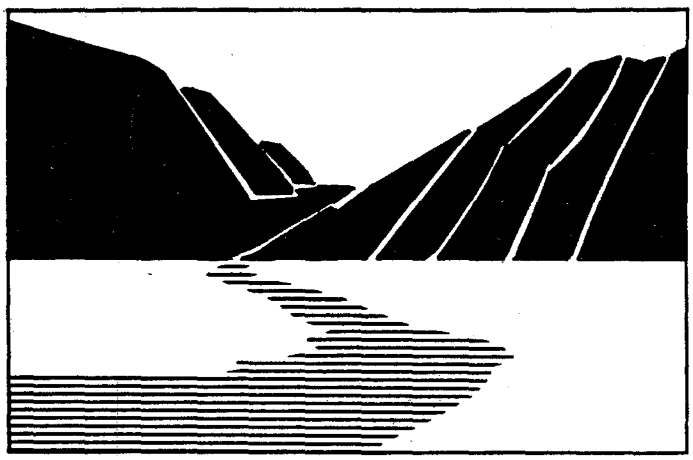
COLORADO RIVER WATER QUALITY IMPROVEMENT PROGRAM



LOWER GUNNISON BASIN UNIT
NORTH FORK AREA

PRELIMINARY FINDINGS REPORT

DECEMBER 1989

UNITED STATES DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

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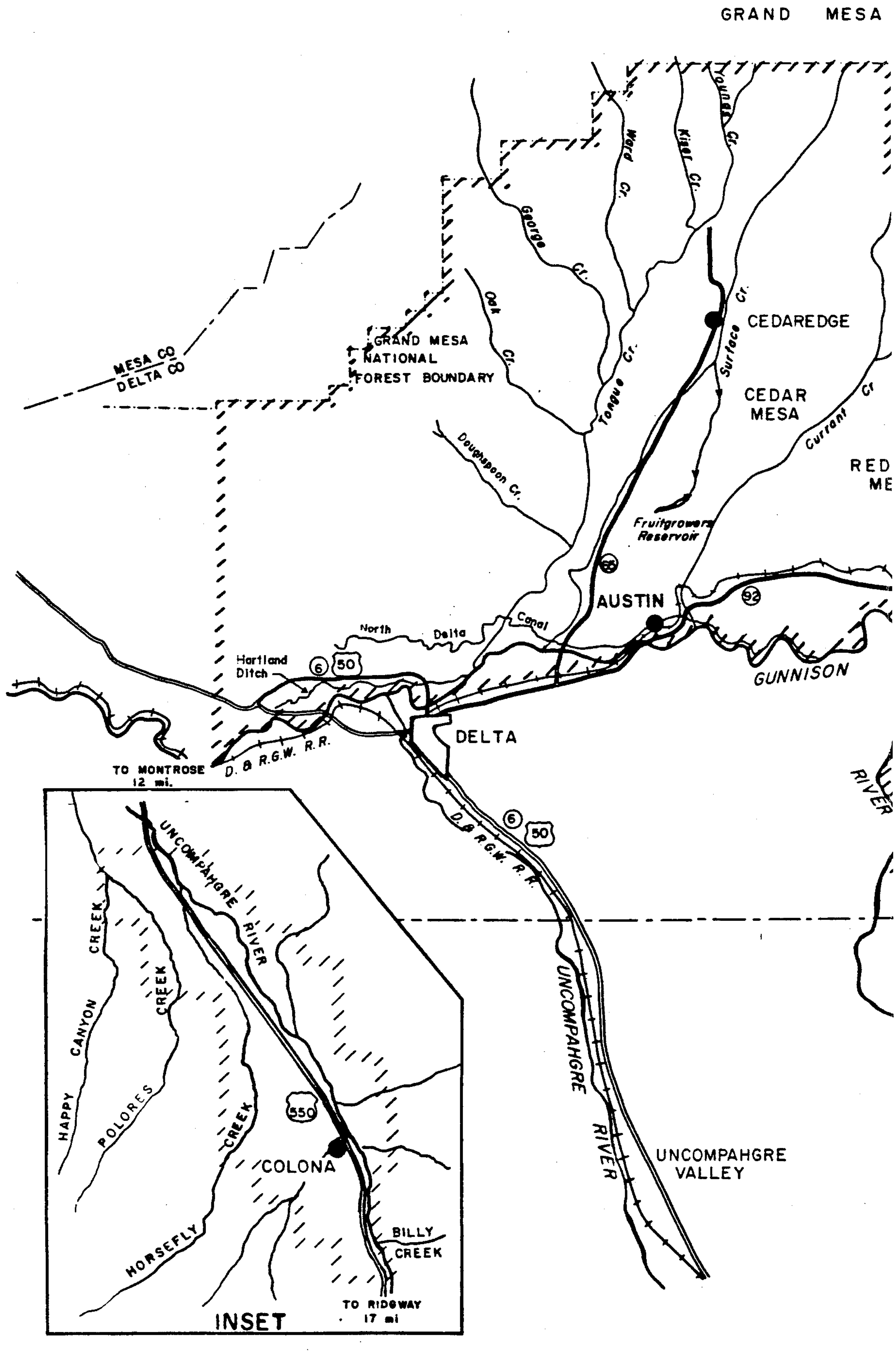
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550
COLONA
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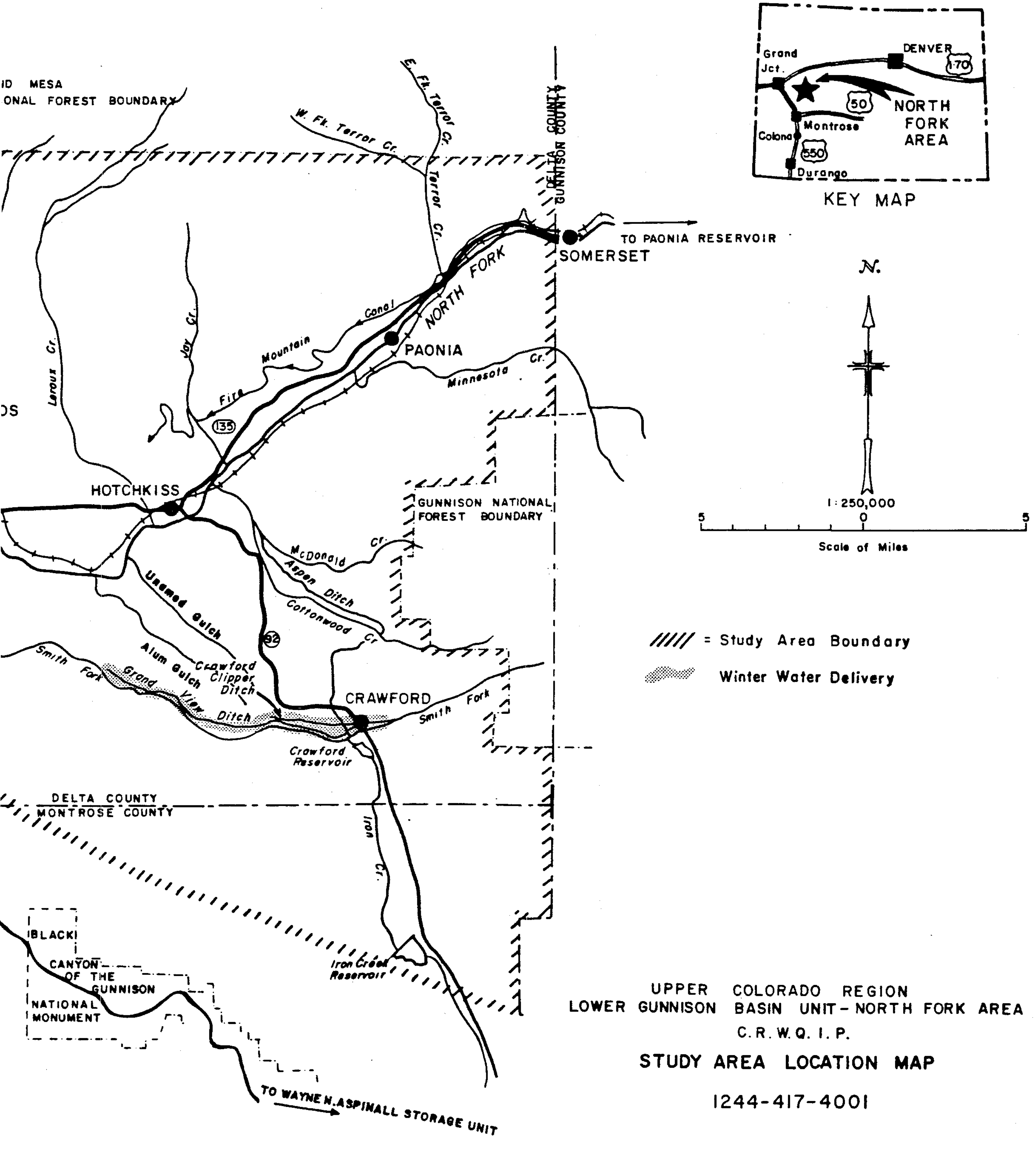
TO RIDGWAY 17 mi
INSET

