A STUDY OF SALINITY IN THE LOWER SOUTH PLATTE BASIN

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Project Overview

The second-year study of contract number 00FC601426 has been completed. This cooperative agreement between the Northern Colorado Water Conservancy District (District) and the United States Bureau of Reclamation (Bureau) provides federal funding for the project titled “A Study of Salinity in the Lower South Platte Basin.” The purpose of this project is to collect information regarding salinity issues and their impact on water quality and conservation within the District boundaries. This project will help build the foundation on which salinity issues are identified and from which management decisions are developed.

The level of severity of salinity in the Lower South Platte must be assessed. This will be accomplished by 1) collectively looking at past history/data regarding salinity issues, 2) monitoring salinity levels throughout the water delivery system, 3) monitoring groundwater salinity level and depth, and 4) conducting a District-wide soil assessment. The information collected will facilitate the building of a database exploring the scope of salinity issues within the District boundaries.

The District continues to research and collect past information regarding historical salinity concentrations throughout the Lower South Platte. This information will be used to form consensus on the severity of the salinity effects on the Lower South Platte. The Annual Summary report of 2001 listed additional information on this process. The District continues to gather information from other cooperating entities to further develop the District’s salinity database.

The 2002 season proved to be a very difficult and troublesome year for anyone involved in water related projects. The salinity study for the Lower South Platte basin was no exception. The 2002 season will be recorded as one of the driest years on record for the Lower South Platte. The South Platte River, tributaries, irrigation ditch systems and reservoirs recorded some of the lowest levels and/or flows on record. Many growers throughout Northeastern Colorado experienced severe crop loss due to the drought. Most growers fell short of meeting crop water requirements in the late season causing crop stress and decreased production. Because of the deficient water supplies, the agriculture and municipal sectors struggled to manage water delivery to their constituents. Consequently, water conservation has been elevated to a new benchmark with the reduction in water supplies experienced in 2002.

The salinity study was also affected by the drought of 2002. With the reduction in water supplies, many agricultural irrigation ditch systems made limited deliveries to growers resulting in very dry soil conditions. The growers who owned ground water wells seemed to weather the drought better than surface water users. In 2001 the District purchased a Dual-Dipole Electrical Conductivity (EM38-DD) meter form Geonics Limited to conduct the soil salinity surveys. Soil moisture is a concern when correlating the EM38-DD electrical conductivity (EM) reading to actual electrical conductivity (EC_e) readings. Soil moisture has perhaps the greatest single influence on reliable correlations between EM and EC_e readings. Several trials conducted by the United State Salinity Lab (USSL) showed conclusive data that correlations between EM and EC_e deteriorates as soil moisture decreases. Knowing this, the District spent considerable time exploring options to determine soil moisture during the field surveys.
After consulting in-house and with other cooperating entities it was determined that by increasing the soil sampling frequency in the field more emphasis could be placed on \( EC_e \) than on the correlation of the EM readings. ESAP, created by the USSL, is the software used to conduct the statistical analyses when correlating EM and \( EC_e \) relationships. If ESAP determines a poor correlation, the EM38-DD does not accurately identify salinity issues within the field, and the \( EC_e \) could be used in place of the EM readings. However, the current procedure calls for a minimal amount of sampling sites, relying more on the EM readings.

To fairly represent salinity levels within a dry field, the number of soil samples will need to increase. These additional samples would possibly double the amount of time required to survey but would be necessary in order to reasonably represent salinity issues within a field. This method would not generate the most desirable result in the form of a variable \( EC_e \) map, as with the EM readings, but it would keep this project moving forward. Hopefully the weather will cooperate more in the year to come. The final sampling process will be chosen during the field surveys based on soil moisture conditions.

While the soil salinity surveys did not go as planned, the drought provided beneficial time and conditions to install the 20 automated stream flow monitoring sites and groundwater observation (GWO) wells. Currently the automated sites are continually reading Electrical Conductivity in the water (EC\(_w\)) at three locations on the Cache la Poudre River, three locations on the Big Thompson River, one location on the Little Thompson River, four locations on the Saint Vrain River and six locations on the South Platte River. The three other stations are located on agricultural irrigation canal systems. The automated sites have been revisited to determine if their location and installation are the most beneficial. Some modifications will be made in 2003 to expand and insure the best possible coverage in the lower South Platte Basin.

