameter timber would greatly enhance the financial feasibility of this alternative. In some areas, the thinned material may be used for poles, posts, or fuelwood, thereby helping to offset the costs of the thinning. Additionally, a biomass power plant that would burn Colfax fuelwood is being considered.

If a commercial market for the harvested material cannot be found, the thinnings would have to be chipped and scattered, piled and burned, or broadcast burned. Lopping and scattering costs approximately $55 to $65 per acre, while the cost of chipping and scattering is slightly less. Piling costs around $65 to $75 per acre, and burning slash piles costs another $26 to $35 per acre, depending on the number, size, and accessibility of the slash piles. Prescribed fire, or broadcast burning after thinning, is the cheapest treatment at $9 to $12 per acre.

Piñon-juniper areas are used primarily for fuelwood and livestock production. Past practices included chaining followed by seeding, but this was costly, induced severe erosion in some areas, and was subject to considerable public resistance. Broadcast burning is generally not feasible because there is not enough fuel to carry the fire during the conditions conducive for controlled burns. Overall, the costs of trying to alter or intensively manage these areas have far exceeded the potential return, and these practices have thus been largely discontinued.

Reestablishing a functioning riparian zone with native riparian vegetation can be very costly, as many streams and rivers have been subjected to substantial alterations to channel morphology and their natural flow regimes (National Research Council, 1992). In such cases, extensive earth moving may be required to restore the natural processes such as overbank flooding and sediment deposition, which could require establishing a functional channel and floodplain at the appropriate elevation relative to the existing flow regime and sediment load. These areas often have to be planted and seeded, and relatively intensive efforts to control exotic species may also be required, particularly in the first few years after planting. Fencing can be one of the most cost-effective means to improve riparian habitat, but the cost of a new, four-wire fence to control grazing is approximately $3,500 to $4,000 per mile.

A moderate-cost method of addressing riparian health is time-controlled grazing, which can be achieved by moving cattle through fenced pasture, without necessarily fencing the riparian zone. The vast majority of the piñon-juniper and riparian vegetation areas are privately owned, and the implementation of an aggressive range management program to restore riparian areas will require substantial expenditures with relatively small financial returns, at least in the short or medium term. Hence some kind of financial assistance program generally will be needed if large areas are to be treated or restored.

8.2.5 Hydrological Impacts

The technical, financial, and political issues associated with increased forest harvest suggest that the usable increases in water yield that might be gained from active forest management are likely to be relatively small. The potential gains could be quantified by sub-basin once the areas to be treated are specified, the amount of basal area that would be removed per year, and the intervals between treatments. A relatively accurate estimate of the change in water yield would also require estimates of the monthly precipitation in each of the areas to be treated, as well as the density and composition of the stands to be treated. Estimates of the potential adverse environmental effects would require specific information on the harvest method(s), slash treatment(s), and transportation network.

The paired-watershed study that is most directly applicable to the study area is the Wagon Wheel Gap study, which was conducted in south-central Colorado (Bates and Henry, 1928). The 200-acre treated watershed was dominated by aspen, Douglas fir, and Englemann spruce, and the elevation range was from 9,245 to 10,950 feet. Average annual precipitation was 533 mm or 21.0 inches. Clear-cutting 100 percent of the treated basin yielded an average annual water yield increase of 1.0 inch (Bates and Henry, 1928). This increase is consistent with the results of other paired-watershed studies as reviewed by Bosch and Hewlett (1982).

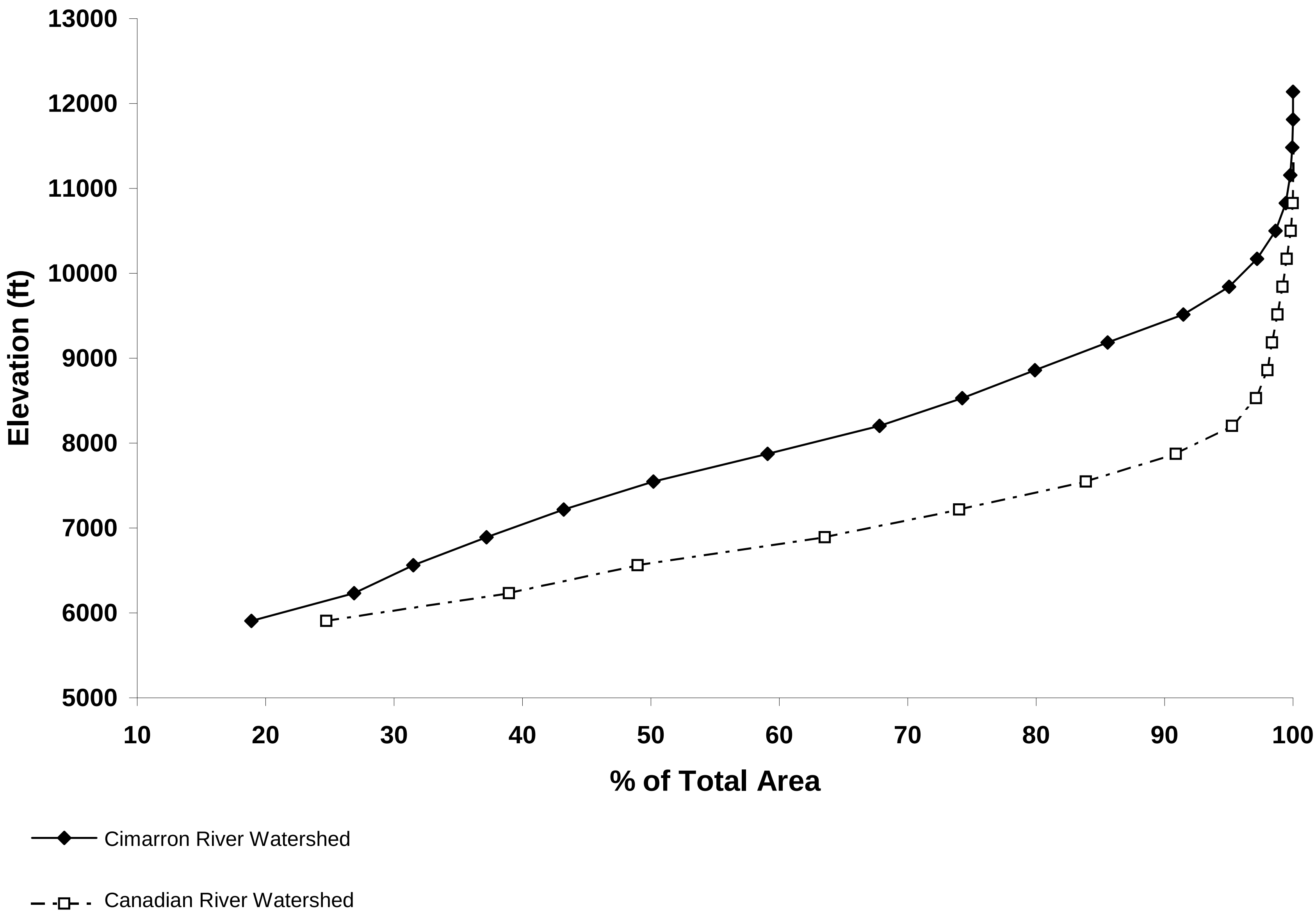
In larger basins, a smaller proportion of the watershed will be subject to harvest, and the potential increases in water yields will therefore be proportionally reduced. For example, only 24 percent of the 4,100-acre Coon Creek basin in the Medicine Bow National Forest could be harvested due to various management constraints, and the observed initial increase in seasonal water yield was 3.0 inches per unit area harvested, or 0.7 inch when averaged over the entire watershed (Troendle et al., 2001). This increase in annual water yield is consistent with the results of other paired-watershed studies in the central Rocky Mountains. At a yet larger scale, Rector and MacDonald (1987) estimated that intensive management of national forest lands in the California Sierra Nevadas could result in a sustained increase in water yields of only about 0.1 inch, as much of the land is not suitable for timber harvest or is subject to other management constraints.

Troendle and Nankervis (2000) estimated that the increase in forest density since the late 1800s on the 1.34 million acres of national forest land in the North Platte River basin has probably decreased water yields by about 185,000 ac-ft/yr. This equates to about 1.7 inches of water per unit area, or 2.0 inches of water per unit area of forest land. Approximately 54 percent of the total area, or 66 percent of the forested area, is classified as land suitable or potentially suitable for timber harvest. Intensive forest management on these lands could potentially yield an average of 55,000 acre-feet of additional water per year, or slightly more than one-third of the "losses" that are already occurring as a result of the increased forest density. The 55,000 acre-feet converts to 0.9 inch per unit of suitable forest land, or 0.5 inch per unit of national forest land.

These values from the North Platte study probably represent an upper bound on what might be expected from the forested areas in the planning region, as two-thirds of the forested areas on national forest lands in the North Platte basin were classified as suitable or potentially suitable for timber harvest. Furthermore, forest types with a relatively high potential for increasing water yields (spruce-fir and lodgepole pine) accounted for nearly 85 percent of the forested area; ponderosa pine and aspen occupied only 13.5 percent of the forested area (Troendle and Nankervis, 2000).

Given the strong dependence of precipitation, forest vegetation, and runoff on elevation, only some of the higher elevation sub-basins in the study area would have any potential to increase water yields through forest management. As discussed in the water supply and demand evaluations (Sections 5 and 6), there is no consistent relationship between precipitation and elevation in the study area, even though forest density generally increases with increasing elevation, indicating more available water. The precipitation data do show that all stations below 7,000 feet have less than 17.5 inches of annual precipitation, so any decrease in vegetation below 7,000 feet is highly unlikely to result in any measurable increase in water yield. Approximately 80 percent of the Canadian River watershed and nearly 40 percent of the Cimarron watershed lie below this elevation (Figure 8-1).

The relationship between elevation and annual runoff is much stronger than the relationship between elevation and precipitation, indicating that precipitation is spatially much more variable



COLFAX REGIONAL WATER PLAN

Hypsometric Curve for the Cimarron River and Canadian River Watersheds

Daniel B. Stephens & Associates, Inc.

Figure 8-1

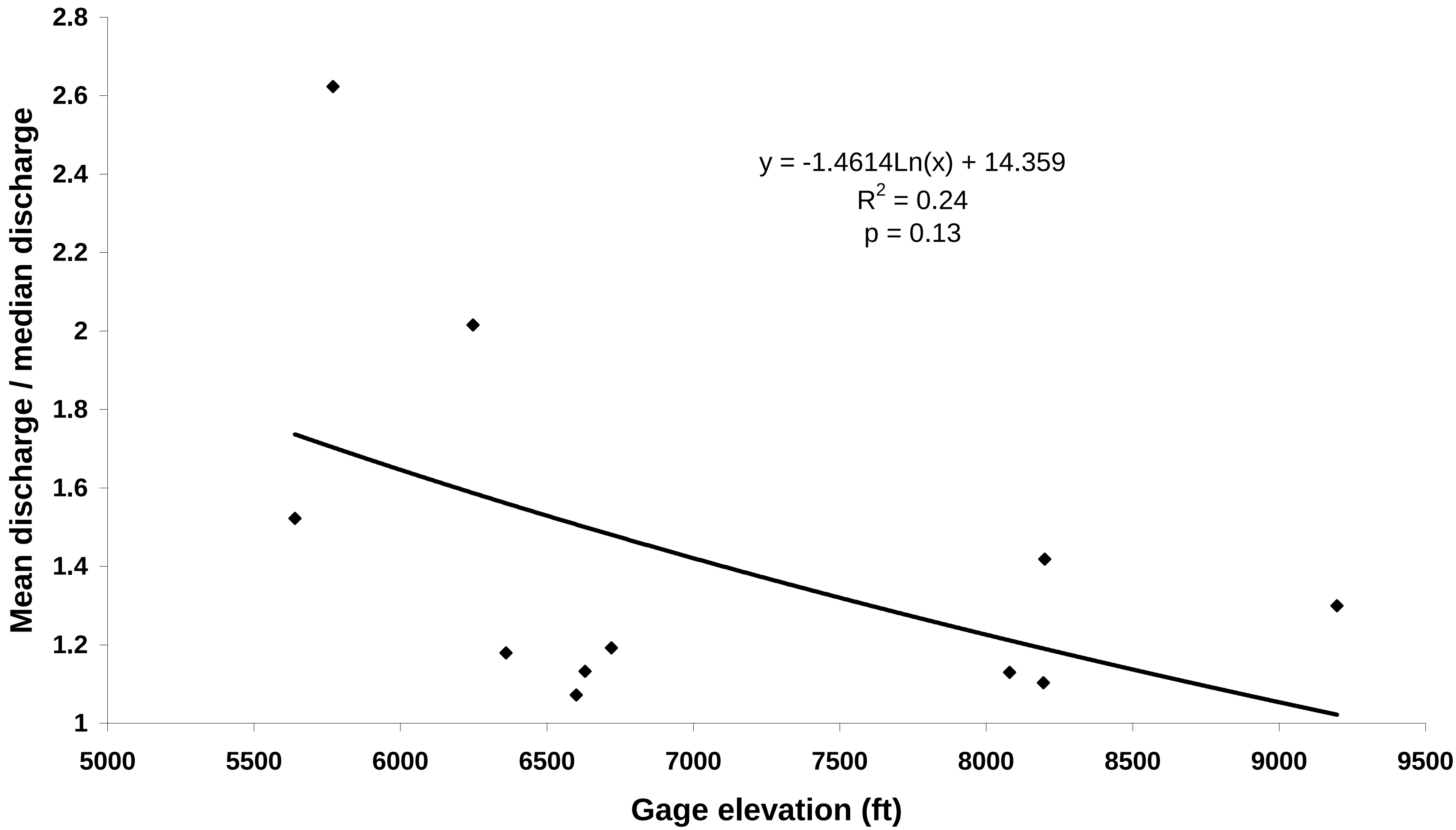
than runoff. As with precipitation, the relative variability of annual water yields tends to decrease with increasing runoff. Because a few years with high water yields can greatly increase the mean, the distribution of annual water yields is highly skewed, and the median annual runoff is a better index of typical annual water yields than the mean. This point is illustrated in Figure 8-2, which shows that the ratio of the mean to the median annual water yield tends to approach 1.0 with increasing elevation, demonstrating that annual water yields become increasingly reliable with increasing elevation.

Further analysis shows that the median elevation of a watershed is strongly related to the median annual runoff (Figure 8-3). This relationship is strongly non-linear, and it clearly shows that the absolute amount of runoff per unit area is very low until the median elevation of a basin approaches 8,000 feet. This elevation probably represents a much more realistic threshold for a potential increase in water yield due to forest management.

Only about 8 percent of the Canadian River watershed lies above 8,000 feet, while approximately 38 percent of the Cimarron River watershed is above this elevation (Figure 8-1). Thus the potential to increase water yields through forest management is relatively small in the Canadian River watershed as compared to the Cimarron River watershed. Additionally, yield increases in the Cimarron watershed are further strengthened by the large storage capacity of Eagle Nest Reservoir relative to the average annual inflows (Section 5).

As noted in Section 8.2.2.1, prescribed fires would not be expected to cause an increase in water yields because they would not eliminate much of the dominant tree canopy. From a purely hydrologic perspective, wildfires can cause a large increase in runoff, but this is usually regarded as a negative effect because high-severity fires can increase the size of peak flows by a factor of 10 or more (Robichaud et al., 2000), and the resulting erosion rates can increase by a factor of up to 100 (Robichaud et al., 2000; Benavides-Solorio and MacDonald, 2000, 2001). The large increase in erosion rates is caused by the nearly complete loss of the protective surface cover, the development of post-fire water repellent layers at or near the soil surface, and the very low erosion rates in undisturbed forests prior to burning (DeBano, 2000).

Furthermore, in some soil types the increase in runoff causes extensive channel incision in headwater channels, and this can be a larger source of sediment than erosion off the hillslopes.



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Ratio of Mean to Median Discharge vs. Gage Elevation

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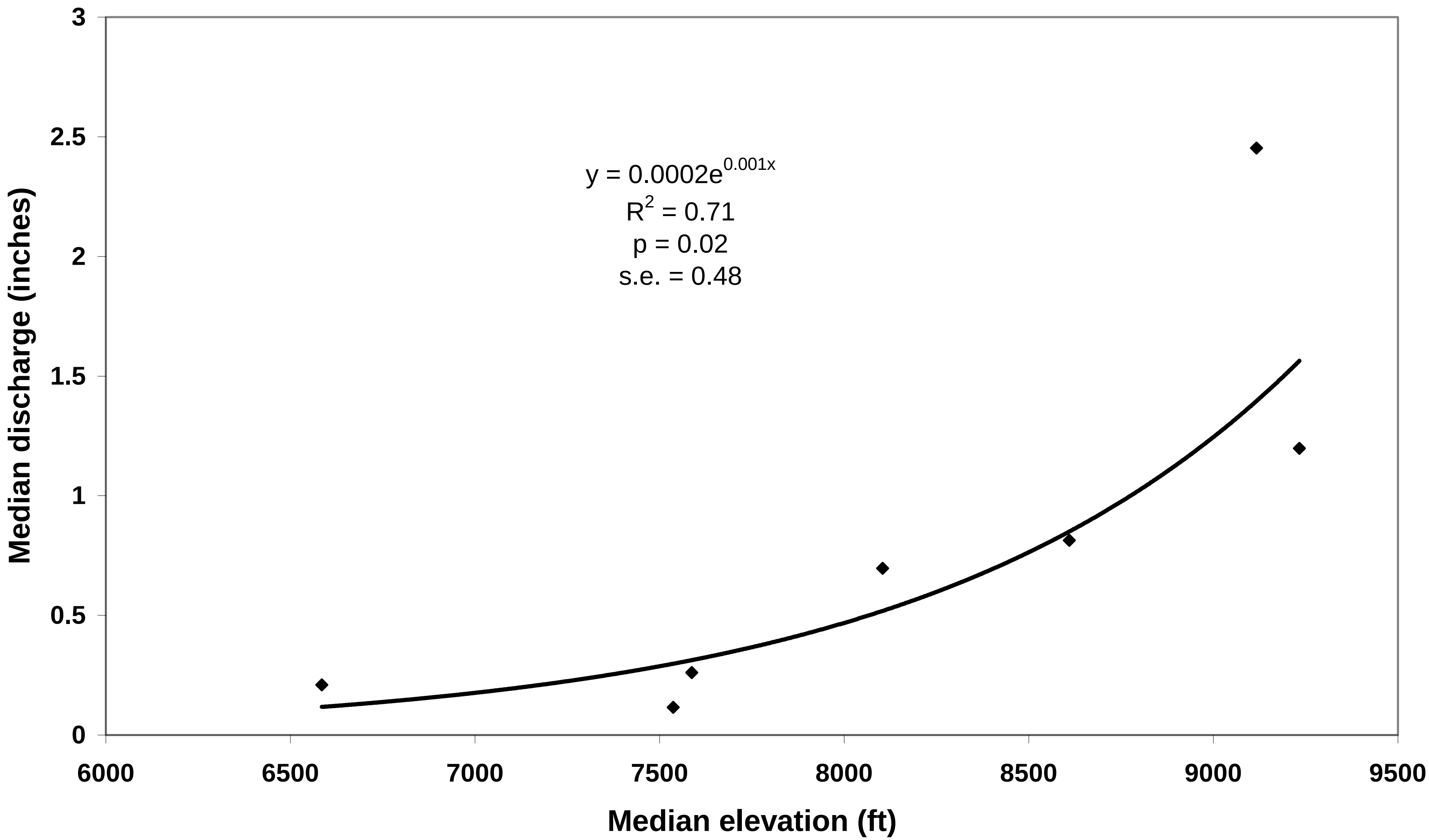
Figure 8-2



COLFAX REGIONAL WATER PLAN

Median Discharge vs. Median Elevation

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Figure 8-3

The higher peak flows and large amounts of erosion can deposit very large amounts of sediment in downstream areas. For example, sediment from the Buffalo Creek fire in Colorado filled in one-third of the Strontia Springs reservoir, and after the 2002 Hayman fire, sediment from a 0.6-inch rainstorm completely buried the cutoff wall and a 12-foot flume that had just been installed in a 2-square-mile catchment. Erosion rates after severe fires generally drop to near background levels after three or four years due to the increase in cover (Moody and Martin, 2001; Benavides-Solorio and MacDonald, in preparation), but the downstream sediment deposits may persist for many decades.

In the piñon-juniper zone, management actions might change the flow paths of water, potentially causing some changes in water quality as well as the amount and timing of runoff. Without specific information on a proposed management action, it is very difficult to provide an explicit, qualitative prediction of the possible effect of that action; thus the lack of published data makes it difficult to estimate the effect of either prescribed fires or wildfires on runoff and erosion rates in piñon-juniper. Quantitative predictions are even more difficult (i.e., carry a very high degree of uncertainty) because of the spatial and temporal variability in key processes such as rainfall amounts and intensity, infiltration rates, and vegetative cover.

In general, efforts to manage grazing and increase infiltration on hillslopes and riparian zones would likely have a much greater effect on water quality than water quantity. Most of the additional infiltrated water would be lost to evapotranspiration, suggesting that the reduction in surface runoff resulting from improved range conditions would be larger than the associated increase in groundwater recharge (Hillel, 1998). The reduction in the amount of surface runoff could, however, lead to improved water quality. A reduction in surface runoff and an increase in infiltration could be expected to reduce the size of peak flows and possibly result in more sustained flows, depending on how much of the infiltrated water passes through the rooting zone and into the stream channel. Any effort to improve piñon-juniper management will require extensive outreach programs, as the vast majority of piñon-juniper lands are privately owned, and rapid changes over large areas will likely be difficult to achieve.

Similarly, the success of efforts to restore or manage riparian zones will depend on the actions taken, the location and magnitude of these actions, and the site conditions in areas where these actions are taken. In general, management actions cannot be expected to have much of an effect on water yields, but could significantly affect water quality. Improved management will usually require more time and money than many private landowners can afford unless they receive education and assistance, and an extensive outreach program will be needed to treat a substantial proportion of the riparian areas. Additionally, markets for timber, especially small-diameter timber, from forested areas would improve the likelihood of being able to complete forest management projects.

The amount of water that can be gained from watershed restoration is affected by current laws and regulations, which specify that any “additional” runoff created by watershed management becomes part of the public water supply and is subject to the prior appropriation system. This effectively means that any appropriator could obtain the increased water generated, regardless of their role (or lack thereof) in the land management activities leading to the increased supply. No mechanism exists whereby the person or entity that increases the amount of runoff can lay a priority claim to the water produced. Furthermore, any permit obtained to use that water would be a new, very junior water right.

8.2.6 Environmental Impacts

The primary forest management options are some combination of commercial harvest, commercial and non-commercial thinning, and prescribed fires. While each of these treatments can be expected to increase erosion rates, studies have shown that the careful design of treatments and the use of best management practices can reduce the watershed-scale impacts of thinning or prescribed fire to very low levels (Troendle et al., 2001; Benavides-Solorio and MacDonald, in preparation). In steeper areas, less ground-disturbing yarding methods should be used to minimize erosion, and these more expensive methods may further increase the costs of any proposed management action.

In general, one of the greatest concerns in forest management is the effect of the roads on runoff and erosion. If new roads have to be constructed, particularly in steep areas, this could have a much bigger effect on erosion rates than the various treatments, even though the latter will affect a much larger proportion of the watershed.

The change in forest density from any of these treatments will have different effects on different species. A more open forest will generally increase the amount of feed for large ungulates such as deer and elk, while a high canopy density will favor other species. In many cases, too little is known about the habitat requirements of all the different species to accurately predict the likely effects of a proposed treatment. In addition, whether the net effect of a treatment is considered acceptable will depend on the relative value assigned to each species that is affected, and there may be considerable disagreement about those values.

