7-94

ONLINE IRRIGATION SCHEDULING CONSULTANT FOR THE BELLE FOURCHE IRRIGATION DISTRICT

Topical Report RSI-2192

prepared for

Natural Resources Conservation Service
Conservation Innovation Grants
P.O. Box 2890
Room 5239 South Building
Washington, D.C. 20013-2890

January 2011

RESPEC
CONSULTING & SERVICES

ONLINE IRRIGATION SCHEDULING CONSULTANT FOR THE BELLE FOURCHE IRRIGATION DISTRICT

Topical Report RSI-2192

by

Jared K. Oswald

RESPEC
P.O. Box 725
Rapid City, South Dakota 57709

prepared for

Natural Resources Conservation Service
Conservation Innovation Grants
P.O. Box 2890
Room 5239 South Building
Washington, D.C. 20013-2890

January 2011

TABLE OF CONTENTS

LIST OF TABLES

TABLE | PAGE

LIST OF FIGURES

1.0 INTRODUCTION

The Belle Fourche Irrigation District (BFID), identified in Figure 1-1, is a gravity-fed, canal-based system located in western South Dakota. Recurring droughts often limit the amount of water available for irrigation in the BFID. In 1998, the South Dakota Department of Environment and Natural Resources (SD DENR) listed the Belle Fourche River, which flows through the BFID, as impaired because of excessive amounts of total suspended solids (TSS). Simply put, the water quality of the river made it hard for fish to thrive. A Total Maximum Daily Load (TMDL) study, completed by the U.S. Environmental Protection Agency (EPA) in 2003, determined sediment-laden return flows originating from irrigated lands of the BFID were a significant contributor to the sediment entering the river. The study recommended several best management practices (BMPs) that would help reduce sediment concentrations in the river, one of which was irrigation scheduling. The Belle Fourche River Watershed Partnership (BFRWP) received a Conservation Innovation Grant (CIG) in 2007 to design a Geographic Information System- (GIS-) enabled Website that would give the individual producers in the BFID a variety of tools to manage and analyze the application of water to each field. The purpose of this project was to provide producers with a reliable, easy-to-use means to monitor and schedule irrigations that will conserve water and reduce the amount of sediment-laden irrigation return flows that are discharged into the adjacent Belle Fourche River.

The online irrigation scheduling consultant (OISC) software allows producers with Internet access to create a secure, personalized Web page that provides irrigation scheduling advice for a particular field. The software collects daily weather data to estimate rainfall and calculate crop evapotranspiration (ET) using the American Society of Civil Engineers (ASCE) Penman method and locally adapted crop coefficients Irrigation delivery amounts, entered online by the producer, are added to the rainfall estimates for that location The OISC software then calculates a soil water balance and provides day-to-day irrigation scheduling for the field. Soil moisture sensors installed at two depths are recorded to provide online tracking of relative soil water changes throughout the irrigation season. The producer has the option to adjust the calculated soil water balances or measured rainfall amounts based on the recorded soil moisture data or their observations at the field. Using the daily information provided by the Website in the form of a Soil Moisture graph and color-coded map value rendering daily water instructions, producers are better able to gauge their individual water needs so as not to over- or underapply