FIGURE 1



UPPER COLORADO REGION
LOWER GUNNISON BASIN UNIT - NORTH FORK AREA
C.R.W.Q.I.P.

STUDY AREA LOCATION MAP

1244-417-4001

CHAPTER I

INTRODUCTION

Findings and Recommendations

Preliminary studies in the Lower Gunnison Basin Unit - North Fork Area failed to identify any significant salinity control options with cost effectiveness values less than $100 per ton. Therefore, it is the recommendation of this report to conclude salinity control investigations for the unit. The purpose of this report is to document pertinent study results and to terminate the program.

Background

The Lower Gunnison Basin Unit-North Fork study has been conducted under the Federal Water Pollution Control Act of October 18, 1972, (Public Law 92-500); the Colorado River Basin Salinity Control Act of June 14, 1974 (Public Law 93-320).

The study was conducted to identify the source and quantify the amount of salts entering the Colorado River system from the study area, to analyze the salt loading mechanisms, and to formulate solutions that would reduce the salt contribution. The study concentrated on: 1) seepage losses from unlined irrigation delivery systems that dissolve and transport salts to the river; and, 2) on point source contributions from abandoned gas and oil exploration wells.

The study area is located in Delta, Montrose, and Ouray Counties in west-central Colorado and consists of irrigated lands along the Gunnison, North Fork of the Gunnison, and Uncompahgre Rivers. The major portion of the study area is bounded by the Gunnison River to the south, Grand Mesa National Forest to the north and west, and the Gunnison National Forest to the east. A small portion of the area is located in the Uncompahgre River Valley south of the city of Montrose. The study area is shown on the frontispiece map.

Colorado State Highways 92, 135, 65, and U.S. Highway 550 traverse the study area. The Denver and Rio Grande Western Railroad parallels the North Fork of the Gunnison River in an east-west direction and terminates just east of the Delta County line. Larger communities in the study area include Paonia, Hotchkiss, Crawford, Delta, and Cedaredge. Paonia and Delta have small airports, while the nearest commercial airport is at Montrose, about 20 miles south of Delta. Elevation in the area ranges from about 5,000 feet near Delta to almost 9,000 feet north of Cedaredge.

Problems and Needs

In the study area, an estimated total of about 422,000 tons of salt are picked up annually and conveyed to the Colorado River system. Most salt pickup is attributable to conveyance system seepage and deep percolation as water passes through the weathered and fractured shales of the Mancos Formation. Consumptive use of water and salt pickup by ground-water return flows leave higher salt concentrations in water returning to the river. Additional salt sources in the study area include saline water flowing from abandoned oil and gas wells and salt from soils derived from Dakota Sandstone. The frontispiece map depicts the location of salt sources in the unit area.

Information based on 9 years of record shows that the inflow water quality varies from 50 milligrams per liter (mg/L) total dissolved solids (TDS) in the mountain streams to 84 mg/L TDS in the North Fork of the Gunnison River at Somerset gauge and 176 mg/L TDS in the Gunnison River above the confluence with the North Fork. Outflow water quality of the Gunnison River as it leaves the unit area averages 398 mg/L TDS, while tributaries in the saline areas are as high as 7,000 mg/L TDS for individual samples.

Ground-water quality varies from 1,000 to 12,000 mg/L TDS below irrigated areas. Records confirm that TDS concentration in an old unplugged gas well near Austin has reached 30,416 mg/L TDS, the highest recorded concentration in the study area.