The primary environmental advantage of reducing forest density is the reduced risk of high-severity fires. As noted in Section 8.2.2.1, high-severity fires in coniferous forests can increase runoff and erosion rates by one or more orders of magnitude relative to unburned conditions, and these increases can have severe downstream effects in terms of flooding, reservoir sedimentation, and adverse effects on aquatic habitat. The effects of prescribed fires on runoff and erosion are generally minimal, as the fire severity is mostly low to moderate, resulting in much less soil water repellency or highly discontinuous patches that are water repellent (Huffman et al., 2001). Areas burned at moderate or low severity also have much lower percentages of bare ground, which according to recent research, correlate very strongly with lower erosion rates. As long as the percentage of bare ground is less than about 20 to 30 percent, post-fire erosion rates should be very low and therefore pose little or no threat to water quality and downstream water resources (Benavides-Solorio and MacDonald, 2001, in preparation).

An important concern in the case of prescribed fire and broadcast burning is the effect on air quality. Fires in forested areas produce a large number of particulates that are a hazard to human health. Smoke also has an adverse effect on visibility and visual esthetics. For this reason, prescribed burning programs often encounter considerable public resistance, and the agencies that regulate air quality may also have some reservations about issuing permits that may result in a substantial, albeit temporary, reduction in air quality.

Management goals for piñon-juniper woodlands are typically to increase the amount of forage and vegetative ground cover, reduce erosion, and re-establish native riparian species. More aggressive treatments such as chaining are generally not acceptable because of the excessive ground disturbance and potential increases in erosion. In general, efforts to improve range conditions and reduce grazing impacts should help reduce erosion, enhance habitat quality in the riparian zone, and improve water quality.

As in the case of the forest zone, any vegetative treatment in piñon-juniper woodlands will favor some species at the expense of others. Whether the net effect is acceptable will depend on the relative values of the species affected and the intended use of the area after treatment. In most cases, a reduction in tree density will increase the ground cover, thereby increasing the productivity of the land for grazing by large ungulates. The use of fencing and best management practices related to movement and location of livestock will help eliminate the tendency to overuse some areas and underuse others, with a net benefit on erosion rates and downstream water quality.

The restoration of riparian zones is generally regarded as being environmentally beneficial. A healthy riparian ecosystem is critical to the health of the adjacent stream in terms of temperature regulation, bank stability and sediment inputs, input of organic matter and large wood, and filtering of sediment and nutrients from overland flow.

8.3 Dredging

Reservoir sedimentation gradually decreases the storage capacity of reservoirs, ultimately limiting their life span. Loss of storage is a long-term problem in Colfax County that worsened as a result of the 92,000-acre Ponil Fire in 2002, which caused increased erosion and downstream sedimentation. This fire occurred along Ponil Creek, upstream of several agricultural reservoirs and Springer Lake, which supplies both agricultural and municipal users. One of the methods used to regain lost storage due to sedimentation is dredging, which involves the excavation of soil material or sediment deposits underwater. Dredging is a highly specialized technology used primarily in ports, waterways, and mining.

This section examines dredging options on the basis of technical and economic feasibility as compared to alternative options for the control of sedimentation or other methods for increasing storage capacity in specific Colfax County reservoirs. The main advantage of dredging is that it has the twofold effect of removing nutrient-rich sediments and deepening the water body. The main disadvantage is finding suitable and economically viable disposal sites for the spoils (sediment), as it is imperative that removed spoils do not run directly back into dredged reservoirs.

The cost of dredging reservoirs is relatively high compared to that of alternative sediment control methods. However, in recent years technical developments and a more scientific approach in the dredging industry have narrowed this gap to a point where dredging should be considered a viable technique for controlling sedimentation. The application of this technology is particularly valid in situations where catchment or hydraulic sediment control methods cannot be implemented successfully. The technology is also useful in areas where suitable sites for new dams are limited, where socioeconomic factors limit construction for increasing storage capacity, and where environmental concerns related to the construction of additional dams exist.

There are three main types of dredging: mechanical, hydraulic, and pneumatic. An additional distinction is “dry” versus “wet” dredging. Dry dredging involves dewatering the reservoir followed by mechanical dredging, which is an excavation operation similar to conventional earth moving. Wet dredging projects are conducted under water with no dewatering activities required and can be carried out with all three types of dredging (mechanical, hydraulic, pneumatic). These dredging methods are described below:

- *Dry dredging:* As stated above, dry dredging is the process of dewatering a body of water and then using standard soil excavation methods to remove sediment from the reservoir bottom. Dewatering can be done by evaporation and/or pumping depending on the size and depth of the reservoir as well as its need as a continuous water supply. Once dewatering is complete, excavation is typically done by a scraper or excavator/haul truck. Due to the low moisture content of excavated material, it can be hauled directly to the spoils disposal site without intermediate drying in a slurry pond.

- *Wet dredging:* Wet dredging involves removing sediment from a reservoir while it is still full of water. The three main methods of wet dredging are described below.

- *Mechanical dredging:* Mechanical dredging involves using a bucket device to remove sediments in "scoops" from the bottom of the reservoir. This can be done with either a "clam shell" bucket and crane or an excavator. Another form of mechanical dredging is dragline, which uses a crane to drag a bucket across the reservoir bottom to collect sediment.

- *Hydraulic dredging:* Hydraulic dredges, otherwise known as "mud-suckers," use a pump and pipeline to "vacuum" sediment from the reservoir bottom and transport it to a slurry pond for drying. Some hydraulic dredges also use a cutting wheel to scrape or churn up sediment that is then vacuumed up by the pump. Hydraulic dredging equipment is typically mounted on a steel barge that can be either self-propelled, towed by another watercraft, or towed from shore.

- *Pneumatic dredging:* The pneumatic dredge system uses the hydrostatic pressure of the overlying lake to push material through a buried pipe into a pressure tank vented to the atmosphere. When the tank is filled with sediment, compressed air is introduced into the cylinder and the inlet valve is then closed, forcing the slurry to be discharged to the surface through an outlet at the top of the tank. The air is then vented to the atmosphere and the cycle repeats itself at approximately 20-second intervals. Three tanks are typically clustered together to form a dredgehead. In this case, compressed air is fed to each cylinder through an air distributor, and the slurry discharged from each tank passes into a manifold common to the three tanks. The material is therefore discharged as a continuous stream rather than in batches. The dredge equipment is typically mounted on a steel barge with the dredgehead hung from a tower that is mounted over an opening in the dredge floor.

8.3.1 Technical Feasibility

The feasibility of dredging reservoirs is dependent on many variables, including site conditions, disposal requirements, the ability to drain the reservoir before dredging, and the amount of sediment requiring removal. It may not be necessary to remove all accumulated sediment. At some reservoirs a dead storage zone for sedimentation has been provided, with the lowest water release valves located above this zone. Consequently, dredging of the dead storage zone may not be desirable because the water stored below the water release valves cannot be used.

8.3.1.1 Dry Dredging

Dry dredging is feasible at only some of the reservoirs in Colfax County. The two main factors affecting dry dredging feasibility are whether the reservoir can be dewatered by evaporation or pumping in a reasonable amount of time and whether there is an alternate source of water available. Draining a reservoir or “drying” the reservoir involves a major coordination effort among the local water users and operators of the reservoir, and convincing all users to agree may be very challenging if not impossible. Also, if the reservoir is used year round (i.e., for drinking water), an alternate source of water must be available for a period of several months. In cases where the reservoir is used only at certain times of the year (i.e., agriculture), it may be possible to schedule dry dredging activities around the required operation period.

The time required to drain the reservoir may range from several weeks to several months. Additional time will be required for the evaporation of moisture from the sediment material, and stormwater may need to be controlled during the dredging activities to keep the reservoir sediments from being resaturated during precipitation events. Drying the sediment to the maximum extent possible will facilitate complete sediment excavation with fewer problems in the field (e.g., vehicles getting stuck).

Excavation is typically done with scrapers or an excavator/haul truck. Although surface sediments may appear stable, excavation equipment must be used carefully. Scrapers would theoretically be quicker and less expensive, but their use requires their presence on the sediment, and the likelihood of them getting stuck is high. The average dry density of sediment is approximately 35 pounds per cubic foot, which is typically not suitable for supporting heavy loads. To avoid this problem, it may therefore be more desirable to use an excavator and a team of haul trucks as opposed to scrapers. An excavator could advance over stable areas where sediment has already been removed and the base clay or sand of the reservoir bottom exposed.

The biggest advantage of dry dredging is that the majority of the material handled is sediment and not water. Some methods of wet dredging (hydraulic dredging) require a large amount of “carrier” water, as the slurry that is pumped can be no more than 10 percent solids. Another advantage is immediate disposal of spoils because they are dry and do not require an intermediate slurry drying step as there is in wet dredging. Therefore, the material is only handled once, allowing for greater efficiency and lower dredging costs.

8.3.1.2 Wet Dredging

It is technically feasible to wet dredge all reservoirs in Colfax County, although the costs may be prohibitive. The main advantage of wet dredging is that water is left in place and is therefore available for consumptive use, thus minimizing the impact to users and the environment. However, dredging can resuspend sediments, which may then need to be filtered out before water goes to the distribution line.

The disadvantages of wet dredging are twofold:

- A greater volume of material must be handled to remove the desired sediment. As mentioned in Section 8.3.1.1, some hydraulic dredging rigs can remove only 10 percent solids without clogging pumps. The high volume of water thus required can often increase the amount of material to be removed up to an order of magnitude. Other types of wet dredging, such as pneumatic and mechanical methods, can remove sediment at much higher percentages (e.g., 60 percent), but the amount of material handled is still greater than that required for dry dredging.

- The material must also be dried on-site in a slurry pond to increase the solids content of the material before final disposal, and finding a suitable on-site location for this purpose may be difficult. In addition, the material gets handled twice, potentially doubling the overall cost of the project.

8.3.1.3 Disposal of Spoils

On-site disposal of dried spoils may be technically feasible at some sites depending on the topography. However, it is important to ensure that the dredged sediment cannot easily flow back into the reservoir or off-site during a storm event. Consequently, it will be desirable to dispose of sediments behind dams, in pits, or in other low areas that can be filled in with sediment. Once the sediment has been applied to an area, it should be vegetated to hold it in place.

Off-site disposal involves hauling dried spoils to areas where they can be applied. As in on-site disposal it is desirable to fill in pits, excavations, or other low areas with the spoils. Because spoils are typically rich in nutrients from decaying vegetative matter that settled to the bottom of the reservoir, it may also be possible to apply the sediment to land as fill or as soil amendments for agricultural purposes. In such cases, off-site disposal costs can be reduced or a small profit might even be earned. However, the spoils alone should not be used as structural fill since the density of dredged sediment is not high enough to properly support heavy loads (Section 8.3.1.1). If it is necessary for sediment to be used as structural fill, it should first be processed and mixed with other soils so that the final product is suitable to support loads.

8.3.2 Political Feasibility and Social/Cultural Impacts

One potential concern with reservoir dredging is environmental effects, although maintenance of an existing reservoir should pose far less of an environmental concern than construction of additional storage capacity. The primary environmental issue would be disposal of dredged material and/or downstream water quality and siltation effects. Accordingly, a Clean Water Act Section 404 permit, which governs the removal and disposal of sediment spoils during dredging operations in U.S. waters, may be required.

The disposal of spoils could also present a political issue. The steering committee indicated that some landowners near reservoirs would not want to deal with spoils from dredging operations.

8.3.3 Financial Feasibility

Because each reservoir may require different methods of dredging and spoils disposal, each site must be evaluated on a case by case basis. The two main critical factors that will determine the cost of the project and therefore its feasibility are the method of dredging to be performed (i.e., wet or dry) and the location of spoils disposal (on- or off-site).

Feasibility-level studies would have to be completed to determine the appropriate dredging method for the reservoir in question, determine the best location for spoils disposal, calculate project costs, and identify the benefits of the increased storage capacity. As a rough estimate, such a study would cost approximately $50,000 to $100,000 and take six months to complete.

Conceptual costs for dry dredging may be expected to be in the range of $3,000 to $6,000 per acre-foot of sediment removed depending on whether the material can be disposed of on-site (i.e., on-site disposal is less expensive). These costs are within the range of the cost of purchasing a new water right, which may be on the order of $3,500 per acre-foot.

Conceptual costs for wet dredging are higher and may be expected to range from $7,000 to $14,000 per acre-foot of sediment removed depending on the disposal location (on- or off-site). As an example, wet dredging of 1,613,333 cubic yards (yd^3) of saturated sediment at Miami Lake may be expected to include the following costs:

- Project mobilization/demobilization: $24,000
- Slurry pond construction: $7,000
- Sediment removal: $3,000,000 ($1.85 per yd^3)
- Off-site hauling: $4,000,000 ($2.50 per yd^3 for 2,000-foot haul distance, including loading)
- Total: $7,031,000

If Miami Lake were dredged under dry conditions, it is assumed that the volume of dry sediment would be approximately 1,000,000 yd^3 (less than the figure given above, since the sediment is no longer saturated). This volume will vary greatly depending on the moisture content of the sediment at the time of dredging. The moisture content of the material may also vary during the course of dredging activities because of precipitation events. Dry dredging costs at Miami Lake for removal of 1,000,000 yd^3 of dry sediment will potentially include:

- Project mobilization/demobilization: $50,000
- Sediment removal (two options)
  - By scraper: $2,500,000 ($2.50 per yd^3, 2,000-foot haul distance)
  - By excavator and dump truck: $4,000,000 ($4.00 per yd^3, 2,000-foot haul distance)
- Total: $2,550,000 to $4,050,000

Lake Alice in Sugarite Canyon was dredged in 1993 (personal communication between Scott Salvas, DBS&A, and Dan Campbell, Manager of Raton Water Works, November 2002). The lake was drained and dry dredged using bulldozers and loaders to remove approximately 70,000 yd^3 of sediment, consequently restoring more than half of the capacity of the lake. The material was then hauled to a farm approximately 4 miles away. The total project cost was approximately $400,000 and the per-unit sediment removal cost was $4.66 per yd^3.

Disposal costs tend to be the limiting factor in dredging projects because they are highly variable and determined on a case-by-case basis. If material can be disposed of a few thousand feet away from the source, the project will most likely be economically feasible. If the material needs to be hauled a few miles away, however, the costs will rapidly escalate. If long hauling distances are required it may be advantageous to look at other alternatives such as storage tanks or the construction of a new reservoir if space permits. Other cost-saving dredging-related alternatives might involve finding a buyer of the spoils to recuperate some of the dredging costs, dredging only a fraction of the accumulated sediment, and/or using the spoils to build an embankment around the edge of the reservoir. The latter option would involve stabilizing the sediment so that it would not wash back into the reservoir; this option would also provide the reservoir with additional capacity.

Because of the high costs associated with sediment removal, project beneficiaries would likely need federal and/or state funding, which would require repayment contracts. Local repayment could be accomplished through increasing water user fees and issuing bonds. Grants, which normally require local cost-sharing, could be pursued for planning studies and compliance activities. Costs to local beneficiaries could theoretically be reduced or eliminated by entering into contracts with third parties (municipal and industrial water users) whereby the third party would pay for some or all of the dredging costs in exchange for some portion of the increased water storage.

8.3.4 Hydrological Impacts

Removal of sediment will not increase the water supply. However, the greater storage capacity that can be obtained through dredging will allow for more water to be stored and therefore can potentially provide additional water supplies during times of drought (i.e., additional water can be stored in wet periods and used in drier periods or to extend the irrigation seasons). Maximizing storage capacity is critical in Colfax County, where more than 95 percent of the use is surface water.

Operators of some of the reservoirs in Colfax County (Antelope Valley No. 2, Maxwell No. 12 Reservoir, Maxwell No. 2 Reservoir, Miami Lake No. 2, Springer Lake, and Stubblefield Reservoir) have estimated storage volumes lost to sedimentation by periodically measuring reservoir depth. Based on these estimates and the assumption that the other reservoirs have lost and can regain 30 percent of their original storage capacity, a total volume of approximately 39,000 acre-feet of additional storage capacity could be gained if all of the reservoirs in the county are dredged.

8.3.5 Environmental Impacts

Because dredging activities can have a significant impact on the local environment, an environmental impact analysis may be required before dredging can begin. Wet dredging tends to be less intrusive on the local ecosystem because water remains in the reservoir; however, the resuspension of sediment in the water can significantly raise the concentration of total suspended solids and potentially raise the concentration of total dissolved solids.

Conversely, dry dredging can have a dramatic impact on the local ecosystem. Because all of the water is removed during this process, any aquatic plants and animals will be destroyed during dredging activities. In addition, animals that depend on the reservoir as a source of water will be affected. Finally, mobilization of equipment into the area will be harmful to established vegetation and will most likely disturb the habitat of many animals in the area.

8.4 Develop County and City Ordinances for Conservation

An important aspect of regional water planning is water conservation, which allows the region to make efficient use of existing resources. Because the agricultural sector is the largest water user in Colfax County (Section 6.1), the steering committee identified agricultural water conservation as a key issue. Accordingly, a detailed agricultural water conservation plan has been prepared and is included in Appendix H. The remainder of this section focuses on methods of addressing municipal water conservation. Though municipal conservation will not greatly affect the overall water budget in Colfax County, it can provide benefits to individual systems.

8.4.1 Summary of the Alternative

Water conservation ordinances are a clear way to engage the public in water conservation activities. The primary topics covered by conservation ordinances, in separate or combined legislation, include:

- Prohibiting outdoor water waste (fugitive water) and/or requiring low-water landscapes.
- Changing water rate structures to encourage conservation and reduce water use by residential, industrial, commercial, and institutional customers.

These types of ordinances are discussed in Sections 8.4.1.1 and 8.4.1.2; Section 8.4.1.3 discusses the use of water meters to support enforcement of these ordinances. Conservation can also be implemented through education and voluntary measures, as discussed in Section 8.11.

8.4.1.1 Water Waste

Many of the main conservation issues can be addressed in an ordinance addressing water waste. The OSE suggests that water waste can be defined in an ordinance as water that flows or is discharged from a residence or place of business onto an adjacent property. Such discharges occur most often from landscape irrigation or leaking water pipes. In addition to the loss of potable water, these events have safety and maintenance impacts. Water running onto streets, especially when it freezes, can cause vehicle accidents and, if it pools, damage road surfaces.

A prototype for a water waste ordinance provided by the OSE is included in Appendix J1. This ordinance template includes measures applying to water emergencies and includes the following main elements:

- Types of prohibited water waste:
  - Water running off an area during landscape irrigation
  - Washing of impervious surfaces with a hose (except in cases where it is needed to protect public health and safety)
  - Water leaks not fixed within eight hours
  - Landscape watering outside prescribed hours (e.g., before 10 a.m. and after 6 p.m.)
- Fines and penalties for violations that increase with the number of citations assessed to a property, including:
  - Imposition of a water waste surcharge to any customer in violation
  - Temporary or permanent restriction or discontinuance of flow to a property with recurring violations
- Exceptions, cure of violations, and refunds of surcharge
- Administrative appeal process for customers (e.g., appeal to administrative hearing officer, water utility's general manager, or the board of directors)

An emergency water ordinance can include additional measures such as:

- Emergency rationing (water allotment to different customer classes)

- Prioritization of water service according to customer class

The OSE prototype ordinance assumes implementation and enforcement by the utility general manager and board of directors. If a county-wide enforcement system is developed, a certain amount of coordination is needed in developing and enforcing the ordinance. Examples of municipal water conservation ordinances enacted by other municipalities in New Mexico are discussed below.

- The City of Albuquerque adopted water conservation through a resolution and two or more ordinances (Appendix J2):

  – In 1995, the City adopted the *Long-Range Water Conservation Strategy Resolution,* which outlines the comprehensive water conservation program.

  – The *Water Conservation Landscaping and Water Waste Ordinance* also passed in 1995 (amended in 1998 and 2001). This law defines restrictions and creates the basis to enforce penalties for violations.

  – An ordinance outlining water conservation guidelines for large users (industrial, commercial, and institutional) was also passed.

- In 1996, the City of Las Cruces passed a water conservation ordinance (Appendix J3). Major features of ordinance are:

  – Watering restrictions regarding time of day and odd/even day designations
  – Prohibition of water waste and requirement for use of hose nozzles
  – Mandatory time frame for leak repairs (within five days)

  Las Cruces has had an inclining block rate structure since 1975. In 1996, the slope and rates were increased in accordance with its water conservation ordinance.

- The City of Santa Fe has implemented a conservation ordinance associated with its water emergency declarations (see Appendix J4 for a summary of the ordinance). Because of the real limits to their water supply, the restrictions are more severe and less voluntary than other case examples. However, by implementing conservation ordinances that restrict watering to three days a week during drought periods, the City of Santa Fe has reduced demand by 22 percent on a per capita basis since 1995.

Although these conservation ordinances are all for larger municipalities, the same concepts can be applied to the smaller municipalities in Colfax County.

8.4.1.2 Water Conservation Incentives Through Rate Structuring

Nationally, many utilities are using price as a demand management tool. According to a 1992 American Water Works Association (AWWA) survey, approximately 60 percent of the utilities in the United States use a conservation rate structure. There are four different types of rate structures that can generally be classified as conservation oriented:

- *Uniform commodity rates:* All usage is charged at the same unit rate. Although not often viewed as being a water efficiency-oriented rate, uniform rates are an improvement over declining-block rate structures in which the price of water decreases as the volume of water used increases.

- *Flat seasonal rates:* This rate structure incorporates two or more different uniform volume charges for different seasons during the year. Generally, a higher rate is charged during the peak water usage season than is charged during the off-peak season.

- *Inverted block rates:* An inverted-block rate structure involves the use of increasing rates for units of water consumption at higher levels of usage. (In addition to encouraging water conservation, this rate structure could help balance the impact of conservation on loss of revenue to the utility.)

- *Excess use rates:* An excess use rate structure involves establishing an average base water usage volume during the non-peak period and a corresponding base water usage rate. During the peak period or season, water usage above this base level is charged at the base rate plus an excess use rate. Several variations of the excess use rate structure exist. Some utilities provide an allowance above the base usage during the peak season to recognize an increase in non-discretionary use during peak periods.

More information about these types of rate structuring is provided in Appendix J5.

The New Mexico OSE recommends that the inclining block rate be favored. However, utilities should analyze whether this structure can achieve conservation effects in the local community. If such a structure is implemented, the amount of water required for “basic human needs” should be determined and kept at an affordable rate for low-income households; thereafter, rates can increase. Some municipalities, such as Albuquerque, provide for an administrative waiver for low-income households that have more members than the number allowed for in the “basic human needs” assumptions.

Conservation rate structures may result in uncertainty in forecasting revenue, as these pricing policies usually do not exhibit the high minimum charge that standard rate structures incorporate. A utility must assess the interrelationships between rates, consumption, and costs, and the effect that these issues will have on the revenue requirements of the utility.

8.4.1.3 Metering

Metering is an essential element of water conservation. A regulation, resolution, or ordinance can be adopted that requires the installation and regular reading of meters at all water sources, including import or export points, customer service connections, and public landscape sites. All water provided free of charge for public use should also be metered and read at regular intervals to allow the utility to more accurately account for water use.

8.4.2 Technical Feasibility

Implementation of water conservation programs is both technically and legally feasible and has been done throughout the southwest. According to the OSE Conservation Program Director, a water conservation ordinance has legal stature and is enforceable, and the OSE has not heard of any legal challenges to conservation ordinances (i.e., landscaping requirements or water waste prohibition) (personal communication with Alice Darilek, Water Use and Conservation Bureau, Office of the State Engineer, June 2001).

To save time for police officers and the local court system, an administrative procedure should be set up to enforce the water waste ordinance (write citations and assess fines). As an example, for the City of Albuquerque conservation program, the fines associated with water waste violations and number of citations are listed in the ordinance. Key to the success of the enforcement program is the requirement that the water waste officer videotape the water flowing off the property. The property owner is notified of the violation and fine, and the fine is collected through the water bill (which will require some modifications to the billing system). If the fines are appealed, they go to an Administrative Hearing Officer. Through this process, municipal court, and police officer time is conserved.

Low water landscape requirements in Albuquerque are authorized through an ordinance. They are modeled after and enforced through reference to the zoning and plumbing code. Violations are treated as a “red tag” on a property and are subject to fines associated with plumbing code violations. Appeals go to the Zoning Hearing Officer.