In addition to the automated stream flow monitoring sites, the District planned to install 20 GWO wells. The United State Geological Service (USGS) and the Colorado State Health Department have installed several GWO wells throughout Northeastern Colorado. The District has cooperated with both entities to gain excess to these wells. Currently, District personal are sampling EC\(_w\) and ground water level from 30 GWO wells throughout Northeastern Colorado. This supporting data allows the District to analyze conditions as surface water infiltrates into crop root zones and eventually works its way to the South Platte River. High soil salinity has long been associated with elevated ground water levels. With more then 5,000 agricultural groundwater wells providing irrigation in Northeastern Colorado, the data collected from the GWO wells is a very significant part of this project. Ten of the GWO wells have automated sensors, which continually monitor ground water depth throughout the year. The District will continue to look for additional wells that have already been installed by other cooperating entities. Additionally, the District has five GWO wells (the last of twenty) that will be installed in 2003.

Stream flow data collected during 2002 will be represented by systems. The systems are: South Platte River, Cache la Poudre River, Big Thompson River, Little Thompson River, Saint Vrain River, North Sterling Canal and Prewitt Reservoir, Morgan Canal and Jackson Reservoir, and Riverside Canal. The GWO well data will be represented over
the entire District boundaries. If there are questions regarding this report, please contact Alan A. Halley or Mary J. Hattendorf at (970) 667-2437.
Surface Water Specific Conductivity Sampling

Surface water sampling in 2002 included automated monitoring of streams and selected canal systems. Continuous, automated monitoring shows the variability of specific conductivity in a river system on a temporal and spatial basis. Automated stations were co-located with stream gauge sites. While specific conductivity is a meaningful parameter, salt loading cannot be calculated without flow measurements. Ancillary data collected in addition to the specific conductivity values included water temperature (normalizes electrical conductivity to the 25 C standard reporting value), air temperature, and rainfall.

Manual sampling continued throughout 2002, with data collected from stream sites and canal systems. Co-location of automated and manually sampled sites allowed some comparison between instruments and methods. In this analysis, the datasets were combined where appropriate to provide as much of a year-round data view as possible. Instrumentation of each technique is described in the QA/QC document for this project.

Automated Stream Network

Twenty automated specific conductivity (SpC) stations were installed throughout 2002 (TABLE 1.0, MAP 1.0). Installation of the EC sensor at South Platte Henderson was delayed until early 2003 because of fluctuating water conditions and time issues.

The automated monitoring system reported data on a 15-min average basis from time of installation. Data were condensed to weekly averages to smooth some of the short-term variability and highlight general patterns.
TABLE 1.0 Automated salinity monitoring stations and dates of installation.