Salt reduction estimates for this preliminary findings memorandum were obtained from available Bureau of Reclamation (Reclamation) and U.S. Geological Survey (USGS) gauging station data in the study area. This information was correlated with data from the Grand Valley Unit, Colorado River Basin Salinity Control Project, and Lower Gunnison Basin Unit, Colorado River Water Quality Improvement Program. In or near the unit area, the USGS has 11 gauging stations that monitor daily flows of the Gunnison River and many of the major tributaries. At the North Fork of the Gunnison River near Somerset, USGS also collects water quality data. In addition to the USGS gauging network, Reclamation maintains a variety of gauging stations ranging from monthly grab sample sites to daily flow stations.

Salt loading from the Cottonwood Creek, Unnamed Gulch, Alum Gulch, and North Delta Canal watersheds was estimated with summer and winter grab sample runs for wetted perimeters and water quality on the canals and laterals. Seepage rates were assumed to be similar to those found in the Grand Valley Unit. Ground-water quality was assumed to be similar to that found in the Lower Gunnison Basin Unit for similar geologic formations. The salinity estimates for the remaining watersheds were based on a proration of remaining salt contributions from the off-farm sources.

Many identified ground-water seeps, springs, and abandoned oil and gas wells are believed to be adding to the salt loading of the area. Salt loading estimates of the abandoned oil and gas wells were determined from grab samples obtained in the summer of 1985. Of six abandoned test wells located on the south bank of the Gunnison River, one near Austin intermittently spews saline water as a geyser but does not flow between eruptions. The hole was drilled in 1937 to 406 feet; however, information about the well is meager. The gushing effect may be caused by carbon dioxide. The hole reportedly produced 100,000 to 250,000 cubic feet of carbon dioxide per day during initial drilling.

Of the 422,000 tons of salt contributed annually to the Colorado River system from the study area, about 274,000 tons are attributed to on-farm sources, about 148,000 tons are attributed to off-farm sources, and less than 1 percent is attributed to saline flows from abandoned oil and gas wells. To date, three drainages in the study area have been examined in greater detail. These include Cottonwood Creek, Unnamed Gulch, and Alum Gulch. Of the off-farm sources for the entire study area, an estimated 28,000 tons are attributed to these three drainages.

CHAPTER II

PLAN FORMULATION

Plan formulation for the North Fork study was directed at identifying the salt loading problem in the area, formulating alternatives to reduce salt loading, and evaluating those alternatives.

Criteria and Standards for Plans

Studies were conducted in accordance with the Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (Principles and Guidelines) as well as other applicable Federal legislation and regulations.

Problems and opportunities in the area were identified, and the capability of available resources to meet these problems and opportunities was evaluated. This evaluation of needs and resources provided the basis for developing alternative salinity control plans.

Alternative plans were formulated and evaluated to a sufficient level of detail to determine if they warranted further study. Cost effectiveness, the annual cost of preventing 1 ton of salt from entering the Colorado River, was the criteria used to make this determination for salinity sources for which control options were technically possible.

Identification of Salinity Sources

The results of water quality sampling programs conducted by Reclamation, the Soil Conservation Service (SCS), and United States Geological Survey (USGS) were used to identify subareas within the overall study area which were major salinity contributors. These subareas, described subsequently, are Tongue Creek, Oak Creek, Special Study Area, North Delta, Colona Area, and the Geyser Well.

Two electrical conductivity (EC) profile measurements of the North Fork and Gunnison Rivers were conducted to locate major salt contributors not identified by the water quality sampling stations and grab sample surveys.

The first EC river profile was conducted from June 26 - July 10, 1986; a second EC profile was conducted October 6-10, 1986, to provide additional data not available from the preliminary river profile, confirm the earlier findings, and to gain new insights by taking EC measurements during a lower flow regime. The results of the EC profile surveys have been documented on supporting material.

The EC profiles did not identify additional major salinity sources. Instead, the profiles confirmed the diffuse and gradual nature of the salinity accumulation along the river and reinforced the results of the individual component analyses discussed subsequently.

Salinity Control Component Descriptions and Analyses

After the subareas had been identified and the general salt loading conditions confirmed by the EC profiles, salinity control components were formulated for each subarea.

Tongue Creek canal and lateral lining

Area Description

The Tongue Creek drainage is located in Delta County on the south slope of Grand Mesa. The drainage is tributary to the Gunnison River and has an area of approximately 152,131 acres consisting of 77,608 acres of privately owned land, 18,099 acres of public land managed by the Bureau of Land Management, and 56,424 acres of public land managed by the Forest Service. The 15,750 acres of irrigated land within the drainage is composed of 3,865 acres in orchard and 11,885 acres in grain, corn, hay, or pasture. Due to high TDS concentrations associated with irrigation return flows in this subarea, it was considered as a candidate area for canal and lateral lining.

Snowmelt runoff is the main source of surface water, with Fruitgrowers Reservoir and several smaller reservoirs providing approximately 20,000 acre-feet of supplemental irrigation water after the spring runoff period. No irrigation water is pumped from ground water in the area. Irrigation water is supplied through 89 single owner and 178 group ditches. This drainage usually experiences a shortage late in the season.

Approximately 486 farms are located within the drainage with an average irrigated farm size of 33 acres. Ninety percent of the fields are less than 20 acres with an average field size of 6 acres. About 5 percent of the irrigated land lies on fans and terraces that have alluvial profiles with some horizontal development. A typical soil profile has dark brown to brown surface soils grading into brown and finally pale brown in zones of maximum lime accumulation. The depth to the lime zone is usually 36 inches in the irrigated land and 24 inches in the nonirrigated land.

Textures are loam to friable clay loam and structures are granular near the surface becoming subangular blocky in the subsoils. The topography ranges from 0.5 to 4-percent slope and has a smooth to slightly undulating surface relief with permissible irrigation runs of over 500 feet. This land is well adapted to the production of all crops grown in the area.

About 70 percent of the areas irrigated land is on soils similar to that described above, but the topography creates short runs of less than 500 feet on slopes between 4 to 8 percent (average slope approximately 4 percent). Some surface rocks occur on lands near the northern margin. The remaining 25 percent of the irrigated lands have similar soil properties to that previously discussed but is generally rocky and limited by short irrigation runs of 200 to 300 feet.

A significant problem identified by SCS in the Tongue Creek drainage is the inefficient use of a limited water supply. The SCS estimates that 30 to 50 percent of the water diverted to earthen ditches is lost to ditch seepage, while overall on-farm irrigation efficiencies are presently less than 50 percent. Reclamation studies indicate that a seepage rate of more than 2.0 cubic feet per square foot of wetted perimeter per day (ft/day) would be necessary to produce these 30- to 50-percent seepage rate values. This is considered very high.