Regarding the legality of tiered rates, the California Attorney General published an opinion that a water district, without violating the constitutional limitation placed upon fees for service, may impose a tiered water rate structure that assesses a higher charge per unit of water as the level of consumption increases.

Other challenges associated with water conservation include:

- Mandatory compliance for water waste ordinances can cause resentment if customers perceive them to be excessively restrictive. This can be addressed by a good public relations campaign emphasizing that the guidelines are based on common sense and benefit the whole community.

- Staff training and time is required.

8.4.3 Political Feasibility and Social/Cultural Impacts

The ordinances discussed in Section 8.4.1 will only be adopted if local governmental bodies find them politically acceptable. The public is especially aware of scarce water resource issues after a drought, and the elected officials may find more political acceptance during this period of heightened awareness. Alternatively, if ordinances are not politically acceptable, efforts can be focused on conservation education, as discussed in Section 8.11.

Other political, social, and cultural impacts with regard to water conservation, as raised at a steering committee meeting, include:

- Education is key
- Curbs on growth could set up competition among communities; instead, there should be a county-wide approach to conservation
- Requiring mandatory conservation for new construction could reduce growth within communities
- Springer domestic water is being used by livestock; there should be alternate sources
- Low-flow toilets or high water rates are expensive and therefore have social impacts

8.4.4 Financial Feasibility

The primary financial need associated with implementing a water conservation ordinance is labor. Drafting and implementing a water conservation ordinance requires a staff member to oversee the process and maintain the effort. Utility staff would need to be trained and made available to undertake water waste enforcement duties. Existing field staff could be trained and sworn in as water waste officers if they have several hours available each week. Alternatively, a part-time employee could be dedicated to water waste enforcement. In addition to this enforcement time, an administrative hearing officer needs to have a small allotment of time associated with appeals. The administrative cost of a program can increase as requirements are set up that need to be enforced.

Other costs include the cost of a video camera to document the waste and costs associated with modifying the billing system to reflect changes in rates, fines for violations, and public education messages. Costs associated with public information are discussed in Section 8.11.2 of this plan.

8.4.5 Hydrological Impacts

The success of conservation programs varies depending upon the starting point. In Colfax County, per-person water consumption varies (Appendix G, Table G-5). The per capita water use is a representation of water use based on the amount of municipal water that has historically been pumped or diverted divided by population and includes system losses and water used for public facilities. Angel Fire has the largest potential for savings, given the estimated 273 gallons used per person per day in the community (although system losses, which are unaffected by conservation ordinances, are thought to be a large contributing factor to this high usage rate). Other townships with usage rates that could likely be improved are Raton, Springer, and Eagle Nest. The townships of Cimarron, Maxwell, and Miami already have low per capita usage and may not need to emphasize a water conservation program.

Based on the average number of acre-feet used between 1995 and 1999 in each township (as shown in Appendix G, Table G-2), a 30 percent reduction of water use in the higher-use communities could produce the following savings:

- Angel Fire: 180 acre-feet
- Eagle Nest: 16 acre-feet
- Raton: 554 acre-feet
- Springer: 101 acre-feet

A 10 percent reduction in use for the lower-use communities could result in the following savings:

- Cimarron: 15 acre-feet
- Maxwell: 4 acre-feet
- Miami: 2 acre-feet

The total estimated savings resulting from these percentage reductions is 872 acre-feet. Given the small amount of urban uses relative to agricultural uses in the planning region, however, this amount is much lower than the potential demand reduction associated with agricultural uses (Appendix H).

8.4.6 Environmental Impacts

Water conservation ordinances can significantly contribute to protection of water resources.

8.5 Pursue Water Rights Transfers or Leases that Could Supply Projected Demand

The purpose of this alternative is to pursue water rights transfers or leases that would enable the region to meet future demands or mitigate drought-related shortages. Establishing sale, lease, or option contracts before the water is needed simplifies long-term planning and enables quick responses to water supply issues arising from drought. Water banking, a mechanism used in other western states, can facilitate these water transfers.

8.5.1 Technical Feasibility

The technical feasibility of water rights transfers and water banking is discussed in Sections 8.5.1.1 and 8.5.1.2. Most technical issues associated with this alternative involve legal and administrative requirements rather than engineering or hydrologic studies or evaluations. However, in some cases technical studies are required to evaluate the potential for impairment.

8.5.1.1 Water Rights Transfers

The technical feasibility issues associated with pursuing water rights transfers include:

- Identifying water rights holders potentially interested in pursuing a sale, lease, or option contract

- Identifying water rights that are favorably located for the proposed place or purpose of use and that can provide a dependable water supply even if surface flows were diminished

- Applying for a change in ownership and/or place or purpose of use

- Addressing protests that could occur in response to the application, including the need for simple or complex hydrologic models to demonstrate no impairment

8.5.1.1.1 Identifying Available Water Rights. Identifying water rights available for purchase or lease can be difficult. Water rights transfers within the boundaries of special districts are not subject to OSE approval (NMSA 73-14-47 and 73-13-4) and often are accomplished informally through a network of water users who know each other. Alternatively, prospective purchasers or lessees in the open marketplace will often contact known water brokers or rely on attorneys to find willing sellers. No water rights clearinghouse exists in Colfax County, although key organizations and individuals such as the irrigation and conservancy districts, the OSE Cimarron water master, or even the major water rights holders would be the first point of contact in a search for water rights available for lease or transfer.

Because the entire region is largely dependent on surface water, water rights with associated storage are desirable as they should be less vulnerable to drought than other rights in the region. To protect against the effects of multi-year droughts, rights that are retained in storage for more than one year are the most desirable. Groundwater rights are less vulnerable to changes in surface water flows. However, groundwater rights are managed in conjunction with the streams and are usually junior to surface water rights.

Currently, the only reservoir in Colfax County with storage space available for water rights is Eagle Nest Reservoir, which is now owned by the State of New Mexico. The current capacity of Eagle Nest is 78,000 acre-feet; however, Permit 71 authorizes up to 113,000 of permitted space, potentially presenting an opportunity to construct additional storage space to hold more storage rights. Eagle Nest storage contracts under Permit 71 are available in either bulk or annualized amounts (Eagle Nest Regulations, 1991); however, available water rights must be purchased and then moved into storage in the reservoir. Although water transferred and held in storage is subject to evaporative losses and would be managed in accordance with the priority system, a portion of the purchased or leased water right would nevertheless be available for release when surface flows are not available due to drought.

8.5.1.1.2 Water Rights Transfer Process. Under New Mexico Water Law, water rights sales or leases are subject to notice, publication, and protest. Transfers taking place within the boundaries of an irrigation or conservancy district are not subject to OSE approval (NMSA 73-13-4 and 73-14-47). Transfers outside such boundaries, however, are involved transactions that can take a year or more to complete; such water rights transfers are therefore not a useful means of addressing short-term water needs unless arranged and pursued ahead of time. Temporary transfers of up to 3 acre-feet are allowed under the New Mexico law; however, this limited amount is insufficient for public water supplies or irrigated agriculture needs.

All surface waters in Colfax County have been adjudicated except for a portion of the mainstem of the Canadian River; therefore, water rights amounts and ownership are well established. In areas where adjudications have not occurred, “paper water rights” (declarations or permits) may not prove valid once the OSE evaluates the amount of water that has been beneficially used and is available to transfer; thus a much greater degree of uncertainty exists regarding the amount of transferable water. However, even with a clear understanding of existing water rights, the availability of water to fulfill those rights is limited. Most water rights in the county derive from surface flows, which are vulnerable to annual changes in precipitation and especially to drought. In such cases, storage rights would be necessary to augment supplies during times when natural flow is diminished. Consequently, the existence of storage in Eagle Nest Reservoir is key to planning and managing water supplies.

8.5.1.2 Water Banking

Water banking refers to a streamlined method of reallocating or transferring the use of water through a centralized management entity. Rather than attempting to find buyers or lessees for a particular water right, water rights holders "deposit" their water rights in a "bank," which then leases the water rights to third parties. The water rights holder is protected from forfeiture of the water right and benefits from revenues obtained for use of the water by a third party (DBS&A, 2002a).

The concept of moving water among users to optimize use or address shortages is not new. Irrigation and conservancy districts can have de facto, albeit informal, water banks in place. If the purpose and use remains the same and the transfer is within district boundaries, OSE approval is not necessary. However, a county-wide water bank would involve moving water from existing uses to new uses and would occur throughout a stream system or perhaps on a county-wide basis. The technical feasibility associated with a county-wide water bank consists of:

- Overcoming legal impediments to water banking
- Establishing and managing a water bank, including:
  - Setting up the water bank agency or entity
  - Drafting water bank rules
  - Administering the water bank
  - Training staff

Permit 71 provides a storage capacity and banking system since OSE approval isn't needed to retain water in storage or to sell bulk water. However, storage of non-Permit 71 rights would be subject to OSE approval.

8.5.1.2.1 Legal Impediments to Water Banking. Although the prior appropriation system protects senior water rights holders ahead of other users, in practice water users are neighbors and typically attempt to share the burden of water shortages. For example, senior users may offer to divert less than their entire allocation to prevent junior users from being entirely shut off (Tarlock, 2000).

In the western U.S., the concept of water banking is becoming increasingly popular as a mechanism for moving water rights from existing to newer users. The benefits of this approach are numerous. Rather than become subject to forfeiture for non-use, water rights holders can earn money from the leasing of their water rights without having to engage in complex market transactions. Conversely, buyers or lessees of water rights can apply directly to a banking institution or agency and request a certain amount of water without having to research available water rights on the open market. For example, the Idaho Water Bank has posted an online list of water rights currently available for rent that includes information about the right and the name of the owner (http://www.idwr.state.id.us/waterboard/waterbank.htm).

Water banking is new to New Mexico, and for the moment, no comprehensive water banking system exists. Attempts to pass statewide water banking legislation have failed in the past. Significant opposition to water banking comes from certain representatives of acequias throughout New Mexico (New Mexico Acequia Association, 2000).

Despite this opposition, a limited local water banking initiative successfully passed in 2002 (NMSA 72-1-2.3). The geographic limitation of the water bank (the Pecos River) excluded any acequias. Under this statute, the only entities with the authority to create water banks are irrigation districts, conservancy districts, artesian conservancy districts, community ditches, and water users' associations in the lower Pecos River Basin below Sumner Lake for purposes of compliance with the Pecos River Compact (NMSA 721-2.3A). Among the rules that a water bank may create and the ISC may recommend to the State Engineer for approval are "procedures for the water bank to temporarily transfer deposited water to new purposes and places of use and points of diversion without formal proceedings before the State Engineer" (NSMA 72-1-2.3A(4)).

8.5.1.2.2 Establishing and Managing a Water Bank. The complexities of setting up and managing a water bank will depend on the water banking legislation enacted, the number of transactions anticipated, and whether the bank is a simple clearing house for water rights availability information or an actual provider of the banked water.

Colfax County has several advantages for implementing a regional water banking system. The State of New Mexico now owns the major reservoir where banked water could be stored (Eagle Nest Reservoir). The stream systems in the county have been adjudicated, and in the case of the Cimarron and Rayado systems, are actively managed by the OSE water master.

Once water banking is approved statewide, the technical issues for setting up the bank can be addressed in various ways. For example, the bank can be set up with technical assistance from the state, by hiring an experienced individual or firm to organize the bank, or by training existing staff in the appropriate local districts or agencies to set up the water banking entity.

8.5.2 Political Feasibility and Social/Cultural Impacts

Individual and public concerns associated with water transfers are addressed through the applications process and the public policy protections inherent in New Mexico water law. Individuals concerned that a transaction will harm their water rights may file a protest. Failure to resolve a disputed transfer gives rise to an administrative hearing in which the applicant must prove non-impairment. The general public welfare is protected by requiring that transfers are consistent with public welfare and with conservation of water. However, the protest requirements (i.e., the need to read legal advertisements to be aware of the pending transfer, the filing fee, and the short 10-day timeframe for filing a protest) make it difficult for citizens without legal representation to participate in the transfer process.

In the case of water banking, public policy concerns are the center of the debate around proposed statewide water banking legislation. Water banking has been on the political agenda in New Mexico for several years, with some form of water banking legislation introduced in the last several legislative sessions. Sufficient political support allowed for the passage of the limited water banking legislation in 2002 (Section 8.5.1.2.1). In order for more extensive water banking efforts to move forward, however, additional legislation will be required.

Significant opposition to water banking comes from some key representatives of acequias throughout New Mexico (New Mexico Acequia Association, 2000). Their key concern is that water banking will remove water from traditional agriculture communities to fast-growing urban areas, thereby causing significant impacts to the economy and quality of life in those acequia communities. The other key concern is that movement of water through a water banking process will not allow for sufficient evaluation of impairment on a case-by-case basis.

However, water banking offers opportunities to better manage water shortages by allowing water rights holders to quickly lease their water to other users while avoiding forfeiture and generating income. Many western states have created water banks, and studies show that implementing certain water banking policies and requirements can offset some of potential negative effects of the water transfers (Commission of Geosciences, Environment, and Resources, 1992). Proponents of water banking cite the potential economic gain from banking water and the fact that it would provide a means to secure water for economic development.

8.5.3 Financial Feasibility

The price of a water rights transfer is determined by market forces. In Colfax County, prices vary depending on the location and seniority of the water right being transferred, with some rights going for as much as $4,000 an acre-foot. In addition to the cost of the water right, transfers include transaction costs such as application and attorney's fees. Finally, if the question of impairment arises, a complex hydrologic evaluation that could cost anywhere from $50,000 to $200,000 may be necessary.

Water banking would facilitate water rights transactions and perhaps reduce the cost of finding an available water right. However, the water bank would have initial setup costs and annual budget requirements as well as transaction fees, and these would be borne in part by the buyers and sellers of water rights. Consequently, the prices per acre-foot for water rights may increase. However, the risk of litigation and its attendant costs would be greatly reduced.

Setting up the water bank, hiring employees, and purchasing necessary computer and other equipment constitute the initial startup costs for a water bank. Ongoing, recurring costs include salaries and personnel training, operation and maintenance of existing equipment, and facilities.

Assuming that a county-wide water bank would be housed in the OSE, ISC, or Department of Game and Fish, facilities and equipment would come from existing inventory. Two full-time employees would be necessary. Employees would receive training required to perform the duties of the new positions and would be required to review existing water rights and contracts on the adjudicated stream systems to update current records of ownership.

Based on these assumptions, the first year's costs for starting a water banking program would be $150,000 to $200,000, depending on the geographic extent of the bank. If surface and/or groundwater modeling is required in order to evaluate potential impairment, the costs could be double that estimate. Recurring costs would be approximately $125,000 annually. Potential sources of funding or financing for these costs are:

- Legislative appropriations to the agency housing the water bank
- Income from transaction fees
- General obligation bonds
- Federal or state funding sources (e.g., New Mexico Water Trust Fund)

8.5.4 Hydrological Impacts

Water transfers and water banking will not alter the water supply or the hydrologic system in Colfax County. A water transfer would move an existing adjudicated water right from its current place of use to a different location. In some cases, the change in place of use may alter the timing or amount of flows in certain reaches; however, unless the water right was very large, the change in the amount of overall flow of the stream would be minimal.

In small volume systems such as ditches, transferring a water right out of the system could alter the effectiveness of the conveyance by reducing the volume of the flow. However, for this to occur, a significant percentage of the water would have to be moved to a different location. Additionally, if such a change in the water flow had the potential to impair the rights of other water users on that system, the transfer could be conditioned in a way that protects existing uses.

Eagle Nest Reservoir is the repository for storing Permit 71 banked water. Storage of additional water would simply fill existing storage capacity space. The stream system would not be altered because the releases to the Cimarron River are managed in accordance with the adjudicated decrees. However, downstream users could protest transfers of non-Permit 71 rights into the reservoir.

8.5.5 Environmental Impacts

The environmental impacts resulting from water rights transfers or leases, or from establishing a water bank, depend on where water is moved from and where it is moved to. For example, if a water use is moved from a downstream location to an upstream place of use, the streamflow at the new point of diversion (upstream) will be diminished in comparison to the original point of diversion. Depending on the percentage of overall streamflow that the diversion represents as well as the variations in climatic conditions, these types of transfers can have negligible to significant impacts.

8.6 Appropriate and Reserve Groundwater for the Region

Appropriating available groundwater resources would increase the supply available to the region and protect regional water supplies from appropriation by neighboring regions or states. New Mexico law allows for certain types of water providers and local governmental entities to appropriate water for future use as part of the long-term planning process. In most cases, water users in New Mexico who acquire permits from the OSE to appropriate groundwater or surface water must put it to beneficial use within four years or be subject to forfeiture of the right after receiving notice from the OSE (Appendix D). However, a county or other qualifying applicant can reserve water rights for up to 40 years without putting them to beneficial use if it has completed a 40-year water plan that demonstrates a future need for water (NMSA 72-1-9).

8.6.1 Technical Feasibility

This alternative consists of submitting applications to obtain permits to use (appropriate) groundwater that is unappropriated and available in the region. This discussion analyzes the potential for appropriating groundwater in both declared and undeclared basins within the county. To identify specific wells or well field locations where a diversion might take place, further technical studies would be necessary.

Certain eligible entities may wish to pursue individual applications, especially if they are located near groundwater supplies with the potential to be appropriated and developed. However, a cooperative approach among various eligible entities would allow the costs for developing the wells or well field and conveyance structures to be shared among multiple users. Such an approach would also expand the capacity to secure funding through various types of funding mechanisms. For example, the Jemez y Sangre water planning region is developing a cooperative approach for appropriation and has submitted a notice of intent to appropriate flood waters for future use in the region. Participating entities in the Jemez y Sangre region include cities, counties, and private water suppliers. Participants will determine how water supplies would be allocated among individual entities through a negotiation process.

8.6.1.1 Appropriation in Declared and Undeclared Basins

New Mexico statutes define the process for appropriating waters of the state in declared basins. Most of Colfax County falls within the Canadian or Tucumcari basins (Section 5.2). A small portion of the county is undeclared and does not fall under the jurisdiction of the OSE. In declared basins, the OSE must determine that water is actually available for appropriation and that the proposed application will not impair existing water rights and will not be contrary to public welfare or conservation (Appendix D describes the groundwater appropriation process in more detail).

Although the OSE does not administer undeclared basins, perfected water rights exist in these areas. Until the OSE declares the basin and exercises jurisdiction of those areas, the priority system of allocating water and protecting existing rights is not in place, and no application is needed to drill a well and begin pumping water. This can be an advantage for entities wishing to develop rights in undeclared basins because they are not required to follow the sometimes lengthy and costly application process. However, the disadvantage of developing rights in an undeclared basin is that existing water rights would not be protected against subsequent development. In particular, the OSE would not evaluate the impairment or public welfare implications of the water development projects. Furthermore, because no application process is required, existing users would have no notice of water supply development.

Incorporation of the undeclared portions of Colfax County into declared basins by the OSE would allow for the orderly administration of water in these areas. Existing water users, whose rights are determined by the amount of water beneficially used and the date when the water was first put to beneficial use, would be able to declare their water rights and establish their seniority over subsequent development. Such a declaration would allow the region to monitor out-of-state efforts to appropriate local water supplies.

8.6.1.2 Process for Declaring an Underground Basin

Before the OSE can declare an underground water basin, the waters of the basin must be determined to have reasonably ascertainable boundaries. The boundaries of some basins clearly follow hydrologic boundaries, while other basins have boundaries related to land division boundaries. The eastern boundary of the Canadian underground water basin in Colfax County was determined using both hydrologic and land boundaries.

The OSE may declare underground water basins in special orders without prior notice. Within ten days of promulgating the order, the OSE must set a date for a public hearing and give public notice of this hearing. At past hearings, the proposed manner of administration of the basin has been presented for public comment. Past policy considerations have included how to:

- Optimize the benefit of developing the resource
- Provide a reasonable economic life for the basin
- Prevent depletion of any connected surface waters

To develop and implement the proposed basin administration, detailed knowledge of the hydrology of the basin is necessary. The diverse hydrologic conditions in eastern Colfax County may make it difficult to develop appropriate administrative rules.

After a basin has been declared and a public meeting has been held, the OSE can rule that the basin is closed to further appropriation. Regardless, the OSE must still grant permits for domestic and stock wells.

8.6.1.3 Opportunities for Appropriation in Colfax County

Clearly, the incentive to develop water supplies will be determined by the quality and amounts of groundwater available. The most promising groundwater resource in the undeclared part of Colfax County is the Capulin basin, where combined volcanics and alluvial deposits make up the primary aquifer (Section 5.2). The City of Raton has previously requested that the OSE declare the undeclared Capulin basin in the northeastern part of the county. Additionally, the steering committee has expressed support for declaring the Capulin basin, with the caveat that additional public meetings and communication with residents in that area will be needed.

In addition to reserving water through the declaration process, the county or other entities in the planning region could potentially reserve additional groundwater in some locations within the declared Canadian or Tucumcari basins. In Colfax County, groundwater that is stream-related is considered to be fully appropriated. Groundwater that is not stream-related, however, could potentially be available for appropriation. In-depth hydrologic investigations would identify areas where groundwater may be available and could indicate whether that water is stream-related and whether the supply would require treatment prior to use. In cases where high-quality water is present in sufficient quantities and where the water appears to have limited or no connection to existing streams, the OSE might approve a groundwater permit application, thereby allowing the region to set aside water for the future. With a 40-year plan in place that shows the need for future water, the Colfax region could preserve the water right while conducting technical and engineering studies required to apply the water to beneficial use.

Groundwater applications require a certain amount of specific data, including well location. In the absence of sufficient background research or data to provide the level of detail required in an OSE application, the region could submit a Notice of Intent (NOI) to appropriate the water. This notice begins the application process and would allow the region three years to develop studies and a strategy for submission of a complete application.

The NOI could also be useful in terms of securing funding for the technical work needed to further develop water supplies for the region through the appropriation process. The NOI would demonstrate that local governmental entities or water providers were actively working toward water supply development.

8.6.2 Political Feasibility and Social/Cultural Impacts

Developing water supplies for future use is a means of protecting the region and supporting existing and future uses. Because developing supplies does not involve removing water from existing uses and transferring it to new uses, no major political impediments should exist. Nevertheless, proposed individual wells or well fields could affect existing users and result in either a protest or, in the case of the undeclared areas, political opposition. In pursuing groundwater supply development, existing users should be identified and consulted.

During its May 2002 meeting, the steering committee identified the following concerns and issues related to appropriation of groundwater:

- Existing users may oppose the appropriation, although their senior rights would be protected; therefore, senior users should be consulted.
- The extent of the resource in the Capulin basin is uncertain

Despite these concerns, the committee agreed that Colfax County should pursue getting the Capulin basin declared, provided local residents are part of the process.

8.6.3 Financial Feasibility

The greatest expense in developing water supplies is related to the hydrologic investigations and models that may be necessary to obtain approval from the OSE, as well as feasibility studies, wells, and conveyance structures. This section discusses only the costs for hydrologic investigations and feasibility studies.

Hydrologic investigations are necessary to identify the exact location of favorable groundwater resources and sites for wells or well fields. Section 5.2 provides an overview of existing knowledge of groundwater supplies, but in accordance with regional water planning guidelines, preparation of this section did not involve the collection of new data. To obtain the site-specific data required to evaluate the feasibility of a groundwater appropriation, applicants may need to examine existing well logs, interview well owners, and drill test wells and collect water quality samples in selected locations.

If an application to appropriate groundwater is protested, the applicants will be required to prove that the appropriation would not impair existing rights. Depending on local conditions, a study may be limited to a simple analytical model or may entail a complex numerical model. Costs for such models can range from $50,000 to $200,000.

If a pipeline is needed to bring a new water supply (e.g., the Capulin basin) into use, engineering and environmental studies will be required. The cost for constructing a pipeline would be considerable. Preliminary feasibility studies alone could cost from $200,000 to $1,000,000.

8.6.4 Hydrological Impacts

As discussed in Section 5.3, a preliminary estimate of the amount of water in storage in the Capulin basin is about 550,000 acre-feet, though more detailed studies are required to confirm this amount and to determine what percentage of the water in storage could be extracted. If implemented, this alternative would protect these water supplies from future appropriation by outside users. Without declaration of the Capulin basin, however, the region has no mechanism for protecting this water for future uses.