<table>
<thead>
<tr>
<th>Description</th>
<th>Abbreviation</th>
<th>Date Installed</th>
</tr>
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<tbody>
<tr>
<td>Big Thompson at Canyon Mouth</td>
<td>BT CanyonMth</td>
<td>12 July 2002</td>
</tr>
<tr>
<td>Big Thompson at Loveland</td>
<td>BT Loveland</td>
<td>2 October 2001</td>
</tr>
<tr>
<td>Big Thompson at LaSalle</td>
<td>BT LaSalle</td>
<td>9 April 2002</td>
</tr>
<tr>
<td>Cache la Poudre at Canyon Mouth</td>
<td>CLP CanyonMth</td>
<td>24 July 2002</td>
</tr>
<tr>
<td>Cache la Poudre above Boxelder Creek</td>
<td>CLP Boxelder</td>
<td>29 May 2002</td>
</tr>
<tr>
<td>Cache la Poudre at New Cache head gate</td>
<td>CLP NewCache Hdgate</td>
<td>29 May 2002</td>
</tr>
<tr>
<td>Cache la Poudre below Greeley</td>
<td>CLP Greeley</td>
<td>26 March 2002</td>
</tr>
<tr>
<td>New Cache Canal near Lucerne</td>
<td>New Cache Lucerne</td>
<td>30 May 2002</td>
</tr>
<tr>
<td>Little Thompson at Canyon Mouth</td>
<td>LT CanyonMth</td>
<td>20 March 2002</td>
</tr>
<tr>
<td>St Vrain Creek below Lyons</td>
<td>SVC Lyons</td>
<td>19 July 2002</td>
</tr>
<tr>
<td>St Vrain Creek above Longmont</td>
<td>SVC av Longmont</td>
<td>19 August 2002</td>
</tr>
<tr>
<td>St Vrain Creek below Longmont</td>
<td>SVC bw Longmont</td>
<td>2 June 2002</td>
</tr>
<tr>
<td>St Vrain Creek near Platteville</td>
<td>SVC Platteville</td>
<td>16 April 2002</td>
</tr>
<tr>
<td>South Platte at Henderson</td>
<td>SP Henderson</td>
<td>12 Sept 2002</td>
</tr>
<tr>
<td>South Platte at Kersey</td>
<td>SP Kersey</td>
<td>11 April 2002</td>
</tr>
<tr>
<td>South Platte at Weldona</td>
<td>SP Weldona</td>
<td>10 July 2002</td>
</tr>
<tr>
<td>South Platte at Fort Morgan</td>
<td>SP Ft Morgan</td>
<td>23 August 2002</td>
</tr>
<tr>
<td>Morgan Canal Head gate</td>
<td>Morgan Hdgate</td>
<td>2 April 2002</td>
</tr>
<tr>
<td>South Platte at Balzac</td>
<td>SP Balzac</td>
<td>12 June 2002</td>
</tr>
<tr>
<td>South Platte at Julesburg</td>
<td>SP Julesburg</td>
<td>29 August 2002</td>
</tr>
</tbody>
</table>
Specific conductivity in the river systems increased from the upstream canyon measurement points to the populated areas. On the Big Thompson and South Platte systems, specific conductivity increased going down stream. Specific conductivity leveled off between the populated areas and the stream’s mouth on the Cache la Poudre and St. Vrain systems.

While specific conductivity is an indicator of water salinity, it does not indicate the total mass of salts in a system. The conversion of SpC to total dissolved solids (TDS) in mass per volume multiplied by the total flow volume over a certain time period provides salt loading at the monitoring points. Salt load (TDS) was calculated on a monthly and annual basis for each system when adequate data were available for flow and EC.

MAP 1.1 shows Annual TDS for the lower South Platte system and sampled tributaries. Total Dissolved Solids above Henderson (near Denver) were estimated from several years of USGS specific conductivity and flow data. When data were incomplete for the automated monitoring stations, TDS was calculated on a daily basis where data was available. Average daily TDS was calculated for the monitoring period, multiplied by 365 days per year and summed to get a qualitative estimate of annual loading at each monitoring station. This methodology assumes that this average daily value can qualitatively represent TDS on an annual basis.
The tributaries show comparatively low salt loading on an annual basis. Salt loading was linearly interpolated along the stream segment length between each site to achieve the color gradations (MAP 1.1). Salt load was comparatively low at Julesburg and around Fort Morgan compared to the rest of the South Platte below Henderson. Flow was exceptionally low at some locations, and despite higher SpC at Julesburg, flow heavily weights the annual TDS calculation.

MAP 1.1 Annual Total Dissolved Solids in the lower South Platte.

**Manual (Grab) Sampling**

Sites for grab samples were initially chosen to coincide with stream gauge sites. These data were collected on a weekly basis throughout the growing season and on a bi-weekly to monthly basis during the off-season. Grab sample data filled temporal gaps until the automated stations could be brought on line and were incorporated into the automated database when the data from each method proved to be similar. When incorporated, the manual samples were assumed to represent a 24-hour period and were weighted accordingly. Stream grab sample sites are depicted in MAP 2.0.
MAP 2.0 Manual sample site locations in northeastern Colorado.