The irrigation ditches convey water through permeable soils overlying Mancos Shale. Seepage water contacting the Mancos Shale dissolves salts and transports it to the stream system. Surface water diverted for irrigation has a TDS concentration of less than 200 mg/L.

Salinity concentrations of Tongue Creek return flows, measured by the SCS, range from 1,300 to 6,500 mg/L. Salt contribution to the Gunnison River from the Tongue Creek drainage is estimated by the SCS to be more than 45,000 tons annually.

According to SCS studies, approximately 50 percent of the salt contribution is caused by excess irrigation water applications and that irrigation management could reduce the salt contribution by 10,000 tons per year. This reduction is associated with SCS on-farm management practices only and does not include canal and lateral lining.

Hydrosalinity

Reclamation's study of the Tongue Creek drainage began with an analysis of water quality grab samples and daily flow measurements at the Tongue Creek gauging station located near Cory. The data collected between February 1976 and March 1985 showed an average annual flow volume of 38,940 acre-feet and a salt load of 44,500 tons. A water quality summary of Tongue Creek at the Cory gauge is presented in Table 1.

Table 1
Average TDS values from Reclamation
grab samples at Tongue Creek near Cory
(February 1976 to March 1985)

Month	Number of samples	Average TDS
January	8	1,236
February	7	1,200
March	9	1,032
April	8	752
May	8	1,014
June	10	941
July	9	1,908
August	9	1,970
September	9	1,583
October	10	1,390
November	6	1,166
December	7	1,240

The TDS values shown in Table 1 are relatively constant throughout most of the year, rising significantly during the peak irrigation season when Tongue Creek flows at Cory are at their lowest. The situation at Tongue Creek is the reverse of Reed Wash, Stage One, Grand Valley Unit for example, where the observed TDS values decline during the irrigation season when flows in the wash are greatest. These values are shown in Table 2.

Table 2
Average TDS values from grab samples
at Reed Wash near Mack
(June 1981 to February 1984)

Month	Number of samples	Average TDS
January	22	4,050
February	20	4,235
March	18	3,900
April	19	2,564
May	25	983
June	19	1,009
July	21	1,179
August	26	1,397
September	23	1,260
October	20	1,271
November	18	3,519
December	23	3,630

Comparing Tongue Creek, a perennial stream regulated by numerous small reservoirs upstream, with Reed Wash, a drainage whose flow is almost entirely dependent on irrigation return flows, demonstrates that the Tongue Creek subarea salt loading is derived from a diffuse source heavily dependent upon the flow regime in Tongue Creek.

SCS water quality data collected between October 1978 and June 1984 indicated that Oak Creek, a west side Tongue Creek tributary, contains the highest salt concentration in the Tongue Creek drainage. Oak Creek is a natural stream deeply entrenched in soil derived from Mancos Shale and not significantly affected by irrigation return flows. Chemical analysis of water from the mouth of Oak Creek yielded TDS values of 7,060 mg/L on July 17, 1980; 7,910 mg/L on January 22, 1981; and 6,800 mg/L on May 10, 1981.

No flow data were available for these three samples. The significantly higher values probably result from concentration by evaporation and phreatophyte consumption, not from irrigation deep percolation or ditch seepage passing through the soil profile. The Tongue Creek (Cory) gauge does not indicate this water quality to be typical of the entire drainage; however, it does illustrate the potential for salt loading by natural sources.

To identify the salt loading mechanisms of the Tongue Creek drainage, a base flow separation analysis was conducted. This analysis was used to separate total drain flow into surface and ground-water (base flow) components using known water quality and quantity data.

The Surface Creek gauging station near Cedaredge was the source of data on inflow water quality and quantity. Water quality and the relationship between quantity and drainage area for the Tongue Creek inflows were assumed to be similar to those recorded at the Surface Creek gauge. Assuming that the flow and salt tonnage developed for the Tongue Creek (Cory) gauging station are correctly defined and the inflow quality as defined by the Surface Creek gauging station near Cedaredge is accurate to or ± 100 percent, then the salt load associated with the drain base flow component ranges from 41,600 to 42,600 tons. Based on this sensitivity analysis, the inflow salt load appears to have no significant effect on the results of the base flow separation.

Over the period April 1976 to March 1984, the annual fluctuation in drain base flow volume is considerable. These base flow values range from a low of 4,170 acre-feet in the 1977-1978 drought year to a high of 29,730 acre-feet in the 1983-84 record runoff year. Using these drain base flow volumes to calculate total annual salt loads for the Tongue Creek drainage results in values of 44,500 and 45,500 tons/year, respectively. With the high variation in annual drain base flow volume which corresponds closely to the historic runoff data, there is no possibility of it being induced by irrigation practices exclusively.

Studies in the Reed Wash area in the Grand Valley Unit indicated that canal and lateral seepage accounted for less than 40 percent of the drain base flow tonnage, with on-farm seepage and deep percolation accounting for greater than 60 percent. Applying this distribution of salinity contributions to the Tongue Creek drainage and assuming that the drain base flow value of 42,600 tons is due equally to natural precipitation and irrigation practices, the base flow tonnage associated with canal and lateral seepage is 8,520 tons in the Tongue Creek drainage.

Cost Effectiveness Analysis

Cost estimates were developed for lining all irrigation ditch systems where inventory data was available (102 of 267 systems or approximately 38 percent). These cost estimates were based on unit costs developed from the Grand Valley Unit, Stage Two development. Annual costs were determined using an 8-5/8-percent interest rate, 50-year replacement period, and annual O&M costs derived from the Grand Valley Unit development. A cost effectiveness evaluation was then conducted using a range of seepage rates from 0.1 to 0.9 feet per day. The analysis indicated that to obtain a cost effectiveness value of $100 per ton or less, 70 percent of the total Tongue Creek salt load (or approximately 30,000 tons per year) would need to be removed by lining 38 percent of the irrigation systems in the drainage. This amount of salt load reduction is not possible since the base flow separation analysis indicated that only 8,520 tons were attributable to canal and lateral seepage. Based on this cost effectiveness analysis the Tongue Creek drainage (with the exception of the Oak Creek subbasin) was eliminated from further investigation.

Oak Creek canal and lateral lining

Area Description

Oak Creek, a tributary of Tongue Creek, is located in Delta County, on the southeastern slope of Grand Mesa. The 21-square-mile Oak Creek drainage area contains about 425 acres of irrigated land, approximately 300 acres of which is owned by the city of Delta. Due to the previously discussed high TDS concentrations at the mouth of Oak Creek, the subarea was considered for a canal and lateral lining program.