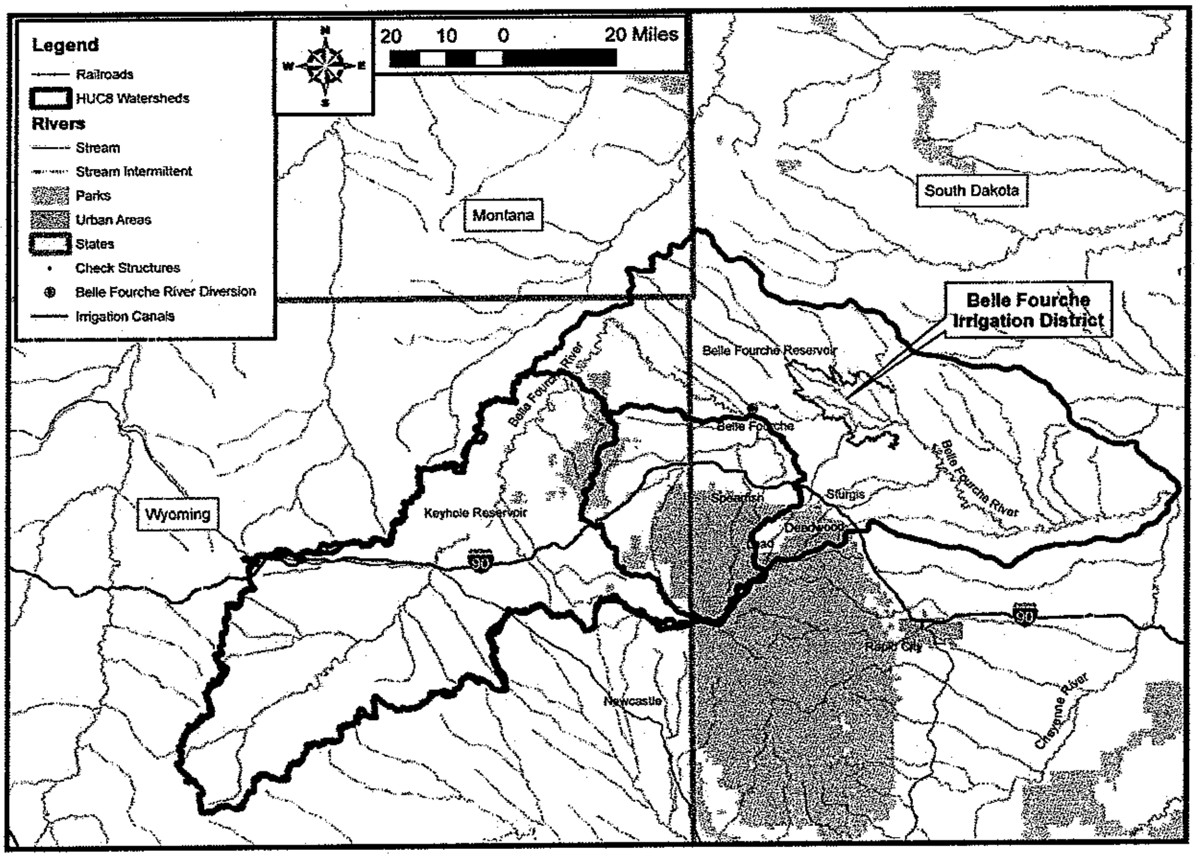

Figure 1-1. Location of the Belle Fourche Irrigation District Within the Belle Fourche River Watershed.

2.0 TIMELINE

The overall project was completed in the timeframe originally proposed. Figure 2-1 displays the originally proposed timeline while Figure 2-2 displays the time frame it took to complete the project. The major difference is that the project planning phase was originally proposed to be complete after the first quarter in 2008. The project team discovered that the development of the database, scheduling calculator, and Web pages along with performance testing of the Website would have to be a dynamic, interactive process that would need to be adaptable to the producer's needs as they arose. Also, cooperating producers were volunteering to participate in the irrigation scheduling program throughout its duration

RSI-1793-11-002

ID	Task Name	Duration	Start
1	**Conservation Innovation Grant**	36 months	Sep-07
2	**Project Planning**	8 months	Sep-07
3	-Order Monitoring Equipment	1 month	Sep-07
4	-Develop Database	1 month	Sep-07
5	-Develop Irrigation Scheduling Calculator	3 months	Oct-07
6	-Develop Web Pages	2 months	Jan-08
7	-Identify Cooperating Producers	6 months	Oct-07
8	-Performance Test Web Site	2 months	Mar-08
9	**Project Implementation**	28 months	May-08
10	-Install Monitoring Equipment	1 month	May-08
11	-First Summer Implementation	4 months	Jun-08
12	-First Summer Calibration	6 months	Oct-08
13	-Second Summer Implementation	4 months	Jun-09
14	-Second Summer Calibration	6 months	Oct-09
15	-Third Summer Implementation	4 months	Jun-10
16	**Public Outreach**	30 months	Mar-08
17	**Financial Status Report**	35 months	Oct-07
18	**Final Report**	2 months	Aug-10

Figure 2-1. Proposed Project Timeline.

ID	Task Name	Duration	Start
1	**Conservation Innovation Grant**	37 months	Sep-07
2	**Project Planning**	37 months	Sep-07
3	-Order Monitoring Equipment	1 month	Sep-07
4	-Develop Database	10 months	Sep-07
5	-Develop Irrigation Scheduling Calculator	33 months	Oct-07
6	-Develop Web Pages	30 months	Jan-08
7	-Identify Cooperating Producers	32 months	Oct-07
8	-Performance Test Web Site	31 months	Mar-08
9	**Project Implementation**	29 months	May-08
10	-Install Monitoring Equipment	1 month	May-08
11	-First Summer Implementation	4 months	Jun-08
12	-First Summer Calibration	6 months	Oct-08
13	-Second Summer Implementation	4 months	Jun-09
14	-Second Summer Calibration	6 months	Oct-09
15	-Third Summer Implementation	4 months	Jun-10
16	**Public Outreach**	31 months	Mar-08
17	**Financial Status Report**	36 months	Oct-07
18	**Final Report**	2 months	Aug-10

Figure 2-2. Actual Project Timeline.

3.0 BUDGET

The proposed and actual project budget is shown in Table 3-1 The project was completed within the budget originally proposed with one minor adjustment. Funds in the amount of $4,000 were moved from the BFRWP administrative cost allocation to the Supplies budget to cover the cost of soil moisture sensors. The purchase was made because the participants' demand exceeded the original estimate. The local match (nonfederal) portion of the budget was provided in cash instead of an in-kind match by irrigators within the watershed installing irrigation water conservation practices. These practices were also more often than not supplemented with EPA 319 funds administered by the SD DENR Not included in this budget estimate are the Natural Resources Conservation Service (NRCS) Environmental Quality Incentives Program (EQIP) dollars that were also invested in the watershed for similar irrigation-related practices.

Table 3-1. Proposed and Actual Project Budget

Budget Category	Proposed		Actual	
	Federal	Nonfederal	Federal	Nonfederal
Contractual	$401,600		$401,600	
South Dakota State University Student Labor	$21,000		$21,000	
Supplies (Rain Gages, Flow Meters, Weather Stations, and Soil Moisture Stations)	$42,000		$46,000	
BFRWP Administrative	$35,400		$31,400	
Producer Cash		$300,000		$500,000
Producer In-Kind		$200,000		
EPA 319	$100,000		$577,600	
Total Budget	**$600,000**	**$500,000**	**$1,077,600**	**$500,000**

4.0 RESULTS

The following sections are summaries of the semiannual reports submitted to the NRCS technical contact on this project. Some of the technology and software developed during these times frames continue to be used today.

4.1 OCTOBER 2007 TO MARCH 2008

A project kickoff meeting was held on November 8, 2007. The meeting was held by teleconference and included consultants from RESPEC in Rapid City, South Dakota, and Albuquerque, New Mexico; Dr. Dennis Todey, climatologist for the state of South Dakota; and Dr. Hal Werner, retired professor and irrigation extension specialist from South Dakota State University. Roles were defined and tasks were assigned with the initial goal of having an online irrigation scheduling tool for producers before the start of the 2008 irrigation season (approximately May 31, 2008).