**Cache la Poudre System**

Weekly average specific conductivity ranged from 0.006 at the canyon mouth to 2.33 dS/m below Greeley. Specific conductivity was typically lowest between weeks 20 and 30 (FIGURES 2.0-2.3). Flow also tended to be higher during this period except at Greeley (FIGURE 2.2), where little flow variation was observed. Increased flow and lower SpC suggest a dilution effect. Flow ranged from 0.8 at Boxelder Creek to 686 cfs at the canyon mouth.
FIGURE 2.2

FIGURE 2.3

FIGURES 2.0-2.3 Cache la Poudre 2002 weekly average specific conductivity and flow.

Annual SpC was plotted against distance downstream in the system. Distance 0 was the monitoring station furthest upstream on the Cache la Poudre. The three measurement points in Fig. 2.4 were at the canyon mouth, at Boxelder Creek (downstream of Fort Collins, and at Greeley (downstream of the waste treatment plant). Standard error bars show the variability of data included at each monitoring location. The Boxelder Creek site showed large variability compared to the other sites on the Cache la Poudre. This was typical even in a USGS water quality dataset spanning several decades.

FIGURE 2.4 Cache la Poudre system 2002 annual specific conductivity and distance downstream.

Grab samples below Fort Collins showed large fluctuations in SpC during 2002 (FIGURES 2.5-2.9). The canyon mouth samples were very low, with variability fairly low except in September and November. Specific conductivity was higher in general at Greeley, but variability of each monthly average was moderate throughout the year.
Overall, TDS was lowest at the canyon mouth, fairly low at Boxelder Creek throughout the year, and moderate to high at Greeley during 2002 (FIGURES 2.10-2.13). In general, salt loading increased with distance downstream. Monthly TDS was highest at the New Cache Canal headgate in May at 6360 T (tons). Limited data were collected at the New Cache Canal headgate site because the canal did not run past August. In months before the monitoring stations were installed, grab sample data represented the entire month for SpC.
Big Thompson System

A low weekly average SpC (0.042 dS/m) was observed at the canyon mouth of the Big Thompson (FIGURE 2.14) just as at the Cache la Poudre canyon mouth. SpC increased with distance downstream. Greatest SpC variability was at Loveland, the second monitoring station on the Big Thompson. Maximum average weekly flow on the Big Thompson was 164 cfs at the canyon mouth during Week 21. Flow diminished to a low of 2.5 cfs at Loveland in the latter part of 2002.

The Big Thompson at Loveland showed a clear relationship of SpC and flow (FIGURE 2.15). When flow increased drastically between weeks 10 and 20, SpC decreased rapidly. Between weeks 40 and 50, flow decreased and SpC increased.

Specific conductivity at LaSalle was uniformly higher with little variation as occurred at Loveland, ranging between about 1.2 to 1.9 dS/m (FIGURE 2.16). Maximum average weekly SpC on the Big Thompson system was 1.88 dS/m near LaSalle.
FIGURES 2.14-2.16 Big Thompson system 2002 weekly average specific conductivity and flow.

Grab samples from the Big Thompson followed the trend of the automated site weekly average SpC. Variability and SpC were lowest at the upstream sampling sites (FIGURES 2.17-2.21). Greatest SpC and variability occurred at LaSalle, the furthest downstream sampling site (FIGURE 2.22).
FIGURES 2.17-2.21 Big Thompson system 2002 monthly specific conductivity grab samples.
FIGURE 2.22 Big Thompson system 2002 annual specific conductivity and distance downstream.

Monthly TDS was highest at LaSalle at approximately 2740 T in December and as expected was lowest at the canyon mouth (116 T) in April (FIGURES 2.23-2.25) During months before the monitoring stations were installed, grab sample data represented the entire month for SpC.

FIGURES 2.23-2.25 Big Thompson system 2002 monthly total dissolved solids and specific conductivity.
Saint Vrain System

Weekly specific conductivity was lowest at Lyons at 0.038 dS/m (FIGURE 2.26). Highest SpC on the St Vrain system was downstream at Platteville at 1.6 dS/m (FIGURE 2.28). The SpC and flow patterns at the site below Longmont (FIGURE 2.27) resembled the cycles of SpC and flow at Platteville. The state gauging station above Longmont was not installed until after July 1, 2002. The NCWCD SpC monitoring station was installed in August. Data from the above Longmont site are therefore limited in 2002. Average weekly flow was highest at Lyons early in 2002 and later in the year. Flows downstream on the St Vrain were higher between weeks 20 and 40.