Unappropriated water supplies in declared basins are also potentially vulnerable to transfer outside of the region, unless protected by the region. Regional appropriation of any water in declared basins that is not stream-connected represents a net gain of water for the region.

8.6.5 Environmental Impacts

There should be no negative environmental impacts from reserving groundwater supplies for future uses within the region. However, the development of groundwater through the installation of new wells may result in surface impacts, particularly if a new road is constructed. The construction of pipelines to convey water could also have potential environmental implications and may require the completion of an environmental assessment if the project is federally funded.

8.7 Develop 40-Year Water Plans and Appropriate Water to Meet Future Demand

Through the use of 40-year water plans, specific water users can acquire and hold unused water rights for up to 40 years (NMSA 72-1-9). Qualifying water users include municipalities, counties, state universities, member owned water systems, municipal water users' associations, and public utilities (NMSA 72-1-9A). This legislatively created planning tool allows counties and municipalities to take advantage of existing opportunities to purchase, lease, or appropriate water rights for future use. Additionally, 40-year plans allow qualifying water rights holders to thoroughly examine current water management practices and identify opportunities to maximize efficient use of their water supplies. Finally, communities with 40-year water plans that demonstrate the need for water rights or system improvements provide a justification for these communities to seek funding from available state and federal funding sources. In particular, applicants with 40-year plans would likely have a more competitive proposal when applying for funding for water supply development from the State Water Trust fund.

8.7.1 Technical Feasibility

A 40-year plan can be developed at any time. Generally a 40-year plan is prepared in conjunction with a water rights transfer. For example, if an entity is acquiring water rights for future use, the 40-year water plan will be submitted to the OSE to justify the need for that water and explain why the water will not be put to beneficial use in the short term. Also, entities with existing water rights that are not currently used, but that need to be protected for future use, may develop 40-year water plans to protect existing rights.

A water plan should be sufficiently rigorous to withstand scrutiny in the event it is challenged, and if possible, plans should be reviewed and updated every five years. To document the future need for water, a water plan would typically address the following questions:

- How much water is available to the user (physical supply and water rights)?
- How much water is necessary to meet future needs of the entity?
- What measures are in place to ensure that future water needs are met?
- Are conservation measures in place to ensure that the water is being used wisely?

Three major water suppliers in the planning region that have prepared 40-year plans are the Villages of Cimarron, Angel Fire, and Eagle Nest. The City of Raton has recently undertaken a 40-year planning effort as well.

8.7.2 Political Feasibility and Social/Cultural Impacts

In general, 40-year planning documents do not have political or social/cultural implications. However, the lack of a 40-year plan may have negative implications because failure to plan for future water needs could affect future economic development initiatives. Possible political and social/cultural issues associated with the planning process include the following:

- Plans should be periodically reviewed to ensure that they continue to reflect the needs of the community.

- Individual transactions to purchase or lease water for the future are subject to protest and must not be contrary to conservation and public welfare.

- It can be costly to fund plans without community development block grants (administered by the U.S. Department of Housing and Urban Development) or other grants.

- Without plans, unused water may be subject to forfeiture.

- The public welfare should be considered as a part of all water plans.

- Water rights transfers inherently address impacts to existing users through an evaluation of impairment.

8.7.3 Financial Feasibility

The cost of 40-year plans is variable, as these plans can range from very simple documents to complex evaluations. Because Colfax County has developed a comprehensive regional water plan that contains some of the information required in a 40-year plan, the cost to qualifying water users for developing a 40-year plan should be reduced. However, the 40-year plan must still provide information about the individual water right status, water supply, and water system information for the planning entity. Therefore, the cost of 40-year plans in the region will likely range from $10,000 to $30,000.

8.7.4 Hydrological Impacts

Because a 40-year plan identifies water supply system improvement opportunities, it lays the foundation for water to be managed more efficiently. Although water supply does not increase as a result of the plan, the ability of the community to meet demand with available supply would improve.

8.7.5 Environmental Impacts

In general, preparation of a 40-year water plan should not have any serious environmental implications. Planning for future water needs should allow communities to factor environmental concerns into the planning process.

8.8 Develop and Implement County and Municipal Septic Tank and Other Water Quality Control Ordinances

This alternative addresses protection of water resources by ensuring that water quality degradation does not occur. Related to this alternative is the reuse of wastewater, which could potentially provide water for some nonpotable uses; details of wastewater reuse are presented in Section 8.9.

The primary mechanisms for protecting water quality through ordinances are:

- Regulating the siting and type of on-site (septic or alternative) wastewater treatment systems that will be allowed
- Providing for wellhead protection areas to protect drinking water supply wells from potential contaminant sources
- Regulating the design and location of subdivisions or other new construction to ensure logical development of infrastructure and provide for adequate drainage and fire protection, thus protecting water supplies from erosion, sedimentation, or other contamination
- Limiting domestic wells and septic tanks in high-density areas, to limit exposure to contaminated groundwater

County-specific regulations could also incorporate other features such as setting forth requirements for connecting to wastewater treatment systems.

At the present time, a major water quality concern in Colfax County, as expressed at many steering committee and public meetings, is the proliferation of septic tanks in high-growth areas, especially near municipal water supply sources. Consequently, this section focuses primarily on methods to address contamination issues related to septic tanks.

8.8.1 Summary of Wastewater Options

Several types of wastewater treatment and disposal (or reuse) methods are used:

- On-site septic tank/leach field systems
- Alternative on-site systems

- Decentralized (cluster) wastewater treatment systems
- Centralized wastewater treatment facility

These treatment methods are described in Sections 8.8.1.1 through 8.8.1.4.

8.8.1.1 Septic Tank Systems

Septic tanks basically function as clarifiers and biological treatment systems; they settle solids and rely on anaerobic or facultative microorganisms to biodegrade organic wastes. Conventional septic tanks and leach fields also include follow-on physical and biological treatment in receiving soils. The technology is well established, and when properly applied, designed, and installed, it provides a known and cost-effective level of wastewater treatment as well as adequate protection for receiving groundwater in many cases. However, if tanks are improperly installed and/or are not maintained, they may leak and cause groundwater contamination.

8.8.1.2 Alternative Systems

Alternative on-site systems can consist of a wide range of treatment systems, the most common of which are:

- Constructed wetlands
- Sand filters
- Peat filters

The constructed wetlands technology is designed to mimic processes found in natural wetland ecosystems. These systems use wetland plants, soils, and their associated microorganisms to remove contaminants from wastewater and other sources. As with other natural biological treatment technologies, wetlands treatment systems are capable of providing treated wastewater suitable for reuse or reclamation. Constructed wetlands may also create or restore valuable wetland habitat for wildlife and otherwise enhance the surrounding environment.

Sand filters have been used in the United States for more than 100 years and have a proven track record. Recent design improvements in the 1990s have resulted in better efficiency and reduced maintenance. Sand filters are a type of aerobic treatment system, meaning that they are oxygen-rich and can therefore support microorganisms capable of biologically degrading wastewater. These organisms live on the sand grains and degrade the wastewater as it slowly trickles through the sand filter. Wastewater treated by sand filtration is generally colorless and odorless.

Many variations of the sand filter technology exist, but every type of sand filter includes a few basic design and operating principles:

- The wastewater is pretreated to remove solids and scum in order to mitigate clogging in the sand filter. Pre-treatment of household wastewater usually takes place in a septic tank, typically using screens to ensure that solids do not carry over into the sand filter.

- After the solids have been removed, a pump regulated with a timer doses wastewater to the sand filter in timed intervals. This intermittent application allows the media to drain between doses, ensuring that oxygen (which is critical to the biological and chemical treatment processes that take place inside the filter) is introduced into the filter with each dose of wastewater.

- After passing through the sand media, the wastewater is collected in an underdrain where it flows to the soil for final polishing and subsurface dispersal.

8.8.1.3 Decentralized and Centralized Wastewater Treatment Systems

Decentralized and centralized wastewater treatment systems use similar treatment technologies but differ in size and treatment capacity. A centralized wastewater treatment system treats an entire population area, typically a town or city, while a decentralized wastewater treatment system is a smaller-scale system serving a limited number of residences or other buildings. Decentralized systems are typically used in remote or isolated areas where the cost and logistics of connecting to a centralized wastewater infrastructure are prohibitive.

These systems can either be prefabricated or constructed in place depending on the required capacity of the wastewater treatment plant. The processes for these systems include physical, biological, and chemical treatment of domestic wastewater by using a combination of screens, filters, tanks, and basins. Final disposal of treated effluent can include the following:

- Discharge to surface water (e.g., a river)
- Subsurface disposal
- Reuse

8.8.2 Technical Feasibility

While each type of wastewater treatment system has merit, site conditions and population served typically dictate which system is more feasible for a particular area. Technical feasibility for each wastewater treatment system type is discussed in Sections 8.8.2.1 through 8.8.2.4. The technical feasibility of wellhead protection and subdivision ordinances is discussed in Sections 8.8.2.5 and 8.8.2.6, respectively.

8.8.2.1 On-Site Septic Tank Systems

On-site septic tank systems are commonly used systems that in some cases provide adequate treatment for domestic wastewater in a cost-effective manner. They are technically feasible to install on most property, but are primarily used in areas of low housing density. A technical limitation to septic tank systems is the need for additional treatment in areas with relatively impermeable soil, shallow bedrock, and/or a high water table. Additional treatment methods are also required for high-strength wastewater, which is typically generated only by commercial or industrial facilities. Standard construction procedures are used for system installation, and some maintenance is required.

Septic tank effluent is typically disposed of below ground through a gravel-filled disposal/dispersal (leach) field. The homeowner is generally responsible for operation and maintenance (O&M), which typically includes pumping the septic tank every one to five years using an approved septage hauler, who also removes solids for disposal at an approved facility.

8.8.2.2 Alternative On-Site Treatment Systems

On-site treatment systems are technically feasible and can be installed on most properties, although they are typically used in areas of low housing density. These alternative treatment systems are less widely used in New Mexico, but interest in them is growing. They have some of the same limitations as standard on-site septic tank systems in that they may not be suitable in areas with a high water table, poor soil, and/or shallow bedrock. However, many alternative treatment systems are capable of providing better treatment of the wastewater and can be installed in areas where septic tank systems are unable to provide adequate protection of groundwater. Again, additional treatment methods may be required for high-strength wastewater, typically generated by commercial or industrial facilities. Construction procedures for alternative systems are relatively standard, but because they can require pumps, electrical controls, float switches, alarms, and additional tanks, they are typically more difficult to install than standard systems, thus leading to increased construction costs.

Disposal of effluent and solids for alternative on-site treatment systems is similar to that of septic tank systems. Other O&M requirements may be more extensive than standard on-site systems, and the homeowner is generally responsible for this work.

8.8.2.3 Decentralized Wastewater Treatment Systems

Decentralized (cluster) systems are less widely used, especially in New Mexico. Efficient operation requires a consistent, medium to large volume of wastewater flow with localized high housing density. The advanced treatment methods associated with decentralized systems are usually capable of treating high-strength wastewater generated by commercial or industrial facilities as well as domestic wastewater. Decentralized systems are technically feasible in all areas because they are not constrained by soil conditions and/or the water table elevation.

Construction procedures for decentralized systems are relatively standard, but they can be more difficult for small contractors to build than standard systems. Therefore, high initial costs make decentralized systems more expensive than on-site treatment systems to install. Since they are not on-site, the homeowner is relieved of O&M responsibility; conversely, ongoing O&M by a licensed operator is required.

Treated effluent may be disposed below ground through gravel-filled dispersal (leach) field(s) or groundwater recharge well(s), or it may be applied to the ground surface for infiltration. Solids are typically disposed of between one and six times a year by a subcontractor at an approved facility. Composting or other beneficial uses may also be considered for the disposal of solids. In addition, decentralized systems may be able to reuse treated wastewater and/or, if subsurface disposal is used, qualify for return flow credits for water rights.

8.8.2.4 Centralized Wastewater Treatment Facility

Centralized facilities are widely used and widely accepted. Efficient operation requires a consistently large volume of wastewater flow along with a widespread housing density. Centralized facilities are technically feasible in areas with poor soil, shallow bedrock, and/or a high water table. The advanced treatment methods associated with centralized systems are capable of treating high-strength wastewater generated by commercial and industrial facilities as well as domestic wastewater. The capital cost is relatively high and a large contractor is required for construction, but procedures are relatively standard. The homeowner is not directly responsible for routine O&M and a licensed operator(s) is required.

As with decentralized systems, effluent from centralized systems may be disposed of below ground through gravel-filled leach field(s) or groundwater recharge well(s), or applied to the surface. Solids are typically disposed of monthly by a qualified subcontractor or facility operator. The solids can be taken to an approved facility, or they may be used for other beneficial purposes such as composting. Centralized facilities may also be able to reuse treated wastewater throughout a widespread area and/or qualify for return flow credits for water rights if subsurface disposal is used.

8.8.2.5 Wellhead Protection

The purpose of a wellhead protection program is to restrict activities with the potential to cause contamination that could impact water supply wells. A wellhead protection program could be implemented in conjunction with septic tank regulations in areas where regulation of septic installations is needed because of proximity to water supply wells.

The Safe Drinking Water Act defines a wellhead protection area as “the surface and subsurface area surrounding a water well or well field supplying a public water system, through which contaminants are reasonably likely to move toward and reach such water well or well field." The primary components of a wellhead protection program are:

- Identification of areas most vulnerable to groundwater contamination
- Delineation of capture zones for existing water supply wells (i.e., the areas of groundwater that might reach the wells within specified travel times)
- Definition of groundwater protection zone boundaries
- Identification of potential sources of groundwater contamination within the protection zones and remedial prioritization of the potential sources based on the degree of threat

Development of wellhead protection areas is technically feasible. To provide a technical basis for delineation of wellhead protection areas, the EPA has specified explicit criteria, including distance, drawdown, travel time, flow boundaries, and assimilative capacity. Delineation methods that may be used to determine mapable wellhead protection area boundaries include (in order of increasing technical sophistication) arbitrary fixed radii, calculated fixed radii, simplified variable shapes, analytical methods, hydrogeologic mapping, and numerical flow and transport models (U.S. EPA, 1987). Numerical modeling requires a significant level of effort, while arbitrary criteria provide only a minimal level of technical justification. A compromise between these extremes is an analytical model, a more cost-effective, yet analytically based, method for delineating wellhead protection area boundaries.

An example of an analytical model is EPA's Wellhead Protection Area (WHPA) model (Blandford and Huyakorn, 1991), which is widely used to determine the configuration of time-related capture zones for supply wells. The WHPA model is a modular, semi-analytical computer code based on standard hydrologic analytical techniques that use certain simplifying assumptions to generate time-related capture zone configurations for pumped wells. It accordingly assesses the travel time and flow boundary criteria specified by the EPA. In Colfax County, a wellhead protection program is most applicable to the communities of Angel Fire, Eagle Nest, and Maxwell, which rely on groundwater for their drinking water supplies.

8.8.2.6 Subdivision Ordinances

Subdivision ordinances relevant to protecting water quality in the region include items such as drainage and fire protection requirements. Additionally, as discussed in Section 8.10, subdivision ordinances may include requirements for ensuring availability of water. Development of drainage and fire protection requirements is technically feasible, and many good examples exist from other communities. Drainage specifications are directed at controlling runoff and erosion. Fire protection requirements include items such as allowing access for emergency vehicles as well as controlling the density of vegetation in close proximity to dwellings. Fire protection requirements indirectly affect water quality by preventing erosion and sedimentation that typically occurs after catastrophic forest fires.

8.8.3 Political Feasibility and Social/Cultural Impacts

NMED currently regulates septic tank and alternative on-site wastewater treatment systems. Decentralized and centralized wastewater treatment systems are regulated by both NMED and EPA. County-specific regulations, such as the Bernalillo County Wastewater Ordinance, adopted by Bernalillo County in 2000, may also govern these systems. Additionally, NMED is currently in the process of updating their regulations; however, to date, no anticipated release date has been set.

Colfax County may either elect to draft county-specific regulations governing wastewater disposal or to accept existing EPA and NMED guidelines. If the county chooses to draft its own regulations, it could use the Bernalillo County Wastewater Ordinance or other existing ordinances as a template. Prior to drafting county-specific regulations, county- or community-wide planning would be required, as well as determining areas in which these types of treatment facilities would be feasible.

Subdivision regulations could also be implemented on a countywide basis. Wellhead protection programs may be most easily implemented by groundwater-dependent communities.

Participants at the May 2002 public meeting felt that county ordinances to protect water quality were important to prevent future problems. Concerns they raised include:

- The focus should be on new construction, not existing buildings
- There is a lack of building inspectors to enforce codes
- There is a need for consistency throughout the county
- Septic systems in the Moreno Valley and Ute Park are a primary concern

Additionally, the option of having a joint powers agreement for an ordinance in the extraterritorial zone around a municipality, rather than throughout the entire county, was suggested.

8.8.4 Financial Feasibility

The financial feasibility of implementing county water control ordinances varies among the options, as discussed below:

- *On-site septic tank systems:* The installation cost of a conventional on-site septic tank/leach field system is relatively low, approximately $2,400. The homeowner is typically solely responsible for both the cost of installation and routine O&M, and state and federal funding assistance is typically not available to owners of septic tank systems.

- *Alternative on-site treatment systems:* As with septic tank systems, the homeowner is solely responsible for both the cost of installation and O&M, and state and federal funding assistance is generally not available. These systems typically cost $3,500 to $7,500 more than conventional septic systems.

- *Decentralized (cluster) wastewater treatment systems:* Homeowners are typically responsible for both the cost of installation and ongoing O&M. Subdivision or area-wide covenants typically dictate responsibilities and fees, which can either be based on usage levels or flat rates. In contrast to individual on-site systems, however, state and federal funding is often available in the form of loans and/or grants to assist with construction of this type of treatment facility.

- *Centralized wastewater treatment facility:* Centralized systems are typically owned and maintained by a county or municipality, but installation costs and O&M are indirectly covered by homeowners serviced by the system. County, city, village, or community regulations typically dictate responsibilities and fees, which are usually based on usage levels or flat rates. State and federal funding is often available in the form of loans and/or grants to assist with construction of this type of treatment facility.

- *Wellhead protection and subdivision ordinances:* The cost of developing wellhead protection and subdivision ordinances should be fairly low. These may be developed as part of the Colfax County Comprehensive Plan (Section 8.10), which is currently funded and is receiving free technical assistance from the Western Environmental Law Center. If wellhead protection modeling is conducted to assist with defining specific wellhead protection zones, the costs could range from approximately $30,000 to $150,000, depending on how many separate locations are evaluated.

The greatest long-term cost for this alternative will be for ongoing monitoring and enforcement to ensure that ordinances are being adhered to. In addition, ongoing technical review and analysis will be required to determine if new developments meet criteria for ensuring availability of long-term water supplies. Also, technical review regarding adherence to drainage criteria will be needed. Some of this review may be completed by county employees, such as a drought task force coordinator or water resources staff, who also address other issues. Issues pertaining to fire protection could possibly be reviewed by the county fire marshal.

8.8.5 Hydrological Impacts

This alternative will not provide for any new water supplies or create any water savings; however, it will protect existing supplies from degradation and help to ensure that existing supplies are available to help meet future demands. Without water quality protections, existing water resources may not be suitable to meet future demand.

8.8.6 Environmental Impacts

This alternative would create positive environmental impacts by protecting groundwater supplies from septic tanks or other contaminant sources. Drainage and fire protection ordinances could help to reduce erosion and sedimentation in the county, prevent severe sedimentation of downstream reservoirs, and prevent loss of forest habitat.

Wastewater ordinances could have the following environmental impacts:

- *On-site septic tank systems:* In areas with relatively low housing density, on-site septic tank systems generally provide adequate wastewater treatment. However, groundwater or surface water can be impacted by these systems, especially in areas of high housing density or in cases where the system is not maintained properly. Additionally, on-site systems are not suitable for sites with certain conditions such as a high water table, shallow bedrock, steep slopes, poorly draining soil, or proximity to surface water or drainages.

- *Alternative on-site treatment systems:* Alternative on-site treatment systems generally provide additional treatment of wastewater beyond what a standard septic system offers. Though they tend to be more protective, the potential for groundwater or surface water impact is still present, especially in areas of high housing density or in cases where the system is not maintained properly. However, they are typically better suited for areas that are not conducive for on-site septic tank systems.

- *Decentralized (cluster) wastewater treatment systems:* Decentralized systems generally provide better treatment of wastewater than standard or alternative septic systems, resulting in increased protection of groundwater. Primarily due to advanced treatment methods, increased monitoring and O&M requirements, and the use of licensed operators, the potential for groundwater or surface water impacts to occur is lower, even in areas of high housing density.

- *Centralized wastewater treatment facility:* Centralized facilities typically provide the highest level of wastewater treatment, resulting in the best protection of groundwater. The potential for groundwater or surface water impacts to occur is lower due to advanced treatment methods, increased monitoring and O&M requirements, and the involvement of a licensed operator.

8.9 Recycle Municipal Wastewater for Agricultural and Recreational Use

Wastewater reclamation and reuse is being practiced successfully in several locations in the western United States as a means of increasing or supplementing the available supply of water and preserving potable water for drinking water uses. Accordingly, the Colfax steering committee has indicated the desire to consider reuse of treated wastewater for nonpotable uses such as agricultural and recreational uses.

In addition to agricultural and recreational uses, treated wastewater has been successfully used throughout the United States for landscape watering, aquifer recharge, manufacturing and industry, and return flow credits. Each of these types of uses requires that the wastewater be treated prior to use and comply with applicable regulatory standards. The degree of treatment and the standards to be met depend upon the end use of the reclaimed water:

- For all reuse options where human contact with the treated wastewater is likely (i.e., irrigation and recreational use), wastewater treatment must include secondary and tertiary (filtration and disinfection) treatment.

- For all reuse options where treated wastewater is likely to come in contact with groundwater (e.g., irrigation, landscaping, and aquifer recharge), a New Mexico Groundwater Discharge Permit is necessary.

- Returning water to a river for return flow credits requires an NPDES permit and may be limited by TMDL standards for the river.

Nevertheless, if proper attention is given to the wastewater treatment to assure the health of recipients, wastewater reuse is an environmentally and socially responsible way to increase local water supplies.

8.9.1 Technical Feasibility

The primary technical challenge in reusing wastewater is treatment of the water to bring it to an acceptable level of quality. Treatment of wastewater for reuse has been practiced at some locations within the U.S. for more than 25 years and the technological feasibility is thus well known. However, the applicable standards that would have to be met for any given reuse application are not well defined. In the absence of firm reuse standards, only a general discussion concerning reuse options and costs is possible.

Current NMED guidelines are unclear or are relatively lenient in comparison to guidelines that exist elsewhere. NMED has recently issued (March 2003) updated draft guidelines for irrigation using treated wastewater, which should be carefully considered as the draft moves toward implementation of new guidelines. NMED has an existing policy issued in 1985 covering use of treated wastewater effluent for irrigation. These guidelines are intended to be used in conjunction with a permit for discharge of the reuse water. This permit, which describes the reuse application (use, flows, etc.) and specifies a water quality monitoring program, must be filed with NMED for each reuse site. NMED guidelines do not allow for reuse of wastewater for potable applications.

To date, no federal regulations have been proposed for either nonpotable or potable reuse (DBS&A, 2002b). In 1992, the EPA published guidelines for water reuse, defining a broad range of reuse applications and presenting guidelines for treatment water quality and implementation; however, these guidelines are not legally binding. Generally, where overlap occurs, EPA's guidelines are similar to or more conservative than NMED's guidelines.

In 1998, Camp Dresser & McKee (CDM) developed a treated effluent management plan for the City of Santa Fe (CDM, 1998) that reviews the significant reuse standards current at that time. The most extensive of those are in the State of California, which since 1978 has regulated nonpotable reuse under Title 22 of the California Administrative Code. In addition, California drafted proposed regulations in 1993 for intentional recharge of potable aquifers with treated wastewater. However, considerable disagreement still exists within the water industry on how such indirect potable reuse should be regulated.