The goal for the first year of the project was to involve eight to ten individual irrigators. A flier was developed and included with the annual newsletter for the producers within the BFID explaining the components of the irrigation scheduling project and encouraging voluntary participation. Approximately 20 irrigators, hand-selected by BFID staff, were invited to attend an informational meeting on January 17, 2008, where the components of the project were outlined and the roles and responsibilities of the producers were defined. From this meeting, nine producers indicated their interest in the project and signed up to participate.

Two members of the project staff, Dr. Hal Werner and Mr. Jared Oswald from RESPEC, were invited to participate in an irrigation schedulers' meeting on February 18, 2008, in Greeley, Colorado. The meeting was organized by Mr. Peter Robinson, Water Management Engineer from the West National Technological Support Center in Portland, Oregon. The objectives of the meeting were to develop a technical cooperation plan between the project team and the Oregon State Irrigation Management Online (IMO) development team and to increase awareness of other scheduling programs and their associated technical components. The meeting was a tremendous success in that it brought together several of the experts involved in irrigation scheduling in the country and provided a great open forum for the exchange of ideas and lessons learned.

Local project staff, along with State Climatologist Dr. Dennis Todey, identified sites throughout the BFID to place full-weather stations and rain gauge sites. A total of three sites were selected to install full-weather stations. The data being transmitted by an existing radio network were sent back to an existing database at the BFID headquarters in Newell, South Dakota. It was also determined that data from an existing weather station maintained by the South Dakota State Climatology Office could be rerouted to the BFID headquarters to further enhance the ability to characterize evapotranspiration throughout the BFID. In addition to the full-weather stations that include measurements of solar radiation, wind speed/direction, temperature, humidity, and precipitation, five stand-alone precipitation sites were selected. Equipment for all of the sites was ordered along with soil moisture blocks and dataloggers that will be installed in the cooperating producer's fields to help provide an on-the-ground reference to the soil moisture balance being calculated by the online irrigation scheduler.

4.2 APRIL 2008 TO SEPTEMBER 2008

In the first week of April 2008, project staff worked with South Dakota State Climatology Office staff to install the three full-weather stations and five stand-alone rain gauge sites selected to help estimate the water balance in the individual producers' fields. A summer intern from South Dakota State University was interviewed and hired to assist in the installation, collection, and interpretation of weather and rainfall data. On April 23, project staff met individually with cooperating producers to install the soil moisture sensors in their fields. Each producer was provided with two soil moisture stations that included two soil moisture sensors, placed at ⅓ and ⅔ of the crop rooting depth, and a datalogger. The datalogger was programmed to collect readings every 10 minutes.

A total of nine different producers and ten fields totaling approximately 394 acres were included in this first year of irrigation scheduling project, as shown in Table 4-1. Irrigation scheduling was conducted on 180.4 acres of alfalfa, 163.8 acres of corn, 33.3 acres of barley, and 16.1 acres of wheat. The wheat producer dropped out of the project on the first of July in preparation for the sale of the land.

Table 4-1. List of Crops Planted and Total Acres of the Individual Field

Crop	Acres
Alfalfa	12.9
Alfalfa	25.1
Corn	130
Wheat	16.1
Alfalfa	23.1
Alfalfa	22.9
Alfalfa	54.5
Alfalfa	41.9
Barley	33.3
Corn	33.8
Total	**393.6**

Work continued on the development of the Web interface used to assess soil water balances and to help provide the cooperating producers a tool to determine the correct timing and amount of irrigation applications. Unfortunately, the Web interface was not ready for public release at the start of the irrigation season in the first part of June. In the meantime, an Excel-based spreadsheet was developed to assess soil water balances. The actual data, graph generated from the data, and actual soil moisture measurements from the field were sent via e-mail to the producers on a weekly basis. Figure 4-1 displays a graph tracking the soil moisture balance, field capacity, and minimum recommended allowable water content to prevent crop stress; ET; and inputs (rainfall plus irrigation) throughout the growing season for a barley crop. Values of weekly and cumulative rainfall and ET were also published in the local newspaper along with a short article describing basic terminology and concepts involved in scientific irrigation scheduling.