FIGURES 2.26-2.28 St. Vrain system 2002 weekly average specific conductivity and flow.

Grab-sampled specific conductivity was uniformly low at Lyons throughout the year, following the trend of upstream SpC being lower than downstream SpC (FIGURE 2.29). Below Longmont, SpC ranged from 0.87 to 1.56 dS/m in 2002 (FIGURE 2.30). SpC was similar at Platteville, ranging from 0.89 to 1.6 dS/m (FIGURE 2.31). Monthly averaged grab samples on the St. Vrain showed similar ranges to the automated monitoring stations. Standard deviations of samples indicated that there was some variability over the monthly period at the downstream sites. The Lyons site had very uniform, low SpC with little variability.
As was typical in each system, SpC increased from the upstream monitoring stations to the downstream monitoring stations (FIGURE 2.32). Specific conductivity leveled off between the below Longmont station and Platteville.
Monthly TDS was highest at Platteville with a salt load of approximately 4900 T in July (FIGURE 2.35). Loading at Lyons was extremely low, less than 700 T at peak in December (FIGURE 2.33).

FIGURES 2.33-2.35 St. Vrain system 2002 monthly total dissolved solids and specific conductivity.

Little Thompson System

With only one monitoring station on the Little Thompson, it was not possible to track SpC or TDS from the upstream monitoring site to the downstream portions of the Little Thompson. More monitoring and sampling sites will be added in 2003.

At the canyon mouth, SpC ranged from a weekly average minimum of 0.26 to a maximum of 0.98 dS/m. Flows in the Little Thompson were extremely low in 2002, ranging from 0.23 (week 32) to 37.21 cfs (FIGURE 2.36).
FIGURE 2.36 Little Thompson system 2002 weekly average specific conductivity and flow.

Grab samples from the Little Thompson followed trends similar to the weekly averaged SpC, although taken from a bridge downstream from the gauging station in the canyon. Variability was greatest when SpC was lowest (FIGURE 2.37).

FIGURE 2.37 Little Thompson system 2002 monthly specific conductivity grab samples.

Total dissolved solids were low also, ranging from 12.4 T/mo to 119 T/mo (FIGURE 2.38).

FIGURE 2.38 Little Thompson system 2002 monthly total dissolved solids and specific conductivity.
South Platte System

No SpC data were available from Henderson in 2002. The most upstream gauging site on the South Platte within the District boundaries is at Kersey, which limits the amount and quality of data that can be obtained from the South Platte system for District purposes. A new site is planned at Fort Lupton for 2003, which should add another upstream monitoring point that will aid in assessing the effects of incoming tributary flow. Other gauge sites may be installed at Sterling, which will provide much-needed data between Balzac and Julesburg.

Specific conductivity ranged from a minimum of 0.8 dS/m at Kersey to a maximum of 2.24 dS/m at Julesburg, Channel 1 (FIGURES 2.39-2.42). No weekly average flow was available for the Fort Morgan gauge site, which was newly installed in 2002. However, weekly average SpC tended to be lower than SpC at Kersey, Weldona or Balzac.

Specific conductivity was generally higher overall on the monitored portion of the South Platte than on the tributaries, which showed an increase in SpC from the canyon mouths to the downstream segments. Because monitoring on the South Platte did not include any points above the plains, this is not an unexpected result.

Flow was variable at Kersey, ranging from less than 200 cfs to above 600 cfs during 2002. Flow at Weldona peaked during Week 29 at over 400 cfs. Flows at Balzac and Julesburg (Ch 1) were low throughout the season, although flow was very high at Julesburg early in 2002. Between weeks 20 and 50, flow was measured in the single digits at Julesburg, thus complicating EC sensor installation.
FIGURES 2.39-2.42 South Platte system 2002 weekly average specific conductivity and flow.