In 2000 NMED, in conjunction with the New Mexico Department of Health, issued a revised draft of its guidelines for reuse, following the approach of California Title 22. Significant adverse comment was received on this proposed revision. Stakeholders thought that following the approach of Title 22 was not appropriate, in particular because changes would be imposed on existing New Mexico reuse practices without providing needed financial support. Reuse of wastewater for irrigating parks, school yards, and certain other areas is currently practiced throughout New Mexico, and objections were raised concerning additional treatment and monitoring that might be required for these activities.

NMED and the New Mexico Department of Health (NMDH) are reviewing the comments received on the draft revisions and are considering options. NMED has reviewed the approaches taken by other states and is considering regulation based on classes of reuse. NMED formed a workgroup to address this issue and has proposed updated guidelines for public comment.

Tables 8-2 through 8-4 summarize possible classes of reuse and associated treatment standards and monitoring requirements that might constitute regulations for nonpotable reuse in the future. These tables were developed based on discussions with NMED prior to the March 2003 release of the new draft guidelines. These latest draft guidelines and subsequent revisions will determine what final reuse standards will be. For this plan, however, the provisions for the classes of reuse outlined in Tables 8-2 through 8-4 for nonpotable uses will be assumed.

Reuse classes A, B, and C are possibilities put forth by NMED and are defined by the quality limits indicated in Tables 8-2 through 8-4. The classes are intended to define the level of water quality and thus the degree of treatment required for various uses of reclaimed water.

Table 8-2. Conceptual Use Classes for Reclaimed Wastewater

Use	Reuse Class [a]		
	A	B	C
Irrigation uses			
Fiber, seed, forage, and similar crops	■	■	■
Silviculture	■	■	■
Orchard or vineyard flood irrigation	■	■	
Orchard or vineyard spray irrigation	■		
Sod farms	■	■	■
Pasture for milking cows	■	■	
Pasture for non-dairy animals	■	■	
Unrestricted access golf course	■		
Unrestricted access landscape	■		
Restricted access golf course	■	■	
Freeway landscape	■	■	
Residential landscape	■		
Parks and playgrounds	■		
School yards	■		
Construction uses			
Dust control	■	■	
Backfill consolidation around portable water pipes	■		
Backfill consolidation around non-potable piping	■	■	
Soil compaction	■	■	
Mixing concrete	■	■	
Other uses			
Livestock watering (non-dairy animals)	■	■	■
Livestock watering (dairy animals)	■	■	
Toilet and urinal flushing	■		
Fire protection systems	■		
Street cleaning	■	■	
Snowmaking	■		
Commercial laundries	■		
Landscape impoundment	■	■	
Recreational impoundment (no significant dilution)	■		
Vehicle and equipment washing (does not include self-service vehicle washes)	■		
Irrigation and other non-potable uses at wastewater treatment plants	■	■	

[a] See Table 8-3 for treatment standards associated with each reuse class.

Table 8-3. Conceptual Reuse Treatment Standards

Category	Reuse Class		
	A	B	C
Treatment required	Secondary, filtration, and disinfection	Secondary with disinfection	Secondary with disinfection
Turbidity limit	3 NTU monthly average, not to exceed 5 NTU in more than 5 percent of monthly samples	None	None
Disinfection limit	Nondetection of fecal coliform in 4 of last 6 daily samples; maximum 23 cfu/100 mL in any single sample	*E. coli* of 126 cfu/100 mL monthly geometric mean; maximum 235 cfu/100 mL in any single sample	Fecal coliform less than or equal to 1,000 CFU/100mL at all times.
Other	---	BOD 30 mg/L; TSS 45 mg/L	BOD 30 mg/L; TSS 45 mg/L

NTU = Nephelometric turbidity units
cfu/100 mL = Colony-forming units per 100 milliliters
BOD = Biological oxygen demand
TSS = Total suspended solids
mg/L = Milligrams per liter

Table 8-4. Conceptual Reuse Monitoring Requirements

Parameter	Reuse Class		
	A	B	C
Turbidity	Continuous	None	None
Pathogen	Fecal coliform, daily	*E. coli,* weekly	Fecal coliform, monthly
BOD5	None	Monthly	Monthly
TSS	None	Monthly	Monthly

BOD5= Biological oxygen demand (5-day)
TSS = Total suspended solids

Current regulations generally require secondary treatment of wastewater in order to meet NMED discharge standards. The degree of wastewater treatment necessary beyond secondary treatment (and thus the cost of the treatment) will depend on the quality standards required for the use of the water. A higher-quality effluent can be provided by applying tertiary treatment with additional treatment processes. The effectiveness of tertiary processes for treating wastewater to a high quality is well documented.

The technical feasibility of selected wastewater reuse options is discussed in Sections 8.9.1.1 through 8.9.1.3. Section 8.9.1.4 discusses current types of reuse in Colfax County and the part those facilities might play in regional water planning. Required maintenance for treatment infrastructure is discussed in Section 8.9.1.5.

8.9.1.1 Use of Treated Wastewater to Supplement Agricultural Needs

Treated wastewater may be pumped directly to agricultural areas for irrigation. As an example, the City of Roswell, New Mexico uses all of its treated effluent for irrigation by selling treated effluent to nearby farmers during nine months out of the year. In New Mexico, treated effluent is most commonly used for non-food crops, such as alfalfa.

Land application of wastewater for irrigation purposes would require a groundwater discharge plan under the New Mexico Water Quality Control Commission regulations. These regulations limit the amount of nitrogen that can be applied to fields to 200 pounds per acre per year, with a higher rate applied for crops with higher nitrogen uptakes. Thus the degree of treatment required is variable depending on the types of crops grown.

Discharging treated wastewater into rivers and streams is another way that effluent can be used to augment irrigation supplies. Secondary wastewater treatment to State of New Mexico standards would be required prior to surface water discharge. An NPDES permit would also be required.

In instances where water will be discharged to a natural water body, the water must be dechlorinated prior to discharge. For wastewater treatment plants (WWTPs) that discharge solely to water bodies, therefore, alternative disinfection methods such as UV radiation or ozone injection may be practical.

Primary costs associated with this option are the cost of pumping the reclaimed water to the agricultural land or receiving water body and the cost for the infrastructure (piping) required to do so. This option is only practical if the point from which the treated wastewater is being pumped is within a reasonable distance of the point of return. Long return pipelines are generally costly and may not always be feasible because of terrain, permits, or other considerations.

8.9.1.2 Use Treated Wastewater for Recreational Uses (Landscape Irrigation)

The primary recreational use of treated wastewater is for landscape irrigation, such as at parks, schools, and athletic fields, as other recreational uses involve bodily contact and potential human ingestion. Raton already uses reclaimed wastewater to irrigate parks, athletic fields, and the golf course (Section 8.9.1.4).

Because of the small acreages normally involved, treated wastewater is usually not economically practical for irrigation if long pipelines must be constructed. As with agricultural uses, therefore, reusing wastewater for landscape irrigation is feasible only if the source of treated wastewater is within a reasonable distance of the reuse point. In addition, the wastewater would require treatment to conceptual reuse class A standards (Table 8-3), which would likely consist of secondary treatment, filtration, and disinfection.

8.9.1.3 Inject Treated Wastewater as Artificial Recharge

In Colfax County, groundwater is the primary water source in the Moreno Valley and, to a lesser extent, in the Capulin basin and the Ogallala aquifer on the eastern side of the county. Because of this reliance on groundwater, the steering committee might also consider the future use of treated wastewater to recharge the aquifers in the groundwater use areas.

Treating wastewater and injecting it as artificial recharge is straightforward technologically. Treated effluent may be recharged to groundwater by pumping it into the ground through injection wells or by percolation from surface recharge basins. Artificial recharge of groundwater is regulated under the OSE Underground Storage and Recovery Regulations (19.25.8 NMAC, effective January 31, 2001). The OSE determines whether the recharged water is fully recoverable using recovery wells or whether an unrecoverable loss occurs.

Unfortunately, determining the treatment requirements for artificial recharge is difficult. Because groundwater is widely used as a drinking water source in New Mexico, injection or percolation of treated wastewater into the ground is considered indirect potable reuse, and the State of New Mexico has not enacted guidelines or regulations regarding acceptable quality for effluent recharge for indirect potable reuse. NMED requirements would typically be expected for recharge effluent quality, depth to groundwater, and minimum setback distance from existing drinking water wells. Any discharge of effluent to an aquifer, however, will require a groundwater discharge plan permit to ensure that groundwater standards are not violated.

The NMWQCC groundwater regulations specify maximum concentrations for many constituents. Degradation of the groundwater quality up to these limits is allowed. Thus, if ambient concentrations were below the specified concentrations, treated wastewater concentrations could be higher than the specified in-ground concentrations. Conversely, if the existing concentration of any constituent in groundwater already exceeds the specified maximum, no degradation beyond the existing concentration would be allowed. A conservative approach would be to ensure that the quality of any treated effluent being used for groundwater recharge is equal to or less than the standard specified in the NMWQCC groundwater regulations.

EPA’s water quality guidelines on groundwater recharge through surface application state that after percolation through the vadose zone, all Safe Drinking Water Act maximum contaminant levels must be met, and fecal coliforms must be nondetectable. Ensuring that this will be the case is difficult, unless an underdrain system is constructed to allow sampling and testing of water that has percolated through the soil.

The most conservative and most publicly acceptable approach to indirect potable reuse involves treatment of wastewater to potable standards using advanced water treatment (AWT). This might require application of one or more of the following processes beyond secondary wastewater treatment: chemical clarification, reverse osmosis (RO), granular activated carbon (GAC) adsorption, air stripping, filtration, and ion exchange. Advanced treatment should be sufficient to remove pharmaceuticals and other trace constituents that may be of concern to the public.

Another potential technology, soil-aquifer treatment (SAT), has been demonstrated in Tucson, Arizona and other areas to be effective in treating wastewater for groundwater recharge. The use of SAT requires particular geological conditions and the availability of considerable land; however, if feasible, SAT may be the most economical option for groundwater recharge in Colfax County.

The primary cost associated with this option is the increased cost of wastewater treatment, most likely to drinking water quality. Piping of the effluent to the recharge area and, if injected, injection well construction and pumping costs will also be necessary. Thus groundwater recharge is more feasible when the wastewater can be treated at a location close to an area suitable for recharge.

8.9.1.4 Current Reuse in Colfax

Six WWTPs in Colfax County serve a significant permanent population. These are the city plants of Raton, Maxwell, Cimarron, Angel Fire, Springer, and Eagle Nest. Other smaller, non-municipal treatment plants exist in Colfax County but are not addressed in this study because they produce small or seasonal flows. Four of the six municipal WWTPs in Colfax County already reuse treated effluent in some way.

Raton has the most sophisticated reuse system. The Raton WWTP treats about 750,000 gallons per day (gpd) in the winter and 850,000 gpd in the summer. Between about February and November, 50 to 60 percent of the WWTP’s treated effluent is used to water the golf course and city parks and sports fields, and to fill a pond on the C S Cattle Ranch and the water hazard on the golf course. The remainder of the summer flow and all of the winter flow is discharged to Doggett Creek from where it eventually flows into the Canadian watershed. Water from the Canadian River is then used for agricultural irrigation by many users, including the Vermejo

Conservancy District. In essence, therefore, all water from the Raton WWTP is reused either for landscape irrigation or to supplement agricultural irrigation supplies.

Results of recent biomonitoring by the EPA may cause Raton's discharges to Doggett Creek to be discontinued. While the flathead minnow flourished in the creek, the water flea cannot survive in effluent from the Raton WWTP. If the issue cannot be resolved, the City plans to store all its winter effluent in a total retention lagoon. This water will then be used in the summer for the landscape irrigation listed above, and any extra water will be applied with sprinklers to the land owned by the treatment plant.

Treated effluent from the Maxwell and Cimarron treatment lagoons also replenishes irrigation supplies. The Maxwell treated effluent is discharged to the Canadian River, and the Cimarron effluent is discharged to French Lake, which is used by agricultural users.

The WWTP at Angel Fire applies its treated effluent to the land surrounding the treatment plant through sprinklers. Though this water is not reused in a formal sense, it is maintaining the local landscape.

Eagle Nest and Springer currently use total retention lagoons to treat wastewater. Water from these lagoons is not reused, but dissipates by evaporation and, if the ponds are unlined, by percolation. Springer has plans to upgrade its treatment facility so that effluent may be reused in the future. Angel Fire and Eagle Nest could discharge to the Eagle Nest Reservoir and Cimarron River system. Springer could discharge to the Cimarron River, thereby supplementing irrigation water for thousands of acres of farmland; however, this system is used for potable supplies as well as irrigation. Supplementing irrigation supplies by discharging to nearby rivers is a reuse option for all of the treatment facilities discussed above.

Like Raton, Angel Fire has a golf course in town. Golf courses use about 1 million gallons of water a day, and the Angel Fire WWTP is sophisticated enough to produce an effluent of sufficient quality for use on the golf course. However, depending on the proximity of the treatment plant to the golf course and the intervening terrain, the piping required to deliver water to the course may be prohibitively expensive.

Potentially all the treatment plants could also reuse their treated effluent for landscape irrigation. Again, depending on the distances and terrain involved, the cost of delivering the water to the point of use could be prohibitive.

8.9.1.5 Required Maintenance

As discussed previously, for any reuse option a high quality effluent must be produced to assure public health and safety, and when human health is at risk, effluent must be constantly monitored and safeguards must be built in. To monitor and safeguard the system, the proper infrastructure must be in place and it must be maintained.

Any WWTP producing effluent for reuse must disinfect the water using some type of treatment process and equipment. Whatever the disinfection methods, the equipment must be constantly monitored and regularly maintained to ensure proper operation and effective disinfection.

The majority of the WWTPs in Colfax County are lagoon systems, which are capable of producing water of sufficient quality for reuse with the addition of filtration and disinfection. Most lagoon systems, however, are not monitored frequently. Lagoons are sensitive to temperature changes and go through a process called “turn over” twice a year, during which time the lagoon is not producing water of optimum quality. During this period of turn over and re-acclimation, water from the lagoon would have to be stored and not reused for any purposes. If water of poor quality did enter the reuse system it would be imminently dangerous to public health. Therefore, careful and frequent monitoring, especially during season changes, is essential.

Managers and operators of a WWTP producing water for reuse must be aware of the health risks that improper operation can cause. Operation and maintenance plans must be implemented and rigorously followed. Emergency action plans must also be in place so that in the event of failure low-quality water will not enter the reuse system.

If the system fails and water is produced that does not meet the requirements, safeguards must be in place at the facility to divert, store, or reprocess the low-quality water. For most plants this means building storage ponds to which low-quality water can be diverted for retreatment or storage. The key to preventing accidents is preparation and timing. The best infrastructure for redirecting low-quality effluent will not avert a hazard if tens of thousands of gallons escape before the problem is noticed or if operational practices do not ensure prompt diversion.

8.9.1.6 Implementation Strategy

The following actions are recommended to examine the feasibility of implementing reuse of treated wastewater as a strategy for conserving potable water supplies in Colfax County:

- Work with the NMED and NMDH on updates to the recently released draft guidelines for nonpotable reuse and indirect potable reuse. Clearly defined rules from the State of New Mexico are needed before serious assessment and planning regarding the long-term potential of reuse options can be undertaken.
- Evaluate the suitability of the standards in light of current science, and assess the impact that would occur if these standards were to become more stringent in the future.
- Assess whether SAT would be a feasible treatment option considering soils and hydrogeologic conditions within Colfax County.
- Identify potential reuse options and sites (agriculture, industrial, lawn watering, etc.) that are reasonably close to current and future wastewater discharge points.
- Identify needed treatment processes for anticipated end uses.
- Once the potential for reuse has been assessed and NMED standards have been established, evaluate and develop financing mechanisms for reuse options and projects.
- Approach decision making regarding reuse with an effective public involvement process to build public support for reuse within the planning area.

8.9.2 Political Feasibility and Social/Cultural Impacts

The primary social concern regarding wastewater reuse is the potential for human contact with wastewater (e.g., when parks where children play are irrigated with wastewater). If treatment is not adequate, or temporarily fails, there is a genuine concern about human health impacts. The steering committee also indicated the following concerns:

- Wastewater reuse is expensive and subject to unfavorable perceptions.
- Treated wastewater cannot be given to cattle or used on hay intended for cattle.

8.9.3 Financial Feasibility

Costs for wastewater reuse alternatives will depend on the standards to be met, the volume treated, the end use, the distance treated effluent must be pumped and/or piped, and the cost of permitting. Costs of effluent reuse fall into several categories:

- Acquisition of raw wastewater supply

- Construction and operation of treatment facilities needed to meet standards for planned end uses

- Construction and operation of storage facilities needed to ensure a reliable supply on a day-to-day basis, accounting for seasonal differences in supply of effluent and use (for instance, turf facilities have peak demand in the summer, and effluent produced in the winter may need to be stored for summer use on these facilities)

- Construction and operation of the transmission and distribution system

- Costs of resolving issues related to diminished return flows for downstream users who have relied upon effluent discharges

- End-user adaptation costs, which can include:
  - On-site hookup and replumbing to connect to the nonpotable system
  - Special equipment, such as corrosion-resistant devices
  - Additional on-site treatment for water-quality-sensitive end uses
  - Idling of other water supply facilities (e.g., groundwater wells) that will no longer be used

- Worker safety and public health practices, as applicable
- Higher maintenance costs (cleaning, reducing clogging) relative to those for other water sources
- More frequent leaching and higher volume of leaching water to control salt buildup in irrigation uses

As suggested by the above list, costs would include both operating and infrastructure costs (Tables 8-5 and 8-6, respectively [DBS&A, 2002b]). Both types of costs are affected by the size of the facility, with smaller reuse facilities typically having a higher unit cost because of the lack of economy of scale, as demonstrated particularly in Table 8-6.

Table 8-5. Estimated Reclamation Treatment Process Costs, 1996 Dollars

Reuse Application	Treatment Process	Annual Cost ($/ac-ft)
Agricultural irrigation	Activated sludge	245–682
Livestock and wildlife watering	Trickling filter	268–711
Power plant and industrial cooling, once through	Rotating biological contactors	379–728
Urban landscape irrigation	Activated sludge, filtration	291–903
Power plant and industrial cooling-recirculation	Tertiary lime treatment	404–1,334
Groundwater recharge, spreading basins	Infiltration-percolation	108–260
Groundwater recharge, injection wells	Activated sludge, filtration, carbon adsorption, reverse osmosis	1,166–3,271

Source: Richard, 1998 $/ac-ft = Cost per acre-foot (1 ac-ft = 325,851 gallons)

Costs are also highly dependent on the type of wastewater treatment process, which differs depending upon the reuse application. Although now somewhat dated, the cost estimates in Tables 8-5 and 8-6 give an idea of the range in treatment costs for different reuse options. In general, these costs would be expected to be higher today, but technology has been changing rapidly, and specific cost estimates would need to be prepared based on the characteristics and conditions of each reuse situation.

Table 8-6. Estimate of Reclamation Facility Life Cycle Costs, 1996 Dollars

Wastewater Treatment	Life Cycle Costs ($/ac-ft[a])		
	1 mgd	5 mgd	10 mgd
Secondary treatment, plus full California Title 22 facility			
Capital	886	388	371
Operation and maintenance	465	351	342
Total	1,351	739	713
Secondary treatment, direct filtration			
Capital	726	331	316
Operation and maintenance	314	215	206
Total	1,040	546	522
Secondary treatment, contact filtration			
Capital	742	350	326
Operation and maintenance	310	215	205
Total	1,052	565	531
Secondary treatment, contact filtration, phosphorus removal			
Capital	748	382	363
Operation and maintenance	594	489	479
Total	1,342	871	842
Secondary treatment, contact filtration, carbon adsorption			
Capital	953	539	529
Operation and maintenance	731	610	600
Total	1,684	1,149	1,129
Secondary treatment, contact filtration, carbon adsorption, reverse osmosis			
Capital	1,415	922	886
Operation and maintenance	1,109	889	859
Total	2,218	1,811	1,745
Secondary treatment, lime treatment, reverse osmosis			
Capital	1,273	745	690
Operation and maintenance	945	757	726
Total	2,218	1,502	1,416

Source: Richard, 1998.
[a] 1 ac-ft = 325,851 gallons

$/ac-ft = Cost per acre-foot
mgd = Million gallons per day

Finally, costs for treatment and reuse of wastewater effluent differ substantially from one area to another across the U.S. The cost of reuse in Colfax County may differ even from one town to another because of local conditions, and a separate assessment of the cost feasibility for each town will therefore need to be made. Reuse options away from municipalities typically are limited due to a lack of locally generated wastewater and the high cost of conveying wastewater.

8.9.3.1 El Paso Case Study

The reuse practices of El Paso, Texas, provide a case study of the economics of wastewater reuse (for a large-scale application). The city recycles treated effluent from three WWTPs:

- Two WWTPs provide reuse water that is treated to advanced secondary wastewater quality using conventional secondary treatment (aeration) and sand filters to meet an carbonaceous biochemical oxygen demand average of 5 mg/L, fecal coliform maximum of 75 colony-forming units per 100 milliliters (cfu/100 mL), fecal coliform geometric mean of 20 cfu/100 mL, and turbidity average of 3 nephelometric turbidity units (NTU). This effluent quality, based on monthly averages, meets Texas standards for unrestricted use in irrigation of landscapes at facilities such as golf courses, schools, and parks.

- A third El Paso plant provides tertiary treatment and injects drinking water quality effluent into the aquifer. This 10-million-gallon-per-day plant uses primary treatment, a two-stage biophysical powdered activated carbon treatment (PACT) process, lime treatment, recarbonation, sand filtration, ozonation, GAC adsorption, and clearwell storage prior to aquifer injection. This plant was completed in 1984 at a cost of $26 million.

The amount of reclaimed water El Paso sells to customers for use is 1,700 million gallons per year. The price of secondary treated reclaimed water is $0.49 per 100 cubic feet (60 percent of the lowest El Paso potable block 1 rate of $0.82 per 100 cubic feet). The price of tertiary treated reclaimed water is $0.66 per 100 cubic feet (80 percent of the lowest El Paso potable block 1 rate). These prices are based on what people are generally willing to pay for reclaimed water.

8.9.3.2 Funding Sources

Funds for planning, design, and implementation of wastewater reuse are available from two primary sources: federal programs and local funding (Section 8.12). Several federal programs exist that can provide grants or loans. The principal federal funding mechanisms include:

- *Title XVI, Reclamation, Recycling and Water Conservation, through the U.S. Bureau of Reclamation (USBR).* Eligible projects include reclamation and reuse of municipal and other wastewaters and naturally impaired waters. The maximum federal cost share is 50 percent for planning and 25 percent each for design and construction. The maximum federal share amount for construction is $20 million for a single project, regardless of total cost. In most cases, the federal share is non-reimbursable, resulting in a de facto grant to the local project sponsors. Projects are funded by congressional appropriations.

- *Water Supply Act projects, through the U.S. Army Corps of Engineers.* In the past, Congress has authorized the Corps to assist specific local communities with municipal water supply and treatment needs not necessarily associated with other Corps projects. These special projects are funded individually through congressional appropriations.

- *Environmental Programs and Management, through the U.S. EPA.* Eligible projects are environmental infrastructure. Maximum federal cost share varies, with the maximum funding for a single project approximately $4 million.

- *State Assistance Grants, through the U.S. EPA.* Eligible projects are environmental programs and infrastructure projects for water, drinking water, and wastewater.

- *Clean Water Act State Revolving Loan Fund, through the U.S. EPA/States.* Eligible projects are wastewater treatment.

- *Safe Drinking Water Act State Revolving Loan Fund, through the U.S. EPA/States.* Eligible projects include drinking water facilities to provide a safe supply and quality improvement.

- *USBR Loan Program.* Eligible projects include conservation, water quality improvement, enhancement of fish and wildlife, and support of Native American self-sufficiency.