RSI-1793-11-004

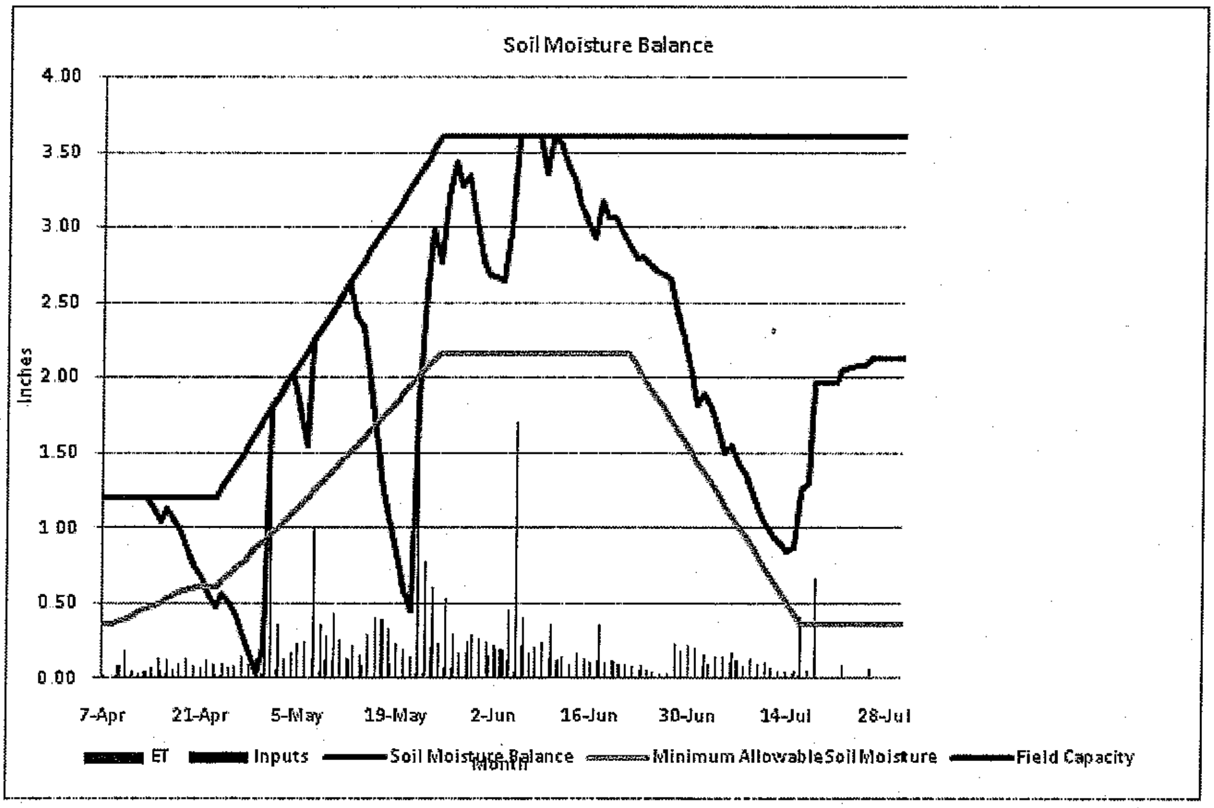

Figure 4-1. Graph Tracking the Soil Moisture Balance Field for a Cooperating Producer in the Belle Fourche Irrigation District.

The Web-based irrigation scheduling tool was ready for use on August 1. Because the irrigation season was nearing its end and the tool had not gone through a rigorous quality assurance/quality control (QA/QC) process, project staff decided to continue providing information to producers via e-mail and officially release the Web-based version before the irrigation season in the summer of 2009. A screen shot of the overview page that was displayed after the producer logged into the Web application is shown in Figure 4-2. On the left of the screen is an aerial photograph that includes the cooperators' field. The field is color-coded based on its soil water balance from green (saturated) to red (crop stress imminent). The current weather conditions at the weather station nearest to the field selected are displayed to the right. The other tabs that the producers have access to are **Field Data, Calendar/Water Orders, Time Integration, Weather Station Data, Define Fields,** and **About**. Currently, there is considerable effort being spent analyzing the look, feel, and contents of the information in these tabs to ensure that the needs and expectations of the cooperating producers were met.

RSI-1793-11-005

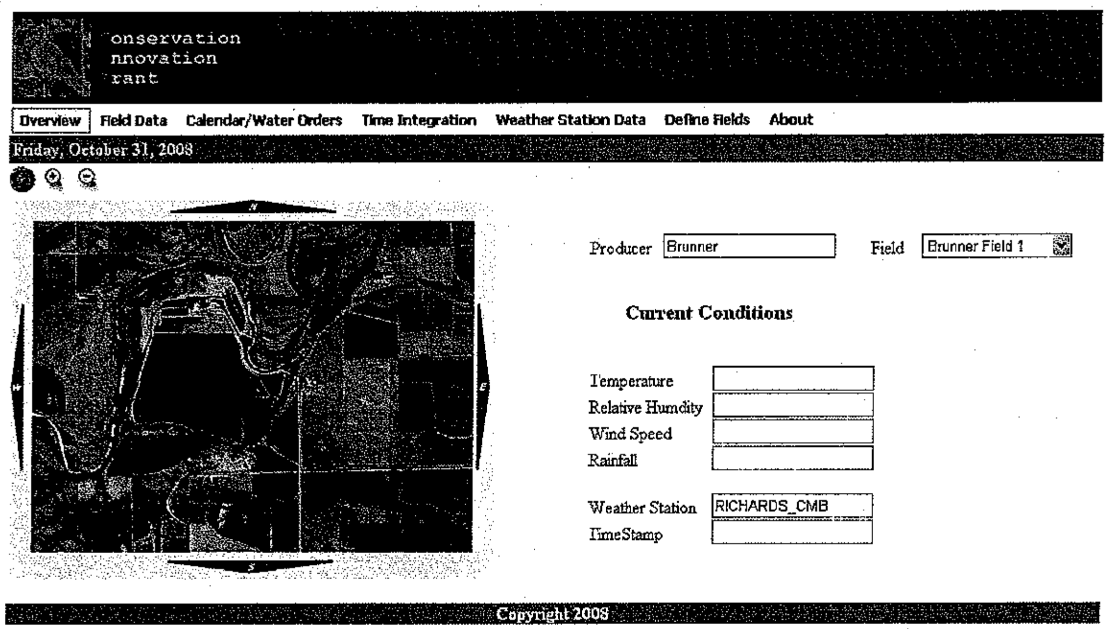

Figure 4-2. Screen Shot of the Overview Page of the Irrigation Schduler Web Application.