The Public Works Director for the city of Delta indicated that the city owns 2,200 acres in the Oak Creek drainage. The city had originally purchased the irrigated land and its associated water rights for use as a late summer supplement to their municipal water supply. The city of Delta's Oak Creek Pipeline has not been used since 1981 because other water sources have been developed.

Snowmelt runoff is the main source of water in the drainage. Oak Creek flows are regulated by four small reservoirs: Dugger Reservoir, 212 acre-feet; Porter No. 1, 202 acre-feet; Porter No. 4, 39 acre-feet; and Morris No. 2, 16 acre-feet. Irrigated lands within the Oak Creek drainage are served by six ditches.

The Sandburg Ditch is approximately 13,000 feet in length and has a water right of 6.0 ft^3/s although its capacity is approximately 15 ft^3/s. The Sandburg Ditch has a junior water right compared to the other ditches with diversions from Oak Creek. The ditch and some of the irrigated lands it serves straddle the drainage boundary between Oak and Camp Creeks which makes a determination of quantity and direction of ground-water flow very difficult.

Oak Creek No. 2 Ditch has an estimated length of 4,500 feet and a water right for 2.4 ft^3/s. This ditch serves the irrigated lands owned by the city of Delta.

The Oak Valley Ditch has a water right for 1.9 ft^3/s. Because only approximately 950 feet of the ditch could be considered off-farm and the remaining portion is used as an on-farm head ditch, the entire ditch was dropped from consideration in the cost effectiveness analysis.

Loucks Ditch has a water right for 0.5 ft^3/s and is currently used as an on-farm head ditch to serve land owned by the city of Delta. Because of its on-farm use, this ditch was also eliminated from the cost effectiveness analysis.

Mountain View Mesa Ditch has a length of 4,800 feet from the diversion structure to where it is used as an on-farm head ditch. The ditch has a direct diversion water right for 5.0 ft^3/s. The ditch diverts water from the Doughspoon Creek drainage adjacent to the Oak Creek drainage. The irrigated lands served by the ditch are in private ownership and straddle the drainage boundary between Oak and Doughspoon Creeks.

Hydrosalinity

Data collected by the SCS indicates that the total average annual salt load of Oak Creek is approximately 4,800 tons per year. However, this data also produced a total average annual salt load for Tongue Creek of 35,600 tons per year which is only 78 percent of the 45,500 tons per year value calculated by Reclamation using a base flow separation technique.

Therefore, the total average annual salt load value developed by the SCS was adjusted proportionately to 6,100 tons per year to provide continuity in the investigation. Using the adjusted value results in an average Oak Creek salt load of approximately 7.3 tons per acre-foot. Assuming an inflow TDS concentration of 0.1 tons per acre-foot results in a net salt loading effect of 7.2 tons per acre-foot.

Cost Effectiveness Analysis

A cost effectiveness analysis was conducted to determine if any of the Oak Creek irrigation delivery systems presented cost effective salinity control opportunities through implementation of a lining program. Cost estimates were prepared for the Sandburg, Oak Creek No. 1, Mountain View Mesa, and Hoosier Ditches utilizing procedures similar to those described in the Tongue Creek area. Using the estimated annual cost of lining the individual systems and a range of seepage rates (0.1 to 0.9 feet per day), corresponding salt loading rates which would produce a cost effectiveness value of $100 per ton were calculated. A curve, representing the combination of seepage and salt loading rates required to support a lining program with an annual cost effectiveness of $100 per ton was developed.

Assuming that the maximum possible salt loading rate from ditch seepage is equal to 7.2 tons per acre-foot, the corresponding seepage rate from the curve is approximately 0.4 feet per day. Based on interviews with water users and field observations, this value exceeds the seepage rates that could reasonably be expected to occur in the Oak Creek drainage.

Additionally, the future development of Delta's water rights in the area are not defined. Currently the city operates the irrigated lands under short-term lease agreements with the water users; therefore, long-term irrigation of these lands is questionable. Based on the marginal cost effectiveness and uncertain future of land use practices, the Oak Creek drainage was eliminated from further investigation.

Special study area—canal and lateral lining/winter water replacement

Area Description

The Special Study Area (SSA) is located in the southeastern corner of Delta County, and the drainages are tributary to the North Fork of the Gunnison River. The drainage basins in the SSA include Alum Gulch, Cottonwood Creek, and an unnamed gulch lying between them. The total drainage area is approximately 22,000 acres which includes 6,600 acres of irrigated land. The Smith Fork Project encompasses a major portion of the SSA. The area was selected for study because of the degraded outflow water quality and the knowledge that nearly all irrigation water is imported into the basin, and is therefore quantifiable.

The majority of irrigation supplies are imported from the Smith Fork River via the Needle Rock, Crawford Clipper, and Grand View Ditches. All ditches are privately owned and operated except for the Aspen Canal which is a feature of the Smith Fork Project. Crawford Reservoir on Iron Creek stores Smith Fork diversions to provide supplemental water when natural river flows are depleted in late summer.

In addition to providing irrigation deliveries these ditch systems also provide stockwater to area farms and ranches during the nonirrigation season. Therefore, this subarea was analyzed as a candidate for irrigation delivery system lining and winter water replacement.

Grand View Mesa is an undulating plateau which slopes to the northwest and is cut by small drainage channels. The soils are largely formed from residual Dakota Sandstone weathered in place. Depths range from 2 to more than 5 feet with textures ranging from clay to clay loam. The reddish-brown mesa topsoil varies from 1 to 12 inches in depth and is underlain by a pale brown, highly calcareous subsoil. Some residual Mancos Shale overlies the Dakota Sandstone to the north near the outlets of Alum and an unnamed gulch.

Land in the Cottonwood Creek drainage is generally quite broken with irrigable area located on terraces adjacent to the stream. Predominant soils include residual and recent alluvial soils derived from decomposed shale. The residual soils are heavy textured clay and are of relatively poor quality. More recent alluvial soils are weathered from Mesa Verde and Wasatch formations and are of higher quality.

Smith Fork Project soils generally have been well leached. The average total soluble salt content reported in 1959 was 0.1 percent with salts uniformly distributed over the profile. Of the 24,950 acres classified, less than 2 percent were rejected because of total soluble salt content above 0.5 percent. The average pH of the project land was 7.8 and no land was rejected because of alkalinity content. The principal salts reported in the Smith Fork Project area were the sulfates and chlorides of sodium, calcium, and magnesium.