- *Rural Utilities Services (RUS) funding, through the Department of Agriculture.* Grants and loans for communities of 10,000 or less are available for up to 75 percent of the development cost of a project, which helps reduce user costs to a reasonable level.

Additional funding might include:

- *Treated effluent sales.* Contract users of treated effluent can be charged for the quantities of effluent used. Selling treated effluent, rather than providing it at no charge, is standard practice in most communities in the southwestern U.S. Examples of treated effluent rate structures are listed in Table 8-7. In general, rates charged for treated effluent are below the costs of treating and conveying it and must be subsidized to encourage its acceptability and use by consumers. For agricultural reuse, sale of treated effluent may not be possible during the fallow season.

- *Government partnerships/private funding sources.* Entities interested in using reclaimed water could be approached to help fund the costs associated with treatment and reuse.

It is likely that a funding package using several mechanisms will be needed to implement effluent reuse within Colfax County.

Table 8-7. Examples of Treated Effluent Rates

Utility/Municipality	Treated Effluent Rate ($/kgal)	Treated Effluent Rate as Percentage of Comparable Potable Rate (%)
Clark County, NV	2.00	100
Henderson, NV	0.80	57
Tucson, AZ	1.42	60
Phoenix, AZ	1.42-2.12 [a]	80
El Paso, TX (secondary) [b]	0.65	60
El Paso, TX (tertiary) [b]	0.88	80

Source: CDM, 1998, except as noted.
$/kgal = Cost per kilogallon

[a] Varies seasonally.
[b] Source: Personal communication, December 2001.

8.9.4 Hydrological Impacts

Since municipal water (and wastewater) represents a small proportion of the total water used in Colfax County, reuse will not have a large impact on the overall water situation in the county. However, it could improve efficiency in individual municipalities. As discussed in Section 8.9.1.4, Raton currently reuses about 750,000 gpd in the winter and 850,000 gpd in the summer. Based on an average of 800,000 gpd, the current wastewater reuse by Raton is 896 ac-ft/yr. Other communities reuse smaller amounts of wastewater (Section 8.9.1.4). If more restrictive wastewater use regulations are developed, these communities will need to either provide more extensive treatment or replace the wastewater they are currently using with potable water. Additionally, there are some limited opportunities for wastewater reuse by the communities that currently do not reuse their water (i.e., Springer, Eagle Nest, additional reuse in Angel Fire). When considering opportunities for reuse, the current disposal of the water (i.e., evaporation from lagoons versus discharge to a stream or lake used by others) should be considered.

8.9.5 Environmental Impacts

The key environmental issue related to wastewater reuse is discharging the treated wastewater to the environment. If treatment standards are sufficient, there should be no adverse environmental impact from this alternative. However, if treatment is insufficient, environmental issues could arise from this practice. One environmental and public health concern regarding wastewater reuse is the potential for adverse effects on aquatic organisms and/or humans due to contact with chemicals that typical wastewater plants do not provide treatment for (e.g., endocrine disrupters, hormones, and antibiotics). Additional research regarding the impacts of these constituents is required.

8.10 Implement Growth Management and Land Use Planning

Land use decisions are often made independently of water considerations. As an area grows, however, new approaches may be needed to ensure the reliability, safety, and quality of water supplies and service. This alternative evaluates the feasibility and merit of land use policies that incorporate water issues. Specific land use policies that can help to protect and preserve water supplies include the following:

- Criteria for new construction can promote water conservation for interior and exterior uses.

- Provisions for ensuring that adequate water supplies are available can be considered as part of the approval process for new developments. Decisions regarding the timing and location of new subdivisions can consider the physical availability of water and water rights.

- To enable efficient infrastructure and water service investments, development can be encouraged or restricted to the existing service area or land contiguous to the service area.

- Future land use and growth projections can be used as criteria for water infrastructure expansion and improvements so that piping and pumps are installed at appropriate locations and sized adequately.

- Regulations regarding the installation of new domestic wells can be implemented to ensure that development does not occur in a manner that impacts senior water rights holders. The impact of domestic wells in the county is discussed in Section 4.4.2.

- Drainage design standards can help protect the watershed. For instance, nonpoint source pollution can be prevented by such strategies as controlling erosion or filtering runoff through swales and detention basins.

Zoning is the most widely used form of land use regulation. Zoning ordinances include written requirements and standards that define the permitted uses of land and buildings, the height and size of buildings, the size of lots and yards around buildings, the supply of parking spaces, the size and type of signs and fences, and other characteristics of development. The fundamental purpose of zoning is to separate incompatible uses of land. Because traditional zoning is rather inflexible, however, many alternative zoning approaches have been formulated. Table 8-8 lists these alternative approaches as well as other planning strategies to ensure that growth and development occurs in a manner that is financially efficient, maintains local character, and is sustainable both environmentally and fiscally.

At present, a county-wide comprehensive land use plan does not exist in the planning region, but an effort is underway to develop such a plan. A comprehensive plan establishes a basic vision for the area's future and provides a policy foundation upon which to build more detailed plans for the development and expansion of public facilities and places, to coordinate growth and development with public services, and to guide decisions in a way that balances economic and environmental goals. The process of developing a comprehensive plan will involve input and review by community residents.

Water use is an integral part of land use planning; efficient use of this limited resource should be built into plans of future development. Ideally, the Colfax County Comprehensive Plan will address the following:

- Requirements for demonstration of secured water supplies as a criterion for approval of new subdivisions within the county. Any county regulations with such a requirement must be in accordance with the New Mexico subdivision act. The steering committee has indicated that limitations on development that relies on domestic wells in key areas may protect senior water rights holders and may help to limit public exposure to contaminated groundwater. Processes and responsibilities for evaluating the reliability of water supplies and water rights should be defined.

- Requirements for new subdivisions that address fire prevention and protection (such as buffer strips of low timber near development).

- Requirements that address water quality (i.e., wellhead protection, drainage, and septic tank regulation). These are discussed in Section 8.8.

Table 8-8. Land Use Planning Techniques
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Technique	Description
Adequate public facilities requirement/concurrency	A regulation that makes project approval contingent on evidence that existing public facilities have the capacity to support proposed new development. When facility capacity is inadequate, developers may either postpone development or contribute funds and/or facilities to meet local requirements. Also known as concurrency requirements.
Annexation	The act of incorporating an area into the domain of a city.
Conservation easement	A voluntary restriction placed by a landowner on the use of his or her property to protect resources such as wildlife habitat, agricultural lands, natural areas, scenic views, historic structures, or open spaces. The landowner retains title to the property, and the easement is donated to a qualified conservation organization, such as a land trust or government agency.
Cluster zoning	Minimum lot and yard sizes of buildings are reduced and they are grouped together into compact arrangements or clusters while portions of the site are preserved as permanent open space to preserve natural features on the remainder of the site.
Empowerment zone/ enterprise community (EZ/EC) initiative	Program designed to create jobs and business opportunities in economically distressed areas. Communities given EZ/EC status by the federal government receive tax incentives and performance grants and loans to create jobs and expand business opportunities. They also receive support in developing job training, child care, and transportation programs.
Floating zone	A zoning district that is defined in an ordinance, but not used for a particular location until enacted for a specific project. Floating zones are used to anticipate certain types of uses for which locations will not be designated on the zoning map until developers apply for that zoning.
Focused public investment plan (FPIP)	A plan that focuses public investments in specific areas and requires developers to provide services outside the investment area.
Open space/greenway planning	A corridor of undeveloped land, usually in an urbanized area, that is set aside or used for recreation and/or conservation. This open space usually follows natural features, such as ridges or streams, or parts of the human landscape, such as abandoned railways or canals.
Impact fee	A one-time charge imposed on new development to help pay for off-site impacts and costs of development.
Incentive zoning	A type of zoning practice in which incentives are offered to (but not required of) land developers in exchange for the provision of community benefits by that developer. Community benefits may include additional open space, affordable housing, special building features, or public art. Incentives offered to developers may include expedited processing for building permits, adjustments to density, or modification of other requirements in the underlying zoning ordinance.
Overlay zoning	A zoning district, applied over one or more other districts, that contains additional provisions for special features or conditions, such as historic buildings, wetlands, steep slopes, and downtown residential uses.
Interjurisdictional agreement	An agreement between local governments on development plans, standards, and infrastructure extensions in locations of mutual interest.
Land banking	The purchase of land by a local government for use or resale at a later date.

Table 8-8. Land Use Planning Techniques
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Technique	Description
Performance zoning	A type of zoning that permits uses based on a particular set of standards (e.g., environmental impacts) rather than on particular type of use. The requirements may target a single type of impact, or a range of impacts, such as stormwater runoff, emissions, and open space preservation.
Planned unit development (PUD)	A form of development characterized by a unified site design for multiple housing units and nonresidential uses. PUDs usually include provisions for the clustering of buildings, promotion of common open space, and/or mixture of building types and land uses. The PUD review process is more flexible than a conventional zoning review, allowing for the calculation of densities over the entire development, rather than on an individual lot-by-lot basis.
Priority funding areas	A government-designated area that receives funding priority for infrastructure projects such as new roads, water and sewer systems, and schools. The geographic definition of these areas can vary; a priority funding area might include a municipality, a small community, a targeted industrial area, or any region set aside by counties for planned growth.
Purchase of development rights (PDRs)	Voluntary, legal agreements that allow owners of land meeting certain criteria to sell the right to develop their property to a township, city, county, state, or nonprofit organization. A conservation easement is then placed on the land, and the agreement is recorded on the title to limit the future use of the land to agriculture or other open space uses.
Regional planning: organizations	Agencies or councils that define region-wide development concerns, prescribe regional strategies, and coordinate local actions. Many are purely advisory and depend on local governments to implement their plans.
Special taxing district	Entities that provide services to residents within prescribed areas. New facilities are funded by assessments on those who benefit directly from the services. Some districts are entirely independent from local governments, and many are single-purpose, such as those formed for sewer, water, or road construction. They are usually formed by petition from landowners to a local government. In a tax-increment financing (TIF) district, a base year assessed property value is determined, and taxes collected on any increases in property values above the base year value are dedicated to the needed improvements. TIFs are often used for redevelopment areas.
Split rate property tax	A system that taxes land value at a higher rate than the value of buildings and improvements on that land.
Tax base sharing	A system that establishes regional cooperation among local jurisdictions to pool and redistribute part of the tax increases generated by new development.
Urban growth boundary (UGB)	A mapped line that separates land on which development will be concentrated from land on which development will be discouraged or prohibited. Typically, facilities and services necessary for urban development are provided within the boundary, while extension of services outside the boundary is restricted.

- Requirements for siting of development, including, for example, consideration of whether the area is logical for growth and whether infrastructure is in place.

8.10.1 Technical Feasibility

Developing a comprehensive land use plan can be a complex task, especially in balancing the variety of opinions and input. Coherent incorporation of water issues into land use planning requires a determination of projected water supply. For instance, new subdivisions may typically be permitted only if a 70- or 100-year water supply is available.

Thus, the primary technical issue regarding integrating land use and water policies is determining the amount of supply available to support development. This determination may be technically complex. In areas such as the Moreno Valley, where there is extensive groundwater use, the combined pumping of existing and proposed new wells should be considered, and such an evaluation can most easily be made through use of a groundwater model. Although complex, developing an updated groundwater model of the Moreno Valley is technically feasible. Other aspects of integrating land use and water policies are also technically feasible.

8.10.2 Political Feasibility and Social/Cultural Impacts

The political climate may be supportive for developing land use plans that incorporate water planning. Participants at a regional water planning public meeting identified managed growth as a priority, and a movement to develop a county-wide land use plan is already underway. A steering committee for the comprehensive plan has been formed that includes the county administrator, the assistant county manager, a county commissioner, two land use attorneys, a land developer, two city planners, and one representative each from the New Mexico Environment Department, Natural Resources Conservation Service, and large landowners. It is anticipated that there will be some opposition to specific aspects of the land use plan, but it is hoped that the comprehensive plan steering committee will be able to integrate community concerns and develop a comprehensive plan that is socially and politically feasible.

As water is a limited and limiting resource, a coordinated approach helps foster sustainable and compatible development. Accordingly, the comprehensive plan steering committee will coordinate with the regional water planning steering committee and other planning bodies on common issues and will presumably benefit from the discussions and analysis of issues and objectives already undertaken by these other groups. Public outreach will include meetings with stakeholders, presentations to interested organizations, and public meetings in each municipality.

A comprehensive plan will provide a regional perspective to land use and development that is consistent throughout the county. It can also be revised to meet new goals and objectives as they arise. However, many interests and issues will need to be balanced in the development of the plan. The political will by all affected parties to both pass the ordinance authorizing the plan and follow its guidance will need to be fostered. Additionally, for a comprehensive plan to be effective, all municipalities must see it as their plan; keeping elected officials informed and involved will help translate the comprehensive plan from idea to policy.

To achieve these objectives, the following steps are recommended:

- Work with the comprehensive plan steering committee and review the community input they have received.

- Work closely with local officials and citizens of townships and rural areas to better understand local concerns and priorities for land and water use (this effort is underway).

- Gather information on areas of concern brought up by officials and citizens.

- Assess current demographic, employment, and land use trends in the townships as well as socioeconomic forces that have generated change over the last 10 years. Include localized water use information provided by this Regional Water Plan and create maps or localized reports that summarize current and projected factors such as land use, water use, population, and proportion of people working in the various employment categories.

- Link water and socioeconomic information to identify how specific patterns of current and expected future land use may enhance or threaten water resources. This step includes identifying areas that may be suitable for or environmentally vulnerable to future growth. Examples of vulnerable areas are land that currently provides aquifer recharge, riparian areas, and land subject to erosion and potential runoff that can contaminate surface water.

- Conduct an inventory and analysis of various plans and policies in the county that might affect or overlap with local planning activities.

- Develop recommendations for local officials and citizens for an ongoing comprehensive planning process that integrates water issues.

- Identify current land and water uses and then identify which of those, along with their amounts, are projected to (1) remain in the future and (2) no longer be used 5, 10, 20, and 50 years in the future.

Potential land use planning issues identified by the public meeting participants include the following:

- Standards should be uniform throughout the county.

- If municipalities elect to allow developers to pay for water service rather than demonstrating the availability of water rights for a new development, the municipality should set up a fund to segregate those payments.

Managing land use would have the direct benefit of protecting existing rural land and water uses and all the associated socioeconomic and cultural values. This alternative could also optimize conservation and watershed health and productivity. Specific socioeconomic implications of land use planning include impacts on housing costs, tax revenues, the construction industry, tourism, agriculture, and specific groups of people. In particular, issues of fairness may arise if the managed growth system favors one type of development over another or affects when or where a project is built.

To the extent that land use planning smoothes out water demand and prevents overbuilding, it will encourage both businesses that may be reluctant to expand or move to areas with unstable water supplies and agriculture and the communities it supports, which also depend upon a reliable supply. It also will prevent economic disruptions to employees or enterprises whose livelihood is affected by water shortages. A land use plan that favors job-creating uses should have an additional positive impact.

8.10.3 Financial Feasibility

Incorporating water issues into a land use plan will require staff time, coordination, and follow-through. Funding will be needed for (1) a county staff planner to collect information and input, analyze data, and draft the plan, (2) public involvement meetings, (3) printing, and (4) implementation.

The county has received $25,000 of Community Development Block Grant funds from the State of New Mexico to hire a county planner, and the Western Environmental Law Center is providing free assistance in drafting a comprehensive plan. Consequently, no funding issues are foreseen regarding development of land use policies and ordinances. However, more funding is needed to pay for a permanent staff member to develop and implement the plan. The staff salary required could range from $50,000 to $80,000 per year.

In addition, ongoing technical review and analysis will be required to determine if new developments meet criteria for ensuring availability of long-term water supplies and if drainage and fire protection criteria are being adhered to. Some of this review may be completed by county employees, such as a drought task force coordinator or water resources staff member, who also address other issues. Issues pertaining to fire protection could possibly be reviewed by the county fire marshal.

Developing comprehensive groundwater models that could be used to effectively evaluate the sustainability of groundwater supplies in areas such as the Moreno Valley or Capulin Basin could cost on the order of $100,000 to $400,000.

8.10.4 Hydrological Impacts

The feature of this alternative that will have the most beneficial hydrologic impact is the requirement for water supplies to be secured prior to subdivision approval. This requirement will prevent future water shortages due to increased demands on uncertain supplies. Ensuring that development does not rely on domestic wells in areas that are near streams or senior water rights holders will protect the existing water rights in the county. Additionally, integrating water conservation considerations into land use and the design of structures will help reduce the projected demand for water.

8.10.5 Environmental Impacts

Integrating water issues into land use decisions is generally considered to be environmentally positive. For example, planning to ensure adequate water supplies for growth could help to minimize the need to further reduce streamflows, which can negatively impact aquatic communities during drought periods. A good planning process for subdivision development can allow time for the consideration and mitigation of environmental impacts resulting from development.

8.11 Public Education and Outreach Program

A public education and outreach program can play a key role in achieving the goals and objectives identified in the alternatives described in this regional water plan. Public education and outreach efforts can help support:

- Agricultural water conservation
- Non-agricultural water conservation
- Watershed protection

- Water quality protection
- Land and water use policies
- Drought planning

Though many of the topics to be covered are closely related, public outreach programs typically focus on one topic at a time because the audience and activities associated with each may be different. Public education and outreach activities should be constant and consistent to ensure long-term conservation and water quality protection. For example, people need to be reminded that the problem does not go away when a drought passes.

Beneficial outcomes of a comprehensive public education and outreach program include:

- A holistic approach to growth and development through the integration of water and land use issues that helps foster sustainable and compatible development.

- A regional perspective to land use and development that fosters consistency.

- A comprehensive plan that can be revised to include new goals and objectives.

8.11.1 Public Education and Outreach Program Implementation

Table 8-9 presents a framework for developing public education and outreach campaigns. Although water conservation is used as a case example in the table, this approach can be used for all topical areas. Using a public outreach program with features similar to the one described in Table 8-9, Albuquerque's conservation program led to a 24 percent reduction in water use from 1994 to 2001. These results stem from a non-punitive approach that emphasized voluntary measures, with the exception of water waste (water that runs off properties into right-of-ways). This public education campaign involved increased funding and staff time devoted to the conservation effort.

Table 8-9. Implementing a Public Education and Outreach Program
Page 1 of 2

Step No.	Description of Activities	Application to Sample Public Education Program Water Conservation For Non-Agricultural Uses
Step 1: Establish a target audience	Determine the customer classes or categories of water users with the greatest impact on this issue. Within customer classes, different approaches may be needed for different seasons (e.g., if summer use is more than double winter use, the public outreach campaign would target outdoor use).	Analyze water bills to assess who uses most of the water at different times of year. Water billing data provides very useful information by sorting and targeting customer classes and identifying large users, to provide a baseline and assess the potential success of a conservation program, to monitor the savings achieved after a conservation program has been implemented, and to provide data to inform future planning. Messages can vary for residential customers, hotel/resorts, and institutions. Initially, all efforts would emphasize voluntary measures.
Step 2: Assess outreach methods and messages	Examine current public messages and activities to assess what information is missing and identify the communication methods that would most effectively reach the target customers (e.g. newspapers, posters, bill stuffers, or radio public service announcements). When users are asked to change their habits or help alleviate a problem, they need to know: • The existing water supply situation • Why their efforts make a difference • "How-to" methods to (save water)	Water conservation campaigns can be run by a single utility or on a county-wide basis by a public education coordinator (county staff person, contractor, or a stakeholder agency) who identifies conservation strategies for agricultural and non-agricultural uses. A meaningful water conservation campaign clearly communicates the following points: • What the sources and limitations of existing water supply are • Why conservation is the best means of reducing demand • Who uses the water • How to lower water use Possible outreach methods include: • Brochures sent with water bills • Public service announcements on radio and television • Conservation recommendations integrated with weather reports • Media releases, posters and "how-to" manuals • Water audits conducted by utility staff; leak detection and repair • Public meetings and water fairs • School outreach (educate parents by involving children) • Conservation-based rate structures (rates go up with higher usage)

Table 8-9. Implementing a Public Education and Outreach Program
Page 2 of 2

Step No.	Description of Activities	Application to Sample Public Education Program Water Conservation For Non-Agricultural Uses
Step 3: Establish resources needed and garner support among colleagues	Determine available staff and financial resources. Public outreach may range from low cost (posters, bill stuffers, media releases) to higher cost (media messages, public forums, newspaper inserts, billboards, brochures, handbooks, speakers bureaus). Work with network of professionals and active volunteers, (e.g., the drought management task force (Appendix E) or watershed work group (Section 8.2) to integrate water conservation, watershed protection, and water quality protection into field work and daily operations. Provide public information materials on these topics.	Major costs of a public outreach and education program are associated with designing, printing, and distributing materials. To contain costs: • Produce materials internally using resources from water industry trade associations, the Office of the State Engineer or other utilities. • Ask members of water-oriented committees to help "spread the word" by publishing information in their newsletters, distributing manuals and brochures, and contributing ideas. Involve other stakeholders through presentations at civic organizations. • Involve teachers through a water conservation curriculum. Children are excellent vehicles to get water conservation into the home and can have fun doing so (e.g., they can become "water waste detectives"). Some classroom and child-oriented materials are listed in Appendix K.

8.11.2 Public Education and Outreach Program Costs

Costs for public education and outreach programs vary depending on who does the work, the type of materials produced, and the type or amount of media time and/or space needed. An important factor to consider, however, is that outreach efforts may cost less per acre-foot of demand reduction than purchasing additional water rights to increase supply.

Public outreach and education can be implemented on a part-time basis through a county-wide water coordinator position. The estimated part-time staff cost is approximately $20,000 per year plus supplies and materials. Grants may be available for funding this position and associated activities, as discussed in Section 8.12.

Material costs can be minimized by drawing on existing materials produced by the OSE, the AWWA, and other sources, or by getting permission to use and print materials developed by other municipalities. Examples of available materials are provided in Appendix K, along with lists of available publications from AWWA and the OSE. OSE materials are available free of charge. AWWA has produced more than 20 messages in a form suitable for bill stuffers (Appendix K). These color brochures are available at approximately $0.21 to $0.25 each when quantities of 5,000 are purchased (an estimated $1,300 per bill stuffer for all Colfax County households. Other materials such as how-to manuals and informational brochures can be purchased for a similar cost and simple posters can be produced inexpensively.

8.12 Seek Funding for Continued Planning and Implementation

Funding is needed to successfully implement the alternatives discussed in this regional water plan. Potential sources of funding for the alternative categories are identified in Table 8-10. This table also provides links to web sites that can be used by the steering committee to obtain additional information about the funding sources and application requirements.

Table 8-10. State and Federal Funding Sources
Page 1 of 6

Program Title / *Agency* / Web Site or Contact [a]	Funding Areas				Description
	Water Supply Conservation	Development and Infrastructure	Water Supply Protection	Water Resources Management	
General Information					
Catalog of Federal Domestic Assistance http://www.cfda.gov/	■	■	■	■	Good information about funding sources, grant writing, etc.
Federal Drought Programs http://www.iwr.usace.army.mil/iwr/drought/feddrghtprogs.htm#_Toc491241963	■	■	■	■	Summary of federal funding sources available for drought programs.
Catalog of Federal Funding Sources for Watershed Protection http://www.epa.gov/owow/watershed/wacademy/fund/sources.html			■		Topical listing of funding sources related to watershed protection.
Links to private funding sources http://www.epa.gov/owow/nps/capacity/funding.htm#private	■	■	■	■	List of links for private funding sources for various areas.
Funding Programs					
New Mexico Clean Water State Revolving Fund *New Mexico Environment Department*, *Construction Programs Bureau* Santa Fe: 505-827-2806 http://www.nmenv.state.nm.us/cpb/cpbtop.html http://www.nmenv.state.nm.us *New Mexico Water Trust Board* Contact New Mexico Finance Authority (NMFA) U.S. *Environmental Protection Agency (EPA)* http://www.epa.gov/owm/cwfinance/cwsrf/index.htm	■	■	■	■	Eligibile projects include water supply development, conservation, watershed management, and infrastrucrture. Water quality protection projects for wastewater treatment, nonpoint source pollution control, and watershed and estuary management.