4.3 OCTOBER 2008 TO MARCH 2009

A majority of the work performed in this project period focused on further development and refinement of the Web interface. The overall goal of this portion of the project was to provide irrigators with up-to-date field information that was easy to understand and intuitive to operate. One limitation with the previously developed map interface was that the user was not given a simple way to select the field that they wanted to include in the irrigation scheduling project. Another limitation was that the business logic, or soil water balance calculations, was written using a combination of SQL statements and C# code—accessible primarily to Web developers but not to the project staff with knowledge specific to irrigation scheduling. It was decided to build the Web interface using ESRI's **ArcServer** technology. This technology was chosen because it gave project staff several out-of-the-box tools (pan, zoom, select, and turning on and off viewable layers) that were intuitive to use and also provided the ability to make custom tools (field draw) specifically designed to meet the needs of this project. It also gave project staff the ability to modify the water balance calculations easily using ESRI's **ModelBuilder** interface. The project team has experience in the development of a geoprocessing approach to analyze data using **ModelBuilder**, which provides automation and documentation of the water balance calculation. The results of a calculation can be displayed for review by the irrigators on an **ArcServer** Website. Because the geoprocessing framework has been documented, the water balance calculation can easily be modified based on feedback from irrigators or customization to different areas.

Figure 4-3 provides a screen shot of the log-in page for the current Web interface. Once the producer creates a username and password, they are able to use the **ArcMap** tools to locate and either draw or select the field they would like to include in the project. Once an accurate representation of the field is generated, the system then links the field to the representative weather station and rain gauge. The system also determines the size of the field along with the soils located in the field and their associated layer depth and water-holding capacities. All of this information is needed to calculate the water balance and to determine the volume of water (irrigation depth and delivery time) needed to replenish any soil water depletion.

Once a field is identified, the "Field Setup" dropdown becomes active as shown in Figure 4-4. At this point, the producer must input a few basic parameters, including a field description, delivery rate to the field in cubic feet per second (cfs), irrigation delivery method (flood or sprinkler), an initial estimated soil moisture percentage and the date associated with that estimate, and crop type (alfalfa, corn, wheat, or barley).

If alfalfa is chosen, the producer must then enter a thaw date along with estimated cutting dates. The producers can do this manually or simply press the "Auto Calc" button and the system will calculate the data for them based on historical averages. The thaw date is set when the average daily temperature is above 41° Fahrenheit for 5 consecutive days, which normally occurs on April 8 in this region. The actual cutting dates must be entered as the growing season progresses so the system understands when the crop coefficient (*Kc*) must be reset. If corn, wheat, or barley is selected as the crop, the producer must enter a planting date and an assumed maturity date. The assumed maturity date is described to the producer as when they would estimate that the crop will begin to show signs of physical decay. Once all needed parameters are entered, the "Submit" button is pressed to activate the soil water balance calculations. At this point, the system also determines the location of soil moisture sensors that are actively being monitored in the field. The readings from these soil moisture sensors are being recorded hourly by a datalogger. The hourly data are collected and uploaded to the database once a week by project staff.

RSI-1793-09-001

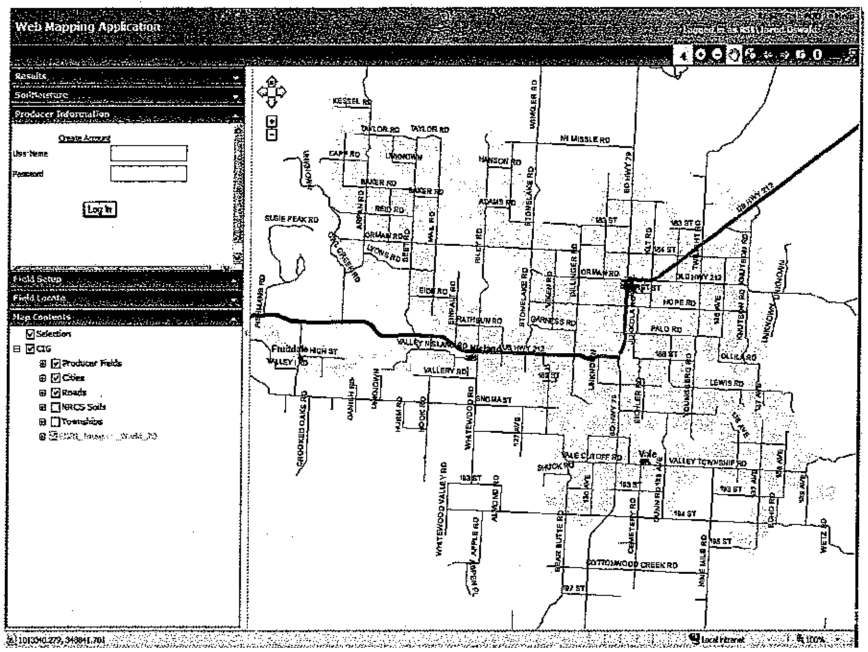

Figure 4-3. Initial Screen Displayed Providing a Map Overview of the Belle Fourche Irrigation District, Along With an Interface to Allow Producers to Create an Account or Log Into an Existing One.