The Grand View and Crawford Clipper ditch systems deliver water to approximately 78 percent of the irrigated acreage within the SSA. The Needle Rock system is composed of systems on the east and west sides of Cottonwood Creek. All of these systems are capable of direct diversion from the Smith Fork River. The A1 and A2 are two small ditch systems that divert water from the lower reach of Alum Gulch. The Aspen Canal supplies supplemental water from Crawford Reservoir. The above described delivery systems were field inventoried to determine canal and lateral lengths, diversion capacities, and the amount of lands served. Tables 3 and 4 present the results of this field inventory.

Table 3
Irrigation system analysis

Ditch system	Within SSA: Canal length (feet)	Lateral length (feet)	Acres served	Outside SSA: Canal length (feet)	Lateral length (feet)	Acres served
Grand View	39,357	35,265	1,943.8	48,396	-	167.0
Crawford Clipper	21,597	222,488	3,165.1	7,734	18,470	237.9
Needle Rock	31,900	38,425	1,193.7	-	-	-
A1	-	7,950	218.5	-	-	-
A2	-	4,605	138.9	-	-	-
Aspen Canal	30,100	2,640	N/A	5,900		
Total	122,954	311,373	6,660.0	62,030	18,470	404.9

Table 4
Field inventory data

Ditch system	Acreage served	Measured diversion (ft^3/s)	Design size (af/30 ac)	Record source
Grand View	2,110.8	81.4	2.29	Measured
Crawford Clipper	3,403.0	157.0	2.74	Smith Fork Report
Needle Rock	1,193.7	41.3	2.06	Water Right
A1	218.5	22.0	5.99	Measured
A2	138.9	9.2	3.94	Measured
Aspen Canal	5,974.3	125.0	-	Smith Fork Report
Aspen Canal	1,193.7	25.0	1.25	Smith Fork Report

Hydrosalinity

Reclamation's study of the SSA began in February 1985 with initiation of a monitoring program to define surface inflow and outflow water quality and quantity. To determine the base flow salt loading, a base flow separation technique was applied.

Seepage losses from off-farm delivery systems were determined from permeability data contained in the Smith Fork Project Definite Plan Report and winter and summer wetted perimeter estimates.

This data resulted in a range of estimated seepage rates of 0.27 to 0.41 feet per day, with an average of 0.38 feet per day. Seepage losses from on-farm delivery systems were estimated using SCS data consisting of a 0.47 foot-per-day seepage rate, head and tailwater ditch wetted perimeters, and ditch lengths.

Deep percolation was estimated from SCS data that indicated a possible range of 0.8 to 1.5 acre-feet per acre per year. Infiltrated precipitation estimates developed by the SCS ranging from 9.23 to 12.22 inches per year were

also used to define ground-water inflow. Using this data, the maximum possible ground-water inflow to the SSA was determined to be 33,500 acre-feet per year.

By assuming the average December surface outflow water quality (2,775 mg/L) to represent the base flow water quality at the terminus of the SSA, the base flow separation technique yields a net salt loading rate of 1.2 tons per acre-foot.

Cost Effectiveness Analysis

A cost effectiveness analysis was conducted to determine if any of the SSA delivery systems presented cost effective salinity control opportunities through implementation of a lining or winter water replacement program.

Cost estimates were prepared for lining the Grand View, Crawford Clipper, Needle Rock, A1, A2, and Aspen delivery systems using procedures similar to those described for the Tongue Creek area.

The cost effectiveness values for lining individual systems ranged from a low of $84 per ton for the Needle Rock laterals to $679 per ton for the Aspen Canal with an overall weighted average cost effectiveness value of $180 per ton for the entire SSA.

Cost estimates were also prepared for a replacement stockwater delivery system. Since there are no existing rural domestic water systems in the area, it was assumed that replacement stockwater would be provided through a piped raw water delivery system, paralleling the existing irrigation delivery systems. No allowance was made for on-farm facilities that would be required to dispense the stockwater. The cost effectiveness analysis indicated an overall cost effectiveness value for the entire SSA of $54 per ton. Total salt load reduction for this salinity control increment is estimated at 11,100 tons per year.

Due to the poor cost effectiveness associated with canal and lateral lining in the SSA, the canal and lateral lining component was eliminated from further consideration. Although winter water replacement in the SSA appeared to present a cost effective salinity control option, the cost estimate used in this analysis did not account for on-farm facilities which have been demonstrated to equal approximately 50 percent of replacement system costs in the Lower Gunnison Basin Unit Winter Water Replacement Program. Based on this uncertainty and the relatively small salinity control benefit, this component was also eliminated from further consideration.

North Delta Canal and lateral lining

Area Description

The North Delta area consists of lands served by the North Delta Canal and Hartland Ditch. The area includes approximately 3,560 acres of irrigated land on the north side of the Gunnison River near the city of Delta.

North Delta Canal and Hartland Ditch serve approximately 2,470 and 1,090 acres, respectively. Both systems obtain their water supply from the Gunnison River, with the North Delta Canal diversion located about 2.5 miles upstream of Austin and the Hartland Ditch 2.5 miles upstream from Delta.

Hydrosalinity

Salinity investigations for the North Delta area were conducted in accordance with recommendations generated from a review of the EC profiles. The recommendations were that further field investigations were warranted to account for an observed rise in the EC profile from 440 to 540 umhos in one specific reach on the right side of the Gunnison River, at cross section 94.

Initially it was believed that seepage from the North Delta Canal caused the EC profile rise in this reach because the canal is located on a weathered Mancos Shale hillside with visible surface salt deposits. However, further investigation of the area indicated that a side inflow of approximately 4 ft^3/s with an associated water quality of 2,362 mg/L was discharging from the north bank of the river at cross section 95.2. The most probable source of this inflow was determined to be from Alfalfa Run and Cedar Run, two minor drainages on the north side of the Gunnison River.

To determine if the observed rise in the EC profile was primarily due to canal seepage, estimates were made of seepage amounts necessary to yield and EC rise from 440 to 540 umhos. Computations were made assuming a range of river discharges with which dilution could occur and an assumed water quality of 3,500 mg/L for the seep water entering the river from the North Delta Canal.

To determine if the rise in EC values could be attributed solely to the Alfalfa Run inflows, calculations were conducted to determine the river flow rate required to dilute this inflow and account for the EC profile rise.

A final set of calculations were performed, incorporating the effects of the observed Alfalfa Run inflows, to determine the required canal seepage rates that would account for the increase in EC values using the previously assumed base flow concentration.