[a] Web site address as of November 2002; address and information found there is subject to change.

Table 8-10. State and Federal Funding Sources
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Program Title / *Agency* / Web Site or Contact [a]	Funding Areas				Description
	Water Supply Conservation	Development and Infrastructure	Water Supply Protection	Water Resources Management	
Community Block Development Grants *Department of Housing and Urban Development* (local office)				■	Funding source for 40-year plans.
Community Facilities (CF) Direct Loans and Grants *U.S. Department of Agriculture (USDA)* http://www.rurdev.usda.gov/rhs/cf/cp_dir_grant.htm		■			Provides loans for the development of essential community facilities for public use in rural areas and towns with a population of 20,000 or less.
Emergency Community Water Assistance Grants *USDA Rural Utility Services (RUS)* *Albuquerque: 505-761-4955* *Raton: 445-9471* http://www.rurdev.usda.gov/nm/index.html http://www.usda.gov/rus/water/programs.htm#EMERGENCY http://www.usda.gov/rus/water/programs		■	■		Assists rural communities that have had a significant decline in quantity or quality of drinking water.
Planning Assistance to States *U.S. Army Corps of Engineers* Albuquerque*: (505) 342-3109* http://www.spa.usace.army.mil http://www.lrd.usace.army.mil/gl/22.htm	■	■	■	■	Assists in planning for the development, utilization, and conservation of water and related land resources and ecosystems.
Reclamation States Emergency Drought Relief Act of 1991 - Title II *U.S. Bureau of Reclamation* Albuquerque Area Office: 505-248-5323 http://www.uc.usbr.gov/progact/waterconsv/wtr_wmp.html http://nris.state.mt.us/drought2001/reports/DRTBuRecDrRelief.html	■	■	■	■	Assistance in the construction and planning of projects that mitigate effects of drought.

[a] Web site address as of November 2002; address and information found there is subject to change.

Table 8-10. State and Federal Funding Sources
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Program Title / *Agency* / Web Site or Contact [a]	Funding Areas: Water Supply Conservation	Funding Areas: Development and Infrastructure	Funding Areas: Water Supply Protection	Funding Areas: Water Resources Management	Description
Conservation Technical Assistance *USDA Natural Resource Conservation Service* Raton Service Center: 445-9571 Albuquerque Office: 761-4407; 1-800-410-2067 http://www.nrcs.usda.gov/programs/cta/			■	■	Planning and implementation of solutions to natural resource concerns, including drought.
Safe Drinking Water Act Revolving Loan Program *New Mexico Environment Department, Construction Programs Bureau* Santa Fe: 505-827-2806 http://www.nmenv.state.nm.us/cpb/cpbtop.html http://www.nmenv.state.nm.us *U.S. EPA* toohttp://www.epa.gov/safewater/dwsrf.html		■	■		Water infrastructure improvements, for small and disadvantaged communities and for pollution prevention to ensure safe drinking water.
Water and Waste Loans and Grants *USDA Rural Development* Albuquerque: 505-761-4955 Raton: 445-9471 http://www.rurdev.usda.gov/nm/index.html http://www.usda.gov/rus/water/programs.htm		■	■		Development or improvement of water or wastewater disposal systems in rural areas.
Snow Survey and Water Supply Forecasting Program *USDA Natural Resources Conservation Service* Raton: 445-9571 Albuquerque: 505-761-4407; 1-800-410-2067 http://www.nrcs.usda.gov. http://www.nrcs.usda.gov/programs/snowsurvey/				■	Monitoring of climatic and hydrologic elements necessary to produce water supply forecasts.

[a] Web site address as of November 2002; address and information found there is subject to change.

Table 8-10. State and Federal Funding Sources
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Program Title / *Agency* / Web Site or Contact [a]	Funding Areas				Description
	Water Supply Conservation	Development and Infrastructure	Water Supply Protection	Water Resources Management	
Reclamation Wastewater and Groundwater Study Program *U.S. Bureau of Reclamation* Albuquerque: 505-248-5323 http://www.cfda.gov/static/p15504.htm	■	■			Appraisal and feasibility studies on water reclamation and reuse projects.
Small Watershed Program *USDA Natural Resources Conservation Service* Raton: 445-9571 Albuquerque: 505-761-4407; 1-800-410-2067 http://www.nrcs.usda.gov/programs/watershed/	■		■	■	Agricultural water management, municipal and industrial water supply, groundwater recharge, and watershed protection projects.
Environmental Quality Incentives Program *USDA Natural Resources Conservation Service* Raton: 445-9571 Albuquerque: 505-761-4407; 1-800-410-2067 http://www.nrcs.usda.gov/programs/eqip/	■		■		Practices to address soil, water, and related natural resource concerns on farm and ranch lands.
Emergency Water Supplies *USDA Rural Development* Santa Fe: 505-476-9600 http://www.dps.nm.org/emergency/em_index.htm Raton: 445-2708 e-mail: rfd@raton.com	■		■		Provision of emergency water supplies to communities that may run out of adequate drinking water.
Finance Authority Emergency Funding and Water and Wastewater Grant Program *NMFA* Contact: NMFA at (505) 984-1454 toll free, 1-877-ask-nmfa		■			Provision of emergency water supplies.

[a] Web site address as of November 2002; address and information found there is subject to change.

Table 8-10. State and Federal Funding Sources
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Program Title / *Agency* / Web Site or Contact [a]	Funding Areas: Water Supply Conservation	Funding Areas: Development and Infrastructure	Funding Areas: Water Supply Protection	Funding Areas: Water Resources Management	Description
Emergency Conservation Program *USDA Farm Services* *Raton: 445-9571* *Albuquerque : 505-761-4407; 1-800-410-2067* http://www.fsa.usda.gov/pas/disaster/ecp.htm	■				Rehabilitation of farm lands and conservation facilities.
Public Assistance /Emergency Measures Program *New Mexico Emergency Management Center* Regional Office Main Number (940) 898-5399 Santa Fe: 505-476-9600 Raton: 445-2708 e-mail: rfd@raton.com http://www.dps.nm.org/emergency/em_index.htm http://www.fema.gov/reg-vi/		■		■	Activities to alleviate consequences of the subject of a Presidential Emergency or Major Disaster Declaration (such as drought).
Economic Adjustment Program: Sudden and Severe Economic Dislocation Components *U.S. Department of Commerce EDA* http://www.osec.doc.gov/eda/				■	Prevention of serious economic dislocations or reestablishment of employment opportunities after a sudden and significant dislocation.
Conservation Reserve Program *USDA Natural Resources Conservation Service* http://www.nrcs.usda.gov/programs/crp/	■				Helps farmers and ranchers address water resource concerns on their lands.
Emergency Watershed Protection *USDA Natural Resources Conservation Service* http://www.nrcs.usda.gov/programs/ewp/ewp.html			■	■	Emergency recovery measures to relieve imminent hazards to life and property as a result of natural disasters.

[a] Web site address as of November 2002; address and information found there is subject to change.

Table 8-10. State and Federal Funding Sources
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Program Title / *Agency* / Web Site or Contact [a]	Funding Areas: Water Supply Conservation	Funding Areas: Development and Infrastructure	Funding Areas: Water Supply Protection	Funding Areas: Water Resources Management	Description
Emergency Well Construction and Water Transport *USACE* *U.S. Army Corps of Engineers Albuquerque District Office* Albuquerque: 505-342-3109 http://www.spa.usace.army.mil		■	■		Construction of wells or transport of water drought-distressed areas.
Water Quality Program *USDA CSREES* http://www.reeusda.gov/nre/water/water.htm			■		Provide watershed- based information for assessing and improving sources of water quality impairment in targeted watersheds.
Unsolicited proposals *U.S. Geological Survey* http://www.usgs.gov/contracts/grants/unsolbk.html	■			■	Research proposals in many earth science areas, including hydrology and conservation.
State-EPA NPS Partnership *U.S. Environmental Protection Agency* http://www.epa.gov/owow/nps/partnership.html			■		Focus on nonpoint source topic-specific needs including: watershed planning and implementation.
Land and Water Conservation Fund Grants to States *National Park Service* http://www.ncrc.nps.gov/PROGRAMS/LWCF/index.html			■		Matching grants to states and local governments for the acquisition and development of public outdoor recreation areas and facilities.
Water Reclamation and Reuse Program *U.S.Bureau of Reclamation* http://www.usbr.gov/tcg/guidelines/		■			Projects for reclamation and reuse of municipal and other wastewaters and naturally impaired waters.

[a] Web site address as of November 2002; address and information found there is subject to change.

In addition to the funding opportunities shown on Table 8-10, local funding mechanisms such as the following can be used:

- *Bonds.* Bonding capacity is a function of the amount and type of revenue available, bond rates, and other factors.

- *Expansion/impact fees.* Expansion fees, also known as tap fees, are typically paid to a municipality by those responsible for the development of new areas or construction of new dwelling units.

- *Water/wastewater rates.* Rate increases could be used to provide needed funds for water projects.

8.13 Support from Political Leaders

The final action that the steering committee recommended was to interact with political leaders and to develop support for the regional water plan and specific projects (alternatives) identified in the plan. Two meetings were held with political leaders: a focus group in October 2001 and a meeting in November 2002. Local government officials (municipal and county) as well as state representatives from the region were invited to attend the meetings. The regional water plan and alternatives were presented at both meetings, and input from the political leaders was incorporated into the plan. For implementation of the plan to be successful ongoing support from political leaders will be required.

8.14 Implementation Schedule

An implementation schedule for the alternatives described in the plan is provided in Table 8-11. Adherence to the implementation schedule will be partially dependent on obtaining funds necessary to complete the projects identified. To assist the planning region in moving forward with implementation, Table 8-11 also lists actions that will support alternative implementation, as well as responsible parties for all the alternatives presented in this *Regional Water Plan.*

Table 8-11. Implementation Schedule and Recommended Actions for Alternatives to Meet Future Supply Needs
Page 1 of 5

Alternative	Implementation Priority [a]	Action	Responsible Party [b]
General actions	1	• Hire a regional water coordinator to manage the activities outlined in this table and assist in their implementation • Provide public outreach and educational activities • Seek funding • Interact with political leaders to generate support for plan and implementation projects	• County • All • County, SWCD, extension service
Water Supply Conservation			
Implement voluntary agricultural water conservation measures, including lining ditches and encasing delivery systems to reduce losses	1	• Design and implement agricultural conservation practices, focusing on reduced distribution losses • Consider other agricultural conservation measures such as on-farm improvements	• Irrigation districts, agricultural users, NRCS, SWCD, county extension agent • Irrigation districts, individual farmers
Develop county and city ordinances for conservation	2	• Review conservation policies and water rates and consider changes • Consider water conservation and supporting ordinances as part of the developing Comprehensive Plan	• Municipalities • County
Xeriscape to conserve (municipal) water	2	• Consider including xeriscaping in conservation ordinances	• Municipalities, County
Implement efficiencies in municipal water supply management (e.g., leak detection)	1	• Conduct leak detection and repair leaks, especially in systems with large loss rates	• Municipalities, Mutual domestic water systems
Remove invasive vegetation; revegetate to reduce riparian evapotranspiration	2	• Survey extent of phreatophyte vegetation in the County • Develop projects to remove phreatophytes	• NRCS, SWCD, individual landowners
Implement efficiencies in industrial uses such as mining	3	• Consider conservation measures as new industries develop in the County	• Industries, County

[a] 1 = Begin implementing immediately
2 = Begin implementing in 1 to 10 years
3 = Begin implementing in 10 to 40 years
[b] Primary responsible parties; others may also be involved

NRCS = Natural Resources Conservation Service
SWCD= Soil and Water Conservation District
JPA = Joint Powers Agreement
OSE = Office of the State Engineer

NMED = New Mexico Environment Department
USGS = U.S. Geological Survey
NMGF = New Mexico Department of Game and Fish

Table 8-11. Implementation Schedule and Recommended Actions for Alternatives to Meet Future Supply Needs
Page 2 of 5

Alternative	Implementation Priority [a]	Action	Responsible Party [b]
Water Supply Development and Infrastructure			
Implement dredging projects to improve storage in reservoirs and ponds	2	• Conduct field testing of sediment depths; develop detailed engineering conceptual designs and cost estimates for individual reservoirs	• Reservoir operators, NRCS, municipalities
Pursue underground storage of available water	2	• Research aquifer storage and recovery options and potential pilot projects	• Municipalities or coalition of local governments through JPA
Build additional water storage capacity	2	• Conduct feasibility studies for increasing storage at existing reservoirs or for constructing new reservoirs	• Reservoir operators/state and federal agencies
Recycle municipal wastewater for agricultural and recreational use	2	• Evaluate specific projects for wastewater reuse	• Municipalities
Implement cloud seeding projects	3	• Support research and monitor effects	• Angel Fire, County
Build a regional delivery system to tie in municipal systems (Cimarron, Springer, Maxwell, Miami, and Raton)	3	• Conduct feasibility study	• Municipalities, Cimarron watershed group
Maintain treatment plant in municipalities and upgrade mains and other infrastructure	1	• Seek funding for maintenance of existing infrastructure and design and construction of new infrastructure as needed by each community	• Municipalities, mutual domestic water associations
Water Supply Quality Protection			
Develop and implement county-wide septic tank and other water quality control ordinances	2	• Include water quality provisions in the County Comprehensive Plan • Consider including water quality studies for development projects as part of the County Comprehensive Plan	• County • County
Construct wastewater treatment systems to replace septic tanks in the Moreno Valley and other parts of the county	1	• Complete preliminary engineer report on wastewater options in the Moreno Valley	• Cimarron watershed group, municipalities

[a] 1 = Begin implementing immediately
2 = Begin implementing in 1 to 10 years
3 = Begin implementing in 10 to 40 years
[b] Primary responsible parties; others may also be involved

NRCS = Natural Resources Conservation Service
SWCD= Soil and Water Conservation District
JPA = Joint Powers Agreement
OSE = Office of the State Engineer

NMED = New Mexico Environment Department
USGS = U.S. Geological Survey
NMGF = New Mexico Department of Game and Fish

Table 8-11. Implementation Schedule and Recommended Actions for Alternatives to Meet Future Supply Needs
Page 3 of 5

Alternative	Implementation Priority [a]	Action	Responsible Party [b]
Implement nonpoint source management projects	2	• Support local and regional watershed efforts to identify nonpoint source problems and implement best management practices • Identify specific nonpoint source projects	• Cimarron and Canadian watershed groups
Draft and implement source water and wellhead protection plans for key water supplies	2	• Delineate wellhead protection areas • Review and consideration of wellhead protection plans	• Municipalities with groundwater supply wells (Angel Fire, Eagle Nest, Maxwell), County
		• Request that NMED conduct a source water assessment and protection study or assist with obtaining funding	• County, Cimarron, Angel Fire, Cimarron watershed group
Monitor methane gas extraction activities for potential impacts to groundwater quality/quantity and consider potential reuse of water	2	• Meet with extractors and New Mexico Oil Conservation Division to evaluate	• County, municipalities, SWCD, watershed groups
Water Resources Management			
Implement drought contingency plan	1	• Hire drought/water resources coordinator • Convene drought task force meeting • Routinely monitor drought indicators	• County • SWCD
Manage watersheds to improve yield, implement projects identified by watershed groups, and obtain funding and adopt watershed management plans that address private and public lands	1	• Survey the county to identify promising locations, and access and biological issues to aid in planning for thinning projects • Conduct pilot forest management studies and monitor the results • Support ongoing initiatives for development of markets for small-diameter timber, and support timber marketing research and pilot projects within the county • Conduct watershed planning efforts	• SWCD, NRCS, County, municipalities, other agencies, watershed groups

[a] 1 = Begin implementing immediately
2 = Begin implementing in 1 to 10 years
3 = Begin implementing in 10 to 40 years
[b] Primary responsible parties; others may also be involved

NRCS = Natural Resources Conservation Service
SWCD= Soil and Water Conservation District
JPA = Joint Powers Agreement
OSE = Office of the State Engineer

NMED = New Mexico Environment Department
USGS = U.S. Geological Survey
NMGF = New Mexico Department of Game and Fish

Table 8-11. Implementation Schedule and Recommended Actions for Alternatives to Meet Future Supply Needs
Page 4 of 5

Alternative	Implementation Priority [a]	Action	Responsible Party [b]
Develop 40-year water plans and secure water to meet future demands (municipalities and other local entities)	2	• Each municipality and irrigation district should develop and submit a 40-year plan • The County should submit a 40-year plan (this regional plan covers the county)	• Municipalities, irrigation districts • County
Pursue water rights transfers or leases to help supply projected demand	2	• Evaluate priority dates, needs, and potential for leases or transfers	• Individual water rights holders, irrigation districts
Implement growth management and land use planning	1	• With public input, adopt a comprehensive plan for the county that addresses water supply and water quality issues defined in this plan	• County
Develop and enact County/municipal regulations regarding domestic wells	2	• Develop County and or municipal regulations to address domestic well impacts on senior water rights (County efforts may be included in the comprehensive plan development)	• County, municipalities
Appropriate and reserve groundwater for the County	2	• Conduct public meeting to determine if there is local support for declaration of the Capulin Basin; if there is, petition OSE • Conduct up-to-date hydrogeologic investigation of resources in the county • Evaluate groundwater level declines in Ogallala Aquifer in eastern part of the county	• County, Steering Committee, SWCD, OSE • USGS, County • USGS, County, OSE
Establish regional water banking (accounting) system	2	• Petition OSE or local political representatives to set up a bank	• All
Actively manage existing storage facilities to optimize efficient use of water/storage. Become well versed in system's more formal practices.	2	• Obtain clarification from the NMGF and OSE on administration of Eagle Nest Reservoir	• All (request), NMGF and OSE

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Table 8-11. Implementation Schedule and Recommended Actions for Alternatives to Meet Future Supply Needs
Page 5 of 5

Alternative	Implementation Priority [a]	Action	Responsible Party [b]
Establish a mechanism to better manage water delivery throughout Colfax County	2	• Hire additional water masters • Computerize delivery records	• OSE • OSE
Establish a Canadian River Water Master	2	• Hire water master	• OSE

[a] 1 = Begin implementing immediately
2 = Begin implementing in 1 to 10 years
3 = Begin implementing in 10 to 40 years
[b] Primary responsible parties; others may also be involved

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References

References

Abbott, P.O., A.L. Geldon, D. Cain, A.P. Hall, and P. Edelmann. 1983. *Hydrogeology of area 61, northern Great Plains and Rocky Mountain coal provinces, Colorado and New Mexico.* Water-Resources Investigations Open-File Report 83-132, U.S. Geological Survey, Lakewood, Colorado. December 1983.

Alley, W.M. 1984. The Palmer Drought Severity Index: Limitations and assumptions. *Journal of Climate and Applied Meteorology* 23:1100-1109.

Anderholm, S.K. 1998. Mountain-front recharge along the eastern side of the middle Rio Grande Basin, central New Mexico. p. 66-68. *In U.S. Geological Survey middle Rio Grande Basin study - Proceedings of the 2nd annual workshop, Albuquerque, New Mexico.* February 10-11, 1998. U.S. Geological Survey Open-File Report 98-337, Albuquerque, New Mexico.

Anderholm, S.K. 2000. *Mountain-front recharge along the eastern side of the middle Rio Grande Basin, central New Mexico.* U.S. Geological Survey Water Resources Investigations Report WRI 00-4010, Albuquerque, New Mexico. 36p.

Austin, S.A. 1999. *Streamflow response to forest management: A meta-analysis using published data and flow duration curves.* M.S. thesis, Department of Earth Resources, Colorado State University, Fort Collins, Colorado. 121p. plus app.

Ballance, W.C. 1967. Arkansas River basin – Geography, geology, and hydrology. p. 13-23 *In* New Mexico State Engineer Office (comp.), *Water resources of New Mexico - Occurrence, development and use.*

Bates, C.G., and A.J. Henry. 1928. Forest and stream-flow experiment at Wagon Wheel Gap, Colo. *Monthly Weather Review* Supp. No. 3, USDA Weather Bureau, Washington, D.C. 79p.

Belsky, A.J., A. Matzke, and S. Uselman. 1999. Survey of livestock influences on stream and riparian ecosystems in the western United States. *Journal of Soil and Water Conservation* 54(1):419-431.

Benavides-Solorio, J., and L.H. MacDonald. 2000. Post-fire sediment production from hillslopes in the Colorado Front Range. *Eos Trans. AGU* 82(47):F510.

Benavides-Solorio, J., and L.H. MacDonald. 2001. Post-fire runoff and erosion from simulated rainfall on small plots, Colorado Front Range. *Hydrological Processes* 15:2931-2952.

Benavides-Solorio, J., and L.H. MacDonald. In preparation. Measurement and prediction of post-fire erosion rates at the hillslope scale, Colorado Front Range.

Blackburn, W.H., R.W. Knight, and M.K. Wood. 1982. *Impacts of grazing on watersheds: A state of knowledge.* Texas Agricultural Experiment Station, Texas A&M University, College Station, Texas. 30p.

Blandford, T. N. and P. S. Huyakorn. 1991. *U.S. EPA WHPA - A modular semi-analytical model for the delineation of wellhead protection areas, version 2.0.* American Institute of Hydrology. March 1991.

Blaney, H.F. and E.G. Hanson. 1965. *Consumptive use and water requirements in New Mexico.* Technical Report 32, New Mexico State Engineer Office. 85 pp.

Bliss, J.H. 1935. Memorandum to Mr. McClure regarding Rayado hydrographic survey, No. 4482. June 21, 1935.

Bosch, J.M. and J.D. Hewlett. 1982. A review of catchment experiments to determine the effect of vegetation changes on water yield and evapotranspiration. *J. Hydrology* 55:3-23.

Brooks, K.N., P.F. Ffolliott, H.M. Gregersen, and J.L. Thomas. 1991. *Hydrology and the management of watersheds.* Iowa State University Press, Ames, Iowa. 392p.

Brown, H.E., M.B. Baker, Jr., J.J. Rogers, W.P. Clary, J.L. Kovner, F.R. Larsen, C.C. Avery, and R.E. Campbell. 1974. *Opportunities for increasing water yields and other multiple use values on ponderosa pine forest lands.* USDA Forest Service Research Paper RM-256, Fort Collins, Colorado. 36p.

Camp Dresser and McKee, Inc. (CDM). 1998. *City of Santa Fe treated effluent management plan.* Prepared in association with Lee Wilson and Associates. May 1998.

Clark, K.F., and C.B. Read. 1972. *Geology and ore deposits of Eagle Nest area, New Mexico.* New Mexico Bureau of Mines and Mineral Resources Bulletin 94. 152p.

Colpitts, R.M., Jr., and C.T. Smith. 1990. Geology of the Moreno Valley, Colfax County, New Mexico. pp. 219-228. *In* Bauer, P.W., S.G. Lucas, C.K. Mawer, and W.C. McIntosh (eds) *Tectonic development of the southern Sangre de Cristo Mountains, New Mexico.* New Mexico Geological Society Forty-First Annual Field Conference, September 12-15, 1990.

Commission of Geosciences, Environment, and Resources. 1992. *Water transfers in the west: efficiency, equity and environment.* National Academy of Sciences Press.

Daniel B. Stephens & Associates, Inc. (DBS&A). 2001. *Preliminary, Water supply and demand, Colfax water planning region.* Prepared for Colfax Soil and Water Conservation District, Raton, New Mexico. 115 pp. plus app.

DBS&A. 2002a. *Alternative: Bank water.* White paper prepared for the Jemez y Sangre Regional Water Planning Council, Santa Fe, New Mexico. July 2002.

DBS&A. 2002b. *Alternative: Wastewater reuse.* White paper prepared for the Jemez y Sangre Regional Water Planning Council, Santa Fe, New Mexico. July 2002.

DeBano, L.F. 2000. Water repellency in soils: A historical overview. *J. Hydrol*. 231-232:4-32.

Dinwiddie, G.A., and J.B. Cooper. 1966. Water-bearing characteristics of the rocks of eastern Colfax and western Union Counties, New Mexico. p. 76-79 *In* Northop, S.A., and C.B. Read (eds.), *Guidebook of Taos-Raton-Spanish Peaks Country, New Mexico and Colorado.* New Mexico Geological Society, Guidebook, 17th Field Conference.