RSI-1793-09-002

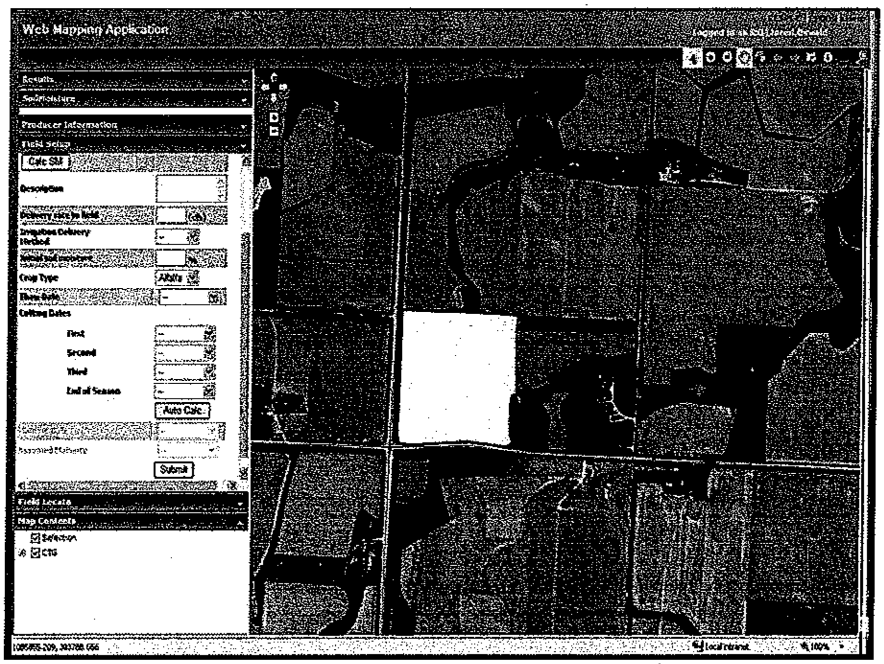

Figure 4-4. Screen Shot of User Inputs Necessary to Set Up a Field Within the Web Application.

Throughout the season, the system updates the soil water balance within the field on a daily time step. The producer can simply select the field of choice from a dropdown menu of all active fields, and current information will be displayed for that field (see Figure 4-5). The map interface provides a color indication of the status of the field (red = in need of irrigation within the next 4 days; green = not in need of irrigation in the next 4 days) along with the location of the soil moisture sensors in the field (indicated by stars). The system also provides historical graphs and current values of the soil moisture sensors and calculated water balance, gives the producer the ability to modify the current calculated balance based on the sensor readings or physical observation, and provides a recommended irrigation start date and hours of application if applicable.

RSI-1793-09-003

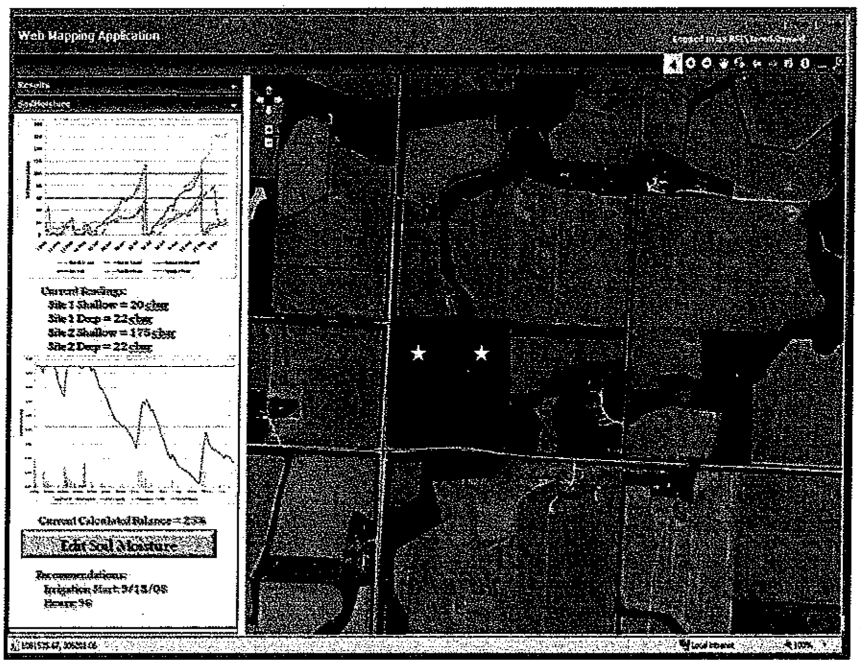

Figure 4-5. Screen Shot of Current Information Available and Irrigation Recommended for a Field Active Within the System.

An informational meeting was held in Newell, South Dakota, on March 19 to identify additional irrigators to participate in the project. A total of 12 irrigators attended the meeting and agreed to participate with an additional 7 irrigators expressing interest in the program but were unable to attend. Project staff also presented the accomplishments of the first year of the project at several local farm shows and fairs to help encourage participation.

4.4 APRIL 2009 TO SEPTEMBER 2009

The work in this project period focused on implementing the second season of the irrigation scheduling methods along with further development of the Web interface. A total of 15 handpicked irrigators participated in the grant The irrigators were limited to signing up one field to include in the program so project staff could continue to accurately analyze the methods used in the scheduling algorithms

Once again during this irrigation season, each cooperating producer was provided with two soil moisture stations. A soil moisture station consists of a Watchdog Data Logger™ (Spectrum Technologies, Inc.) with two Watermark™ soil moisture blocks placed at ⅓ and ⅔ of the crop's effective rooting depth Originally, it was assumed that these soil moisture blocks would merely be used as a visual aid to help the irrigators understand and validate the calculated balance algorithm being displayed on the Web application. As the project progressed however, the project staff found these physical soil moisture measurements invaluable to the accurate tracking of a water balance. Their value allows a better understanding of irrigation application efficiency The strength of the soil moisture blocks is their ability to track the relative soil moisture balance along with an extremely accurate representation of when the soil profile is saturated. The strength of the calculated balance algorithm is its ability to accurately track actual daily gains (rainfall and irrigation) and losses (evapotranspiration) The weakness of the calculated balance algorithm is that it assumes an irrigation application efficiency of 50 percent for all flood-irrigated fields based on literature When comparing the calculated balance to the values reported by the soil moisture block immediately following an irrigation event, project staff found that although all the soil moisture blocks reported that the soil was saturated (which, as stated earlier, can be assumed to be accurate), the calculated balance reported that the soil was below saturation, or field capacity This is because irrigation efficiency was found to vary greatly from irrigator to irrigator and irrigation event to irrigation event. To solve this challenge with the calculated balance, irrigators are encouraged to manually reset their calculated balance to field capacity whenever the sensors in the field indicate the soil profile is saturated.