The calculations indicated that the observed rise in the EC profile can be solely attributed to Alfalfa Run inflows mixing with a river flow equal to 113 ft^3/s. However, the same rise in EC values can also be attributed to Alfalfa Run inflows plus 2 ft^3/s of canal seepage mixing with a river flow equal to 200 ft^3/s. The 2 ft^3/s canal seepage rate is extremely high, approximately 2.5 feet per square foot per day. Also, it appears unlikely that canal seepage could reach the assumed base flow concentration of 3,500 mg/L because of the close proximity of the canal to the river along this reach and the observed surface emergence of canal seepage water. Based on this analysis, it appears that the Alfalfa Run inflows may reasonably explain the EC profile rise. Therefore, canal lining alternatives in this specific reach were dropped from further consideration.

Additionally, a salt loading analysis was conducted to evaluate the salinity reduction potential of lining the entire North Delta Canal and Hartland Ditch systems. All of the irrigated lands served from the two irrigation delivery systems are located on the north side of the Gunnison River.

Water quality samples collected over the period March 1976 to October 1983 from four natural drainages within this reach were used to conduct the analysis. These drainages are Alkali Creek, an unnamed gulch 1/4 mile west of Dieter Gulch, Dieter Gulch, and Dry gulch. To estimate the base flow concentration associated with these drainages, water quality samples taken during the nonirrigation season of November through March were evaluated to determine average TDS values.

The samples from Alkali Creek were taken during periods of low flow ranging from 0.1 to 0.3 ft^3/s and exhibited an average TDS value of approximately 4,200 mg/L. This quality is considered to be representative of the drainage's natural base flow condition.

A wide range of flows from 0.1 to 17.7 ft^3/s occurred in the unnamed gulch during the collection period. However, for periods where flow was less than 1.0 ft^3/s the water quality values ranged from 2,940 to 5,960 mg/L. These qualities are likely to be representative of this drainage's base flow condition.

The flow weighted TDS of 2,917 mg/L for Dieter Gulch is based on a narrow range of low flows from 0.2 to 0.4 ft^3/s. This value is based on a narrow range of samples but appears to be significantly lower than the concentrations for the other drainages in the reach.

The flow weighted TDS of 5,377 mg/L for Dry Gulch is based on samples taken within a range of 0.1 to 1.5 ft^3/s range from 2,100 to 10,900 mg/L and are the highest observed for the four sampling locations in this reach.

None of the Alkali Creek drainage area, and only small portions of the area in unnamed gulch, Dieter Gulch, and Dry Gulch are located below the canal systems. Therefore, observed TDS concentrations are likely to be indicative of natural salt loading conditions and not salt loading due to canal seepage.

The SCS soils map shows that the majority of the land above the North

Delta Canal is located on soils classified as Badlands. Badlands soils consist of nearly barren outcrops of gypsiferous and saline shale with some soil material. The mapping also shows that the majority of irrigated land occurs on Billings silty clay loam which is deep, well drained, and moderately fine textured. The Billings soil is a grassland type formed on alluvial fans washed from adjacent exposures of gray and olive shale and siltstone. This distribution of soils appears to support the assumption that the observed TDS in this reach of the Gunnison River are due primarily to natural loading conditions. Therefore, North Delta canal and lateral lining was dropped from further consideration.

Colona area winter water replacement

Area Description

The Colona area is located approximately 3 miles south of the city of Montrose, in Montrose and Ouray Counties. Irrigation and winter stockwater deliveries are provided by ten private ditch systems. The systems serve approximately 6,600 acres of irrigated land. The ditches are the Heiland, Homestretch, Hotchkiss, McDonald, Old Agency, Ouray, Pinion, Reservation, Stark-Volkman, and Upper Uncompahgre. The ditches divert water directly from the Uncompahgre River and, except for the Stark-Volkman Ditch, are above the Uncompahgre Project service area.

Winter diversion rights are held by only three ditch systems, McDonald Ditch (10.0 ft^3/s), Ouray Ditch (4.0 ft^3/s), and Pinion Ditch (7.5 ft^3/s). The Colorado Division of Water Resources indicates that eight ditches are known to divert winter water, the two not diverting are the Homestretch and Reservation. Winter diversions do not injure senior water rights and the Division of Water Resources does not administer winter diversions as is evident by the lack of winter diversion records. Since the Tri-County Water Conservancy District rural domestic water distribution system has a major trunkline in this area with excess capacity, the Colona area was analyzed to determine its potential for cost effective salinity control by implementing a winter water replacement program.

Hydrosalinity

Reported estimates of the ditch headgate capacities were greater than the irrigation water right for five ditch systems, less than the irrigation water right for three ditches, and equal to the irrigation water right for one ditch. A capacity estimate was not available for the Reservation Ditch. Because of these discrepancies it was assumed that ditch headgate capacity was equal to the irrigation water right and a monthly diversion hydrograph was estimated for each system.

In this analysis, base flow concentration is defined as the TDS concentration that ground water reaches after all possible chemical reactions have taken place, or point of equilibrium where forward and reverse reaction rates are equal. The base flow concentration of 842 mg/L is the average TDS concentration of 21 privately owned wells sampled once during June 1977 and five privately owned wells sampled once during August 1971. Reclamation installed two observation wells within the area which were sampled periodically over a 3 year period. A plot of the wells' water table elevation and TDS concentration over the observation period indicated that the TDS concentration does not vary appreciably over time. This plot indicates that TDS concentration data from wells sampled once, could be used to characterize the areawide long-term base flow concentration.

Nine of the ten ditch systems in the Colona area divert water from the Uncompahgre River above the Uncompahgre Project. Therefore the inflow TDS can best be defined by the TDS concentration of the Uncompahgre River at the Colona gauge. Monthly average TDS concentrations for the Uncompahgre River at Colona are presented in Table 5.

Seepage rates were determined from laboratory permeability tests on 171 samples from 95 auger holes in the Colona area. These tests were conducted for land classification studies for the Dallas Creek Project. The analysis of this data indicates a possible range of seepage rates from 0.17 to 0.32 feet per day. Monthly wetted areas for each system were determined from a wetted perimeter versus discharge relationship developed for the Lower Gunnison Basin Unit. Ditch capacity was assumed to vary linearly from headgate to terminus. Capacity at the terminus was assumed to be 25 percent of the headgate capacity.

Table 5
Monthly TDS concentrations for the Uncompahgre River at Colona
(mg/L)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1961	698	606	335	255	216	218	394	470	444	457	550	614
1962	648	633	623	358	276	277	309	489	601	576	605	659
1963	642	628	560	408	290	438	543	530	522	582	578	611
1964	646	602	650	373	205	215	405	435	582	649	665	636
1965	682	682								554	552	578
1966	606	620	491	299	256	314	472	557	652	701	683	673
1967			601	448	401	398	479	574	662	691	682	
1968					221	255	397	458	555	682	687	704
1969	694	667	627	393	247	277	336	441	523	499	506	533
1970	581	622	655	465	215	284	374	422	360	475	519	567
1971	614	635	473	261	282	282	390	532	513	580	585	594
1972	617	613	452	367	256	273	471	614	578	545	581	595
1973	622	660	701	385	200	184	202	501	571	619	653	683
1974	737	782	753	486	324	322	387	573	655	659	688	690
1975	711	719	567	443	311	234	264	371	556	671	644	603
1976	605	635	621	450	254	274	438	514	640	611	630	643
1977	659	686	679	572	381	417	593	577	506	596	659	673
1978	699	688	643	337	291	253	354	522	642	710	721	695
1979			678	438	286	241	291	436	613	669	636	619
1980	619	450	327	274	230	218	313	589	625	631	609	655
1981	705	714	563	382	269	271	451	554	580	521	512	581
1982	641	639	492	256	241	222	286	300	304	398	512	529
1983	549	682	491	290	336	409	348					508
1984	673	623	296	280	227	142	181	279			325	529
1985	466	329	451	260	175	188	244	380	439	547	585	566
1986	645	582	489	403	219	222	282	415	439	441	494	564
N	23	23	24	24	25	25	25	24	23	24	25	25
Mean	641.7	630.3	550.8	370.1	264.4	273.1	368.2	480.5	546.2	586.0	594.4	612.1
Std	59.6	90.3	122.7	85.8	55.3	75.4	101.5	89.7	96.0	87.9	86.9	57.6
Min	466	329	296	255	175	142	181	279	304	398	325	508
Ma	737	782	753	572	401	438	593	614	662	710	721	704

Monthly salt loading is the difference between the base flow concentration of 842 mg/L, which was assumed to remain constant, and the monthly surface water concentration which varied on a monthly basis. The six months of November through April were considered to be the winter water season.

Winter seepage volumes of 1,238 and 2,331 acre-feet were computed using the seepage rates of 0.17 and 0.32 feet per day, respectively. Salt loading for the winter months ranged from 200 mg/L for the month of January to 472 mg/L for the month of April. Associated annual salt reduction from eliminating winter flows is estimated at 464 tons using the 0.17 foot per day seepage rate and 874 tons using the 0.32 foot per day seepage rate.

Cost Effectiveness Analysis

Cost estimates for the replacement water system were developed from unit cost data presented in the Lower Gunnison Basin Unit, Winter Water Replacement Preconstruction Report. Distribution system layouts were prepared for the delivery locations identified from an inventory conducted by representatives of the private ditches. Net annual O&M costs were determined by applying the existing Tri-County Water Conservancy District domestic water rate to the estimated replacement water volume, minus estimated O&M savings due to discontinuing winter canal diversions.

Capital costs were annualized using an 8-5/8 percent interest rate over a 50-year period. Total annual cost associated with the Colona area winter water replacement program is approximately $119,000 which results in a range of potential cost effectiveness values of $136 to $256 per ton. This component was therefore eliminated from further consideration.

Geyser well point source

Area Description

The geyser well discussed in this analysis is an abandoned petroleum exploration well which regularly discharges highly saline water with a TDS concentration range of 30,420 to 33,440 mg/L. It is located on the south bank of the Gunnison River, about 2.5 miles southeast of Austin.

Research yielded little data on this well, probably due to the date of the exploration—between November 1936 and April 1937. The drill hole was abandoned when petroleum was not encountered at a depth of 406 feet. No record exists of any attempt at plugging the well. Although a lithologic log of the hole has not been found, general geologic information suggests that the hole began in the Morrison Formation; penetrated the Junction Creek, Wanakah, and Entrada Formations; and probably bottomed near the top of Precambrian granite. The located records indicated that the well produced 100,000 to 250,000 cubic feet of carbon dioxide per day, but no mention was made of saline water. Because there is no evidence of geothermal activity, the carbon dioxide is the likely cause of the geyser effect.

Hydrosalinity

Both quantitative and qualitative approaches were taken to determine the effects of the geyser well on salinity levels in the river.

The salt dilution method was used to quantify the surface and ground water contribution of the geyser well area. This technique utilizes the equation relating the mixing of two liquid flow rates of know TDS concentrations.

In this case the two flows are the Gunnison River above the geyser well and the combined surface and base flow components originating from the geyser area.

Surface water discharged from the geyser well was quantified by installing a Parshall flume and continuous recorder. Water quality samples were periodically taken from the geyser well discharge and analyzed for TDS concentrations. Gunnison river water quality was determined by conducting EC cross sections above and below the geyser well. The EC data obtained above the geyser well served to define the Gunnison River water quality used in the salt dilution method. Gauging station data was used to quantify Gunnison River flows. By assuming the geyser well surface discharge water quality to be indicative of its ground-water component, the equation can be solved for the quantity of ground water flow entering the river from the geyser well area.

The results obtained from this method indicated that total geyser area flow is approximately 0.60 ft^3/s, 0.12 ft^3/s in the form of surface discharge and 0.48 ft^3/s from ground-water accretions. Based on the observed duration and frequency of eruption, this amount of flow would translate into an annual salt contribution of approximately 3,500 tons.

Stiff diagrams were used to qualitatively analyze the effects of the geyser well on Gunnison River water quality. Stiff diagrams graphically represent the constituent ions present in a water sample. A comparison of Stiff diagrams prepared for water quality samples taken above and below the geyser well shows little difference. This observation implies that the geyser well has an insignificant effect on the water quality of the Gunnison River and reinforces the results of the salt dilution method.

Six other abandoned petroleum exploration wells are located in close proximity of the geyser well. Since all seven wells are suspected to be situated on the same geologic structure, it is highly likely that a hydraulic connection exists between them. By only plugging the geyser well, surface flow or increased ground-water flow could be induced at the other wells. Since the estimated salt contribution from this area is relatively small in relation to the potential costs associated with conducting a geologic investigation to more thoroughly define the salt loading mechanisms, this area was dropped from further consideration as a salinity control alternative.