Eagle Nest Corporation. 1991. *Regulations of operation of Eagle Nest Reservoir, Eagle Nest Reservoir Corporation.* Real Estate Records Book 2, p. 7078. Filed December 17, 1991.

Fetter, C.W. 1994. *Applied Hydrogeology.* Macmillan College Publishing Company, New York.

Ffolliott, P.F., and D.B. Thorud. 1975. *Vegetation management for increased water yield in Arizona.* Tech. Bull. 215, Agricultural Experiment Station, University of Arizona, Tucson, AZ. 38p.

Freeze, R.A. and J.A. Cherry. 1979. *Groundwater.* Prentice-Hall, Inc., Englewood Cliffs, New Jersey.

Gary, H.L. 1975. *Watershed management problems and opportunities for the Colorado Front Range ponderosa pine zone: The status of our knowledge.* USDA Forest Service Research Paper RM-139, Fort Collins, Colorado. 32p.

Gordon Herkenhoff & Associates, Inc., and W.K. Summers & Associates (Herkenhoff and Summers). 1977. *Geology and hydrology of a site proposed for burial of low-level solid radioactive waste, Western Colfax County, New Mexico.*. Prepared for Chem-Nuclear New Mexico, Inc., Albuquerque, New Mexico.

Gray, R.N. 1997. Hydrologic budget analysis and numerical simulations of groundwater flow in Los Alamos Canyon near Los Alamos, New Mexico. Master's Thesis, University of New Mexico, Albuquerque, New Mexico. 485p.

Griggs, R.L. 1948. *Geology and ground-water resources of the eastern part of Colfax County, New Mexico.* Ground-Water Report 1, New Mexico Bureau of Mines and Mineral Resources, Socorro, New Mexico.

Guan, H. and J. Wilson. 2002. Building an understanding of mountain-block recharge. Poster for 2002 Annual Meeting on Sustainability of Semi-arid Hydrology and Riparian Areas. February 25-March 1, 2002, Tucson, Arizona.

Gutowsky, Pr. 1997. *Water quality strategic plan for the village of Angel Fire.* May 1997.

Hayes, M.J. 1999. *Drought indices.* http://enso.unl.edu/ndmc/enigma/indices.htm. Updated October 12, 1999.

Hillel, D.. 1998. *Environmental soil physics*. Academic Press, San Diego, California. 771p.

Hong, S., J. Woolslayer, E. Small, J. Hendrickx, W. Bastiaanssen, P. Neville, and J. Cleverly. 2000. Regional distribution of soil moisture in the middle Rio Grande Basin (poster). New Mexico Institute of Mining and Technology. Socorro, New Mexico.

Huffman, E.L., L.H. MacDonald, and J.D. Stednick. 2001. Strength and persistence of fire-induced soil hydrophobicity under ponderosa and lodgepole pine, Colorado Front Range. *Hydrological Processes* 15:2877-2892.

Intergovernmental Panel on Climate Change (IPCC). 2001. *Summary for policy makers: A report of Working Group I of the Intergovernmental Panel on Climate Change.* <www.usgcrp.gov/ipcc/wg1spm.pdf>.

Karl, T.R. and R.W. Knight. 1985. *Atlas of monthly Palmer hydrologic indices (1931-1983) for the contiguous United States.* Historical Climatology Series 3-7. National Climatic Data Center, Asheville, North Carolina.

Kilmer, L.C. 1987. Water-bearing characteristics of geologic formation in northeastern New Mexico-southeastern Colorado. pp. 275-279 In Lucas, S.G., and A.P. Hunt (eds.), *Northeastern New Mexico.* New Mexico Geological Society Guidebook, 38th Field Conference.

Moody, J.A. and D.A. Martin. 2001. Initial hydrologic and geomorphic response following a wildfire in the Colorado Front Range. In *Earth Surface Processes and Landforms* 26:1049-1070.

Muys, J.C. 1990. Report of Special Master Jerome C. Muys. p. 61 in *States of Oklahoma and Texas v. State of New Mexico.* No. 109, In the Supreme Court of the United States. October 15, 1990.

National Climatic Data Center (NCDC). 2002. *NCDC: CLIMVIS Information.* <http://lwf.ncdc.noaa.gov/oa/climate/onlineprod/drought/overview.html > October 31, 2002.

National Research Council. 1992. *Restoration of aquatic ecosystems*. National Academy Press. 552p.

New Mexico Acequia Association. 2000. *An acequia perspective on critical water policy issues for the State of New Mexico.* Presentation to the Water and Natural Resources Legislative Interim Committee. (http://www.nmacequias.org/WNRC%20Presentation%20June%208%20Web.htm). June 8, 2000.

New Mexico Department of Agriculture (NMDA). 1962-1998. *New Mexico Agricultural Statistics.*

New Mexico Economic Development Department (New Mexico EDD). 2002. *New Mexico County Statistics – Colfax.* <http://www.edd.state.nm.us/COMMUNITIES/ShowCounty.php> Accessed October 15, 2002.

New Mexico Environment Department (NMED). 2000. *See NMED SWQB 2000-2002 below.*

NMED. 2001a. *Past and current leak sites by city*. <http://www.nmenv.state.nm.us/> Underground Storage Tank Bureau, reports and lists. January 26, 2001.

NMED. 2001b. *See NMED SWQB 2000-2002 below.*

NMED. 2001c. *Major New Mexico municipal and industrial NPDES permittees.* <http://www.nmenv.state.nm.us/> Surface Water Quality Bureau, Point Source Regulation. March 12, 2001.

New Mexico Environment Department, Surface Water Quality Bureau (NMED SWQB). 1999a. *Draft Total maximum daily load for turbidity in Middle Ponil Creek and Ponil Creek.* TMDL Development Section, Santa Fe, New Mexico.

NMED SWQB. 1999b. *Total maximum daily load for temperature on North Ponil Creek.* TMDL Development Section, Santa Fe, New Mexico. November 1999.

NMED SWQB. 2000 -2002. *2000-2002 State of New Mexico 303(d) list for assessed streams and river reaches.* <http://www.nmenv.state.nm.us/swqb/2000-2002_New_Mexico_303d_List.pdf> TMDL Development. Accessed October 2002.

New Mexico Interstate Stream Commission (ISC). 1994. Regional water planning handbook.

New Mexico State Engineer Office (NM SEO). 1982. Letter from Steve Reynolds (State Engineer) to John Dansfelser (attorney for the applicant) regarding Notice of intention to appropriate 10,500 acre feet of water in the Canadian Basin. May 26, 1982.

New Mexico Office of the State Engineer (NM OSE). 2001. *Water information*. <www.seo.state.nm.us/water-info/index.html>. March 12, 2001.

NM OSE. 2002. Impact of domestic wells reported to legislative committee. *In WaterLine*, Winter 2001. <http://www.seo.state.nm.us/publications/waterlines/wl-winter-2001/wl-winter2001/do-wel-4.html>. Last modified January 28, 2002.

NM OSE. 2002. *Water information*. <http://seowaters.ose.state.nm.us/awdProd>. Accessed October 15, 2002.

New Mexico Water Quality Control Commission (NMWQCC). 2000. *Water quality and water pollution control in New Mexico 2000: A report for submission to the Congress of the United States by the State of New Mexico pursuant to Section 305(b) of the Federal Clean Water Act*. NMED/SWQ-00/1.

Palmer, W.C. 1965. *Meteorological drought.* Research Paper No. 45, U.S. Department of Commerce Weather Bureau, Washington, D.C.

Potter, L.D., J.R. Gotz, and C.A. Carlson, Jr. 1984. *Water resources in the southern Rockies and High Plains.* University of New Mexico Press; 347 p.

Rector, J.R., and L.H. MacDonald. 1987. Water yield opportunities on National Forest lands in the Pacific Southwest Region. pp. 68-73. *In Proceedings, California Watershed Management Conference.* Report No. 11, Wildland Resources Center, University of California, Berkeley, California.

Reid, K.D., B.P. Wilcox, D.D. Breshears, and L. MacDonald. 1999. Runoff and erosion in a pinon-juniper woodland: Influence of vegetation patches. *Soil Science Society of American Journal* 63(6):1869-1879.

Resource Technology, Inc. (RTI). 1991. *Colfax County regional water plan.* Prepared for Colfax Soil and Water Conservation District, Raton, New Mexico.

Rich, L.R. 1972. Managing a ponderosa pine forest to increase water yield. *Water Resources Research* 8:422-428.

Roberts, J.W., J.J. Barnes, and H.J. Wacker. 1976. Subsurface paleozoic stratigraphy of the northeastern New Mexico Basin and Arch Complex. pp. 141-152 In Ewing, R.C., and B.S. Kues (eds.), *Guidebook of Vermejo Park, Northeastern New Mexico.* New Mexico Geological Society Guidebook, 27th Field Conference.

Robichaud, P.R., J.L. Beyers, and D.G. Neary. 2000. *Evaluating the effectiveness of postfire rehabilitation treatments*. USDA Forest Service Gen. Tech. Rep. RMRS-GTR-63, Rocky Mountain Research Station, Fort Collins Colorado. 85p.

Robichaud, P.R., and T.A. Waldrop. 1994. A comparison of surface runoff and sediment yields from low-and-high severity site preparation burns. *Water Resources Bulletin* 30:27-34.

Saye, J.A., III. 1990. Hydrogeology of the Moreno Valley—An overview. pp. 62-66. *In* Bauer, P.W., S.G. Lucas, C.K. Mawer, and W.C. McIntosh (eds), *Tectonic development of the southern Sangre de Cristo Mountains, New Mexico.* New Mexico Geological Society Forty-First Annual Field Conference, September 12-15, 1990.

Smith, D.I., M.F. Hutchinson, and R.J. McArthur. 1993. Australian climatic and agricultural drought: Payments and policy. *Drought Network News* 5(3):11-12.

Sorensen, E.F. 1976. *Water use by categories in New Mexico counties and river basins, and irrigated and dry cropland acreage in 1975.* Technical Report 41, New Mexico State Engineer Office.

Sorensen, E.F. 1981. *Water use by categories in New Mexico counties and river basins, and irrigated acreage in 1980*. Technical Report 44, New Mexico State Engineer Office, Santa Fe, New Mexico.

Stednick, J.D. 1996. Monitoring the effects of timber harvest on annual water yield. *Journal of Hydrology* 176:79-95.

Stone, W.J. 1982. Dakota Aquifer system in New Mexico. pp. 62-68 *In Geohydrology of the Dakota Aquifer.* First in the Series: C.V. Theis Conferences on Geohydrology, Proceedings of the Symposium held on October 5-6, 1982, at the Villager Motor Inn Convention Center, Lincoln, Nebraska. National Water Well Association.

Tarlock, D. 2000. *Prior appropriation: Rule, principle, or rhetoric.* 76 North Dakota Law Review 881.

Thorn, C.R. 1995. *Surface water discharge and evapotranspiration rates for grass and bare soil along a reach of the Rio Grande, Albuquerque, New Mexico, 1989-95.* U.S. Geological Survey Open-File Report 95-419, Albuquerque, NM.

Tiedemann, A.R., C.E. Conrad, J.H. Dieterich, J.W. Hornbeck, and W.F. Megahan. 1979. *Effects of fire on water. A state-of-knowledge review*. USDA Forest Service, General Technical Report WO-10, Washington, DC. 28p.

Trauger, F.D. and Kelly, T.E., 1987. Water resources of the Capulin topographic basin, Colfax and Union Counties, New Mexico. , pp. 285-293 *In* Lucas, S.G., and A.P. Hunt (eds.), *Northeastern New Mexico.* New Mexico Geological Society, Guidebook, 38th Field Conference.

Trimble, S.W., and A.C. Mendel. 1995. The cow as a geomorphic agent, a critical review. *Geomorphology* 13:233-253.

Troendle, C.A. 1983. The potential for water yield augmentation from forest management in the Rocky Mountain region. *Water Resources Bulletin* 19(3):359-373.

Troendle, C.A., and M.R. Kaufmann. 1987. Influence of forests on the hydrology of sub alpine forests. pp. 68-76. *In Management of subalpine forests: Building on fifty years of research.* USDA Forest Service General Technical Report RM-149, Fort Collins, Colorado.

Troendle, C.A. and R.M. King. 1985. The effects of timber harvest on the Fool Creek watershed, 30 years later. *Water Resources Research* 21(12):1915-1922.

Troendle, C.A. and R.M. King. 1987. The effect of partial and clearcutting on streamflow at Deadhorse Creek, Colorado. *Journal of Hydrology* 90:145-157.

Troendle, C.A., and J.M. Nankervis. 2000. *Estimating additional water yield from changes in management of national forests in the North Platte Basin.* 51p.

Troendle, C.A., M.S. Wilcox, G.S. Bevenger, and L.S. Porth. 2001. The Coon Creek water yield augmentation project: Implementation of timber harvesting technology to increase streamflow. *Forest Ecology and Management* 143:179-187

United States Department of Agriculture (USDA). 1999. *1997 Census of agriculture: New Mexico state and county data, Volume 1, Geographic Area Series, Part 31.*

United States Environmental Protection Agency (U.S. EPA). 1987. *Guidelines for delineation of wellhead protection areas*. EPA 440/6-87-010.

United States Geological Survey (USGS). 2001 *New Mexico NWIS-W data retrieval.* <http://waterdata.usgs.gov/nwis-w/NM/>.

USGS. 2002. *Daily streamflow for the Nation.* <http://waterdata.usgs.gov/nwis/discharge> Accessed October 15, 2002.

Viessman, W., G.L. Lewis, and J.W. Knapp. 1989. *Introduction to hydrology,* Third edition. Harper Collins, New York. 780p.

Water Resources Associates, Inc. 1973. *Report on availability of water, Angel Fire development, Colfax County, New Mexico.* Prepared for The Baca Grande Corporation, Scottsdale, Arizona. August 1973.

Wilson, B. 1986. *Water use in New Mexico in 1985*. Technical Report 46, New Mexico State Engineer Office.

Wilson, B.C. 1992. *Water use by categories in New Mexico counties and river basins, and irrigated acreage in 1990*. Technical Report 47, New Mexico State Engineer Office.

Wilson, B.C., and A.A. Lucero. 1997. *Water use by categories in New Mexico counties and river basins, and irrigated acreage in 1995*. Technical Report 49, New Mexico State Engineer Office.

Wilson, B. 2002. Unpublished water use data for Colfax County provided by the New Mexico State Engineer Office.

W.K. Summers & Associates, Inc. 1977. *Water resource and development, headquarters area, Vermejo Park Ranch, Colfax Co., New Mexico, Socorro, New Mexico.* May 18, 1977.

Plates

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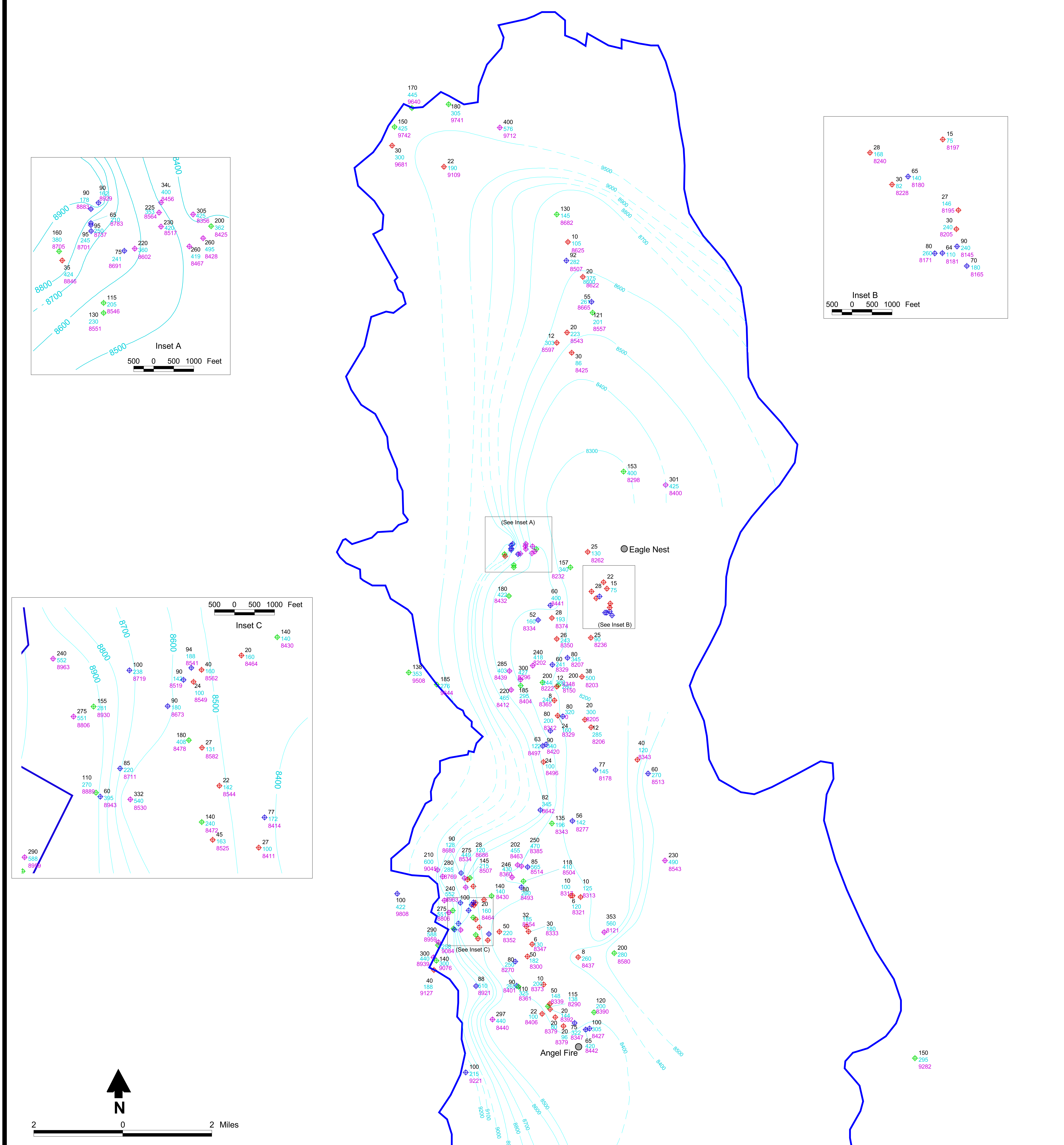


Explanation

195 Water depth
280 Well depth
8854 Water level elevation (ft msl)

Water Depth by Range
- 0 - 50
- 51 - 100
- 101 - 200
- >200

Moreno Valley boundary
Potentiometric surface (ft msl)
Inferred potentiometric surface

Notes

Water level data are from 1990 through 2000 measurements only.

Land surface elevations for OSE data were derived from USGS digital elevation models.

Moreno Valley boundary source: Colpitts and Smith, 1990

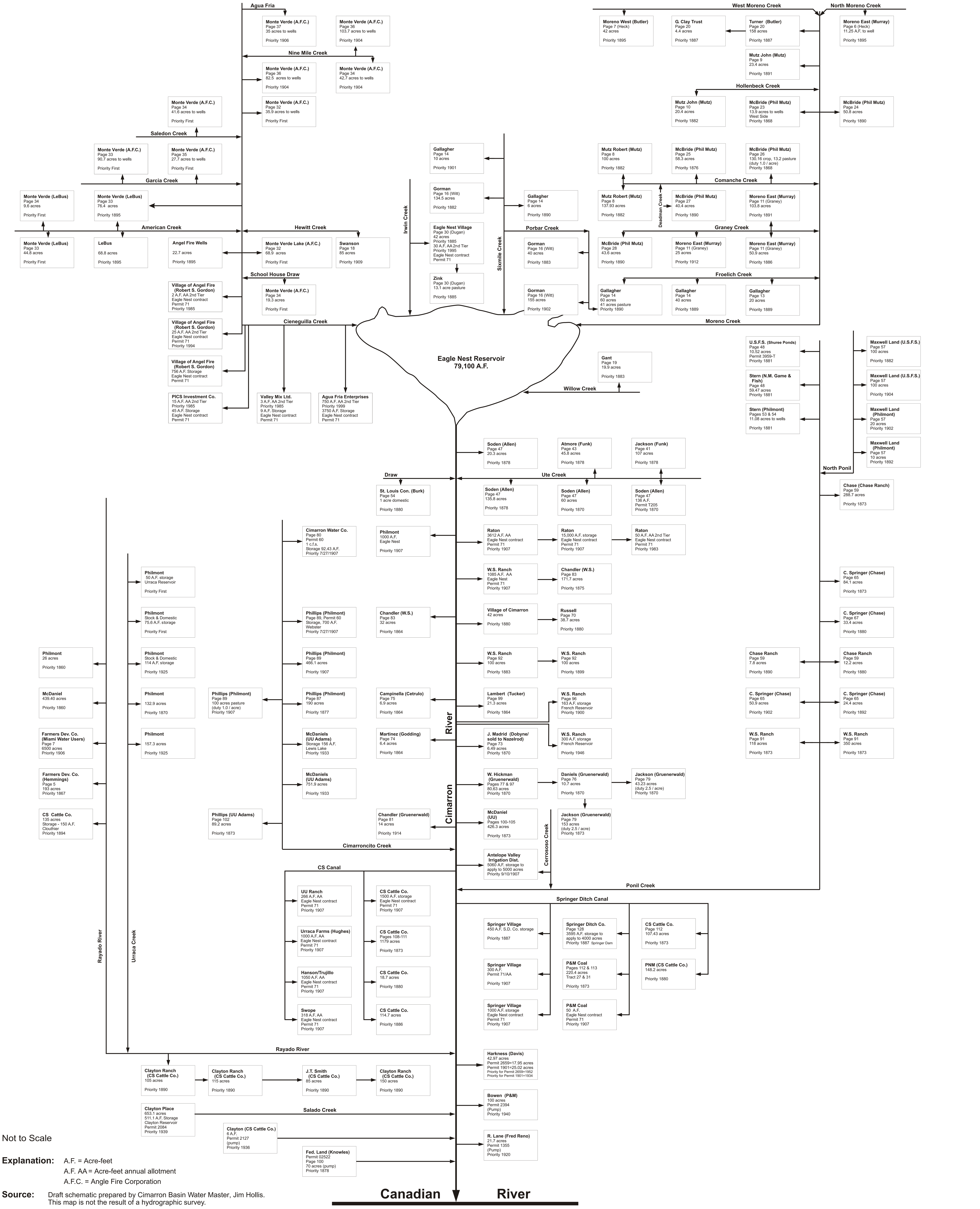
COLFAX REGIONAL WATER PLAN

Groundwater Potentiometric Surface For Moreno Valley

Daniel B. Stephens & Associates, Inc.

03-19-01 JN 9208

Plate 1



Not to Scale

Explanation:
A.F. = Acre-feet
A.F. AA = Acre-feet annual allotment
A.F.C. = Angle Fire Corporation

Source: Draft schematic prepared by Cimarron Basin Water Master, Jim Hollis. This map is not the result of a hydrographic survey.

Notes:
- The information on this plate does not reflect changes in water rights since April 2001.
- Page number refers to Decree Number 5054 in the District Court of Colfax County (Springer Ditch Company vs. French Land and Irrigation Company) 1932. Duty is 1.5 acre-feet per acre per annum (except where noted).
- All Permit 71 rights are either annual inflow held in Eagle Nest Reservoir or storage rights in the reservoir. Storage rights do not have priority dates as they relate to space in the reservoir.
- "Acres to wells" means that the water right was originally a surface water right that is now being taken from a well.
- "Priority First" is a term used in Decree 5054 and means that a priority first right is senior to other rights in that system. The priority date is the 1860s.
- Pasture rights receive 1.0 acre-foot per acre.

COLFAX REGIONAL WATER PLAN

Cimarron and Rayado Stream System Preliminary Schematic of Water Rights

Daniel B. Stephens & Associates, Inc.

3-20-03 JN 9362

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Plate 2