An example of how the soil moisture sensors and calculated soil moisture balance can be used together is shown in Figures 4-6 to 4-8. Figure 4-6 shows the calculated water balance throughout the growing season. This farmer irrigated from July 13–16 As the graph indicates, the calculated current balance never returned to field capacity with the assumed 50 percent irrigation application efficiency. Figure 4-7 shows the tracked values reported by the soil moisture sensors for the same time period. Notice that all sensors became saturated following the irrigation event on July 13–16. Figure 4-8 shows the adjusted calculated current balance after the irrigator reset the calculated balance in response to the saturated readings of the sensors.

An irrigation tour was held on August 18, 2009, within the BFID with one stop dedicated to the CIG project (Figure 4-9). A total of 20 people were in attendance Project staff also presented the current Web application and project lessons learned, successes, and challenges at the 2009 CIG showcase held in Dearborn, Michigan, in July The showcase was an excellent forum for interacting with other CIG recipients and NRCS staff members.

RSI-1793-09-004

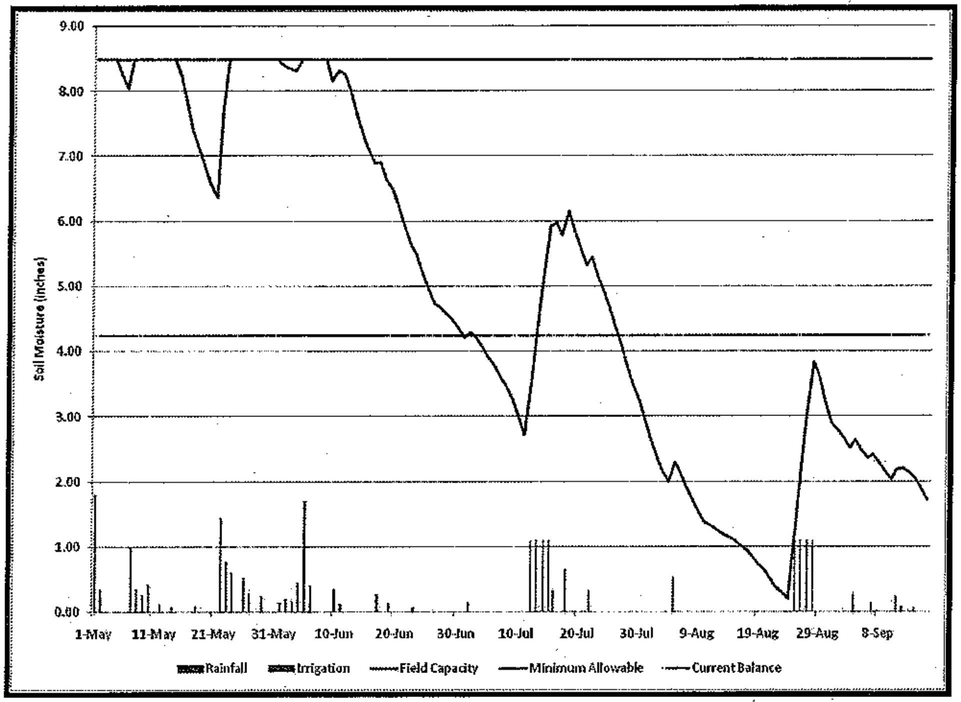

Figure 4-6. Calculated Current Soil Moisture Balance.