Grab samples reflected the trends and tendencies observed in the automated monitoring systems. Variability was moderate at all sites (FIGURES 2.43-2.47).
FIGURES 2.43-2.47 South Platte system 2002 monthly specific conductivity grab samples.

As expected, SpC increased as distance downstream from Henderson increased, with a dip in SpC at Fort Morgan.

FIGURE 2.48 South Platte system 2002 annual specific conductivity and distance downstream.

Total Dissolved Solids reached above 44000 T/mo at Kersey in August. Kersey by far had the highest total annual salt loading of all the South Platte sites (FIGURES 2.49-2.52). Salt loading was lowest at Julesburg, mainly because of the influence of low flow in the TDS calculation.

Specific conductivity above Henderson was estimated from a multi-year average of SpC from USGS data. Annual flow for the TDS calculation was taken at the USGS gauging station at Englewood in 2000. The TDS value at Henderson is therefore not exact but provides a qualitative picture of salt load in the upstream portion of the South Platte.
FIGURES 2.49-2.52 South Platte system 2002 monthly total dissolved solids and specific conductivity.
Canal Irrigation Specific Conductivity Sampling

Riverside Irrigation System

The Riverside Canal system ran through July and August 2002 (MAP 3.0). Specific conductivity during those months was between 1.3 and 1.5 dS/m. Variability was low. Specific conductivity did not change appreciably from the upstream portion of the canal to the downstream (FIGURES 3.0-3.6).

MAP 3.0 Riverside Irrigation System 2002 manual sampling sites.
FIGURES 3.0-3.6 Riverside Irrigation System 2002 monthly specific conductivity grab samples.
North Sterling Irrigation System

The North Sterling Canal system begins at the North Sterling Diversion (MAP 3.1). The Diversion site and the North Sterling Inlet Gauge site ran through November and December 2002. Specific conductivity was about 1.75 to 1.8 dS/m and had little variability (FIGURES 3.7-3.8).

Map 3.1 North Sterling Irrigation System 2002 manual sampling sites.

FIGURES 3.7-3.8 North Sterling Irrigation System 2002 Diversion and Inlet Gauge monthly specific conductivity grab samples.
At the Prewitt Reservoir Diversion, SpC was about 2.0 dS/m in June and July (FIGURE 3.9), but slightly lower at the Prewitt Outlet Spillway in August (FIGURE 3.10). The Johnson and Edwards Outlet ran in June and July also (FIGURE 3.11, with SpC ranging from about 1.8 to just above 2.0 dS/m.

Further east, the North Sterling Reservoir Gauge (FIGURE 3.12) ran in November and December with a SpC of 1.85 dS/m. Little variability was observed. At the reservoir outlet, SpC was around 1.6 dS/m in June, July, and August with small variability (FIGURE 3.13). One-third of the way down the canal, SpC was between 1.5 and 1.6 dS/m in June, July, and August 2002 (FIGURE 3.14), with little change 2/3 of the way down the canal for the same time period (FIGURE 3.15). Specific conductivity at the canal end was also between 1.5 and 1.6 dS/m in June, July and August 2002 (FIGURE 3.16). Specific conductivity measured at the Parshall flumes on the system were nearly identical to values shown in FIGURES 3.12-3.16 and therefore are not shown.

FIGURES 3.9-3.11 North Sterling Irrigation System 2002 Prewitt Reservoir monthly specific conductivity grab samples.
FIGURES 3.12-3.16 North Sterling Irrigation System 2002 monthly specific conductivity grab samples.
Fort Morgan Reservoir Irrigation system

The Fort Morgan Canal sampling scheme is shown in MAP 3.2.

MAP 3.2 Fort Morgan Irrigation system 2002 manual sampling sites.

The Jackson Reservoir Inlet Gauge was sampled in November and December. Specific conductivity was around 1.5 dS/m (FIGURE 3.18). A similar SpC was observed at the Jackson Inlet Reservoir sampling site (FIGURE 3.19). At the Jackson Reservoir Outlet (FIGURE 3.21), the June, July, and August SpC increased from just less than 1.5 dS/m to about 1.7 dS/m in August. The Jackson Outlet Gauge is close to the Jackson Reservoir Outlet and SpC values are very similar (FIGURES 3.20-3.21). Specific conductivity at the Outlet Spillway increased from about 1.3 to 1.6 dS/m from June to August 2002 (FIGURE 3.22).
FIGURES 3.17-3.22 Fort Morgan Reservoir Irrigation System 2002 Jackson Reservoir monthly specific conductivity grab samples.

The Fort Morgan Canal was sampled at the Diversion and Headgate during January, May, June, and July, November, and December 2002 (FIGURES 3.23-3.24). Specific conductivity was between 1.3 and 1.6 dS/m. Specific conductivity changed little at the next downstream sampling site, the D-T Ranch (FIGURE 3.25). Sampling in June, July,
November, and December showed SpC just below 1.5 to just above 1.5 dS/m. Specific conductivity at the Western Sugar Flume, South Side Flume, and the Badger Creek Flume were all approximately 1.5 dS/m throughout the sampling months (FIGURES 3.26-3.28). No data were available from the Pawnee 2 site.

FIGURES 3.23-3.28 Fort Morgan Irrigation System 2002 monthly specific conductivity grab samples.
Groundwater Sampling

The District collected data and sampled several groundwater monitoring wells throughout 2002 (MAP 4.0). The District installed 15 of 20 proposed new groundwater monitoring throughout Northeastern Colorado. The new wells were located to fill in gaps between other monitoring networks. Wells sampled include 319 wells, which are mostly in the eastern portion of the District, plus wells in the northern part of Larimer County. Central Colorado Water Conservancy District has a well network in the southern part of the study area with extensive coverage in key areas. The CCWCD has cooperated with the District by sharing information for the salinity project.

MAP 4.0 Groundwater manual sampling sites 2002.

Groundwater data are a sensitive issue for many landowners. Therefore, groundwater information is aggregated by block kriging over 5-mile square blocks where data existed. From January through April 2002, not enough data existed to perform block kriging. These data are represented as polygon blocks of simple-averages without geostatistical analysis. Because of confidentiality, a single data point will represent of a 5-mile square area. Annual and monthly maps of groundwater specific conductivity show higher specific conductivities in general than surface water samples (MAPS 4.1-4.12).
MAP 4.1 Average annual groundwater specific conductivity, 2002.

MAP 4.2 January 2002 groundwater specific conductivity. Lowest specific conductivity was found in the mid-portion of the District.
MAP 4.3 February 2002 groundwater specific conductivity. Limited sampling was conducted in February. Higher specific conductivity was associated with the western portion of the District near the Front Range.

MAP 4.4 March 2002 groundwater specific conductivity. Sampled only near the Front Range. Specific conductivities were mid-range on a scale of 0 to 7 dS/m.
MAP 4.5 April 2002 groundwater specific conductivity. Groundwater was sampled more extensively from the center of the District to the eastern boundaries. A higher value of specific conductivity was found near the downstream end of the South Platte in Colorado.

MAP 4.6 May 2002 groundwater specific conductivity. Extensive sampling occurred in May 2002. Higher specific conductivity was found near the eastern boundaries of the District, while specific conductivity was fairly uniform throughout the rest of the District.
MAP 4.7 June 2002 groundwater specific conductivity. June 2002 had higher specific conductivity near the Front Range and sections further east.

MAP 4.8 July 2002 groundwater specific conductivity. Specific conductivity was highest near the Front Range. Several high specific conductivity areas were located in the northern portion of Larimer County.
Specific conductivity was lower than in the previous month. Elevated values of specific conductivity were located east of Loveland and Berthoud, and east of Longmont.

MAP 4.10 September 2002 groundwater specific conductivity. Groundwater specific conductivity was elevated near the Front Range and toward Julesburg.
MAP 4.11 October 2002 groundwater specific conductivity. Specific conductivity of groundwater was higher near the Front Range and near the downstream boundary of the District.

MAP 4.12 November 2002 groundwater specific conductivity. Specific conductivity was elevated near the Front Range and downstream near Julesburg.
MAP 4.13 December 2002 groundwater specific conductivity. Values were fairly uniform throughout the District, with some elevated values near the Front Range. Some low values occurred throughout the District.