RSI-1793-09-005

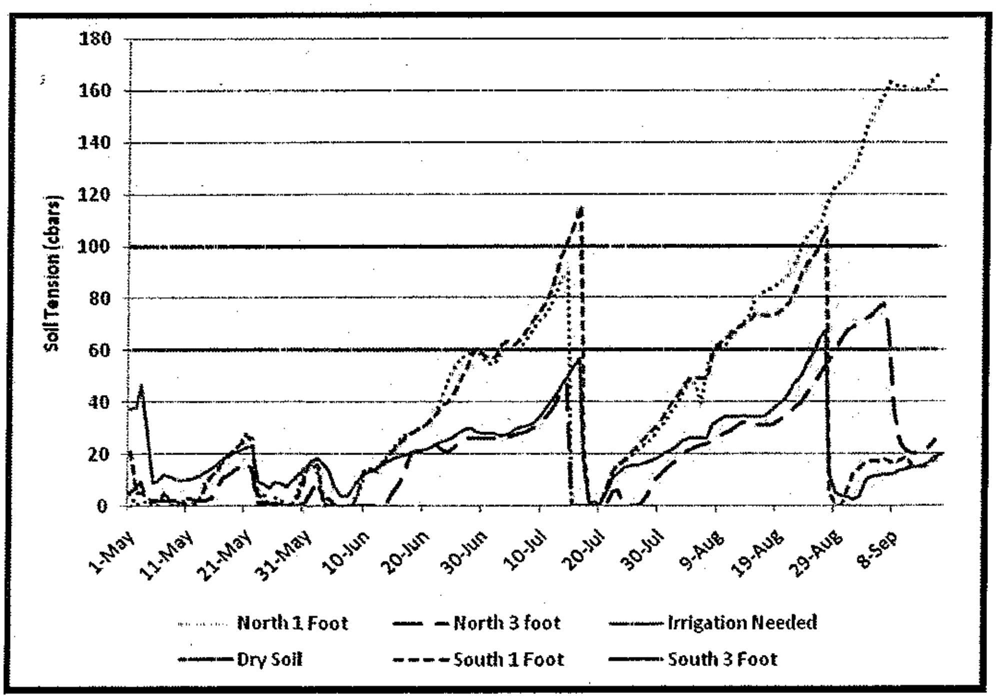

Figure 4-7. Tracked Soil Master Sensor Values

RSI-1793-09-006

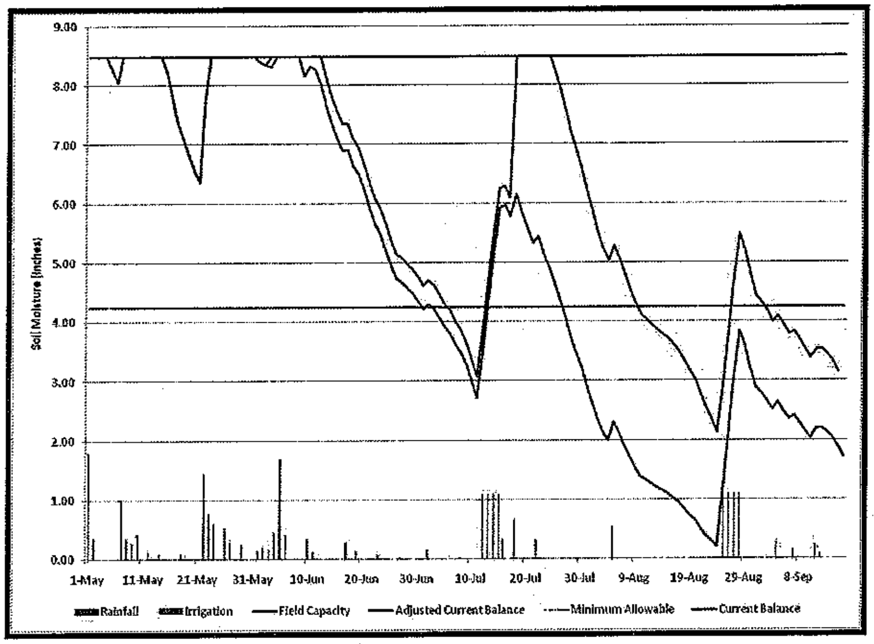

Figure 4-8. Comparison of Original Calculated Current Balance and Current Balance Adjusted to Field Capacity in Response to Saturated Soil Moisture Readings.

RSI-1793-09-007

Figure 4-9. Project Staff Describing the Conservation Innovation Grant Project to Tour Participants on August 18, 2009

4.5 OCTOBER 2009 TO MARCH 2010

The work in this project period focused on further development of the Web interface. The goal was to have a fully functional interface by the time irrigation season began in spring 2010.

Although the look and feel of the Website remain the same, project staff worked on optimizing its performance in response to feedback from irrigators. One added feature to the application is the ability for the individual irrigators to manually enter soil moisture readings. Irrigators have expressed concern over the cost of the soil moisture sensors and associated dataloggers along with the labor cost required to collect and upload it once assistance from project staff is not subsidized by the CIG program. Project staff recommended installing at least two soil moisture stations per field at a cost of $748 per field. The cost to monitor ten fields for the initial summer using this method would be $7,480 for materials along with approximately $2,000 in labor and travel, for a grand total of $9,480. Since the sensors can be used up to 5 years without replacement if properly maintained and dataloggers for at least that long, the cost to purchase and maintain the soil monitoring network for the first 5 years would be approximately $17,480

If the irrigator decided to manually enter the soil information, significant costs could be avoided. They would need to purchase a mobile soil moisture reader for approximately $250 that can be used to collect information from all sensors from any number of fields that are participating in the program. When including the cost for the four sensors installed at the two sites (~$37/sensor or $148/field), the cost for the initial field would be $398. The total cost to monitor ten fields in the initial summer would be $1,730 ($348 for the initial field plus the cost of the sensors ($148/field) for each additional field) assuming readings are collected during normal trips to the fields and no additional labor or travel costs are incurred. If it can be assumed that minimal additional travel or labor costs ($1,000) will be incurred in successive years, the total cost to maintain the soil monitoring network for 5 years would be $2,730 or a savings of $14,750 over the current method of data collection.

What remains to be seen is whether the irrigators will be diligent with updating the soil moisture information throughout the season. The reliability of the data may also be a concern and will need to be monitored by project staff through the Web interface

4.6 APRIL 2010 TO SEPTEMBER 2010

This was the final summer of implementing the OISC software, so significant effort was invested in making sure it functioned properly and was user-friendly for the participants. A total of 20 irrigators used the software to schedule irrigation timing and amount on 990 acres spread throughout the Belle Fourche River Watershed in summer 2010. Scheduling routines were available for corn, soybeans, pinto beans, alfalfa, and barley.

A function developed in response to participant feedback was the ability to simultaneously view the soil moisture sensor readings and the calculated balance. This allowed the user to easily make a decision as to whether a trip to the field was necessary to verify which estimation of soil water balance was correct if there was a discrepancy between the two measurements.

Two irrigators were selected to test the feasibility of having participants enter their own soil sensor readings rather than having project staff upload the information to the Web application for them. It was thought that this could be a cost-saving measure, since the irrigator would only have to purchase a single piece of soil-reading equipment for their entire farming operation instead of a datalogging device designated for each soil moisture station. It was determined that, although the cooperating irrigators often read the soil moisture sensors to optimize irrigation timing, the information was never uploaded to the Web application.

A great example of increased water use efficiency as a result of the education that this application provided to producers was demonstrated on the farm of Mr. Bill Anderson