December 2002
Conclusions

The drought experienced in 2002 will be recorded as one of the worst droughts in Colorado history. It resulted in a very challenging year for the salinity assessment study. The biggest disappointment was the inability to conduct soil salinity surveys. However, it allowed time for evaluating the stream flow monitoring network incorporated by the District. Changes to the monitoring network will be an ongoing effort throughout the term of this project. The changes are necessary to insure that accurate and beneficial data are being collected for the project. The earlier part of 2002 began slowly but as more monitoring sites were installed and wells drilled the network begin to take shape, building an excellent database for future use. The data collected in the drought year of 2002 will provide an interesting perspective when compared to a more normal year. The District hopes for a more favorable year in 2003 and looks forward to the work ahead.
The following table summarizes 2002 expenditures. The labor and cost of materials for installation of the monitor network was the bulk of costs in 2002. Approximately $81,684 will be carried over to the 2003 season. Because of the problems explained earlier not all of the anticipated tasks where completed in 2002.

<table>
<thead>
<tr>
<th>Task category</th>
<th>Budget</th>
<th>Expenses</th>
<th>Difference</th>
<th>Carry forward to fy-2002</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical specialist/consultants</td>
<td>$84,894</td>
<td>$51,568.28</td>
<td>$33,326</td>
<td>$0</td>
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<tr>
<td>Field technicians</td>
<td>$16,800</td>
<td>$41,385.85</td>
<td>$(24,586)</td>
<td>$0</td>
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<tr>
<td>Vehicle usage</td>
<td>$10,000</td>
<td>$20,421.12</td>
<td>$(10,421)</td>
<td>$0</td>
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<tr>
<td>Field computers, software, &amp; cell phones</td>
<td>$1,050</td>
<td>$89.27</td>
<td>$961</td>
<td>$961</td>
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<tr>
<td>Water quality probes &amp; test kits</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>Portable flow meters &amp; equipment</td>
<td>$1,249</td>
<td>$1,239.78</td>
<td>$9</td>
<td>$0</td>
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<tr>
<td>Data loggers, sensors, telemetry, etc.</td>
<td>$31,977</td>
<td>$11,359.74</td>
<td>$20,617</td>
<td>$20,617</td>
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<td>Remote site telemetry operation</td>
<td>$6,000</td>
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<tr>
<td>GPS units</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
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<tr>
<td>DDEM-38 probes</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
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<tr>
<td>Salinity rig &amp; hydraulic soil sampling unit</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>Groundwater monitoring wells</td>
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<td>$4,332.97</td>
<td>$13,304</td>
<td>$13,304</td>
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<td>Cooperative efforts with other organizations</td>
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<td>$0.00</td>
<td>$10,000</td>
<td>$10,000</td>
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<tr>
<td>Interagency coordination/travel/training</td>
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<td>$576.11</td>
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<tr>
<td>Yield sampling/monitoring equipment</td>
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<td>$15,500</td>
<td>$15,500</td>
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<tr>
<td>Laboratory /GIS specialist</td>
<td>$24,000</td>
<td>$46,820.61</td>
<td>$(22,821)</td>
<td>$0</td>
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<td>Laboratory supplies, reagents, etc.</td>
<td>$6,000</td>
<td>$1,600.01</td>
<td>$4,400</td>
<td>$0</td>
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<tr>
<td>Presentations, fact sheets, etc.</td>
<td>$1000</td>
<td>$0.00</td>
<td>$1000</td>
<td>$1000</td>
</tr>
<tr>
<td>Field days, BMP workshops, etc.</td>
<td>$2,400</td>
<td>$0.00</td>
<td>$1,000</td>
<td>$1000</td>
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<tr>
<td>PC projector, laptop, software, etc.</td>
<td>$14,500</td>
<td>$5,439</td>
<td>$9,061</td>
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<td>Web page programming</td>
<td>$2,000</td>
<td>$0</td>
<td>$2000</td>
<td>$2000</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>$250,057</strong></td>
<td><strong>$188,465.55</strong></td>
<td><strong>$61,591</strong></td>
<td><strong>$81,684</strong></td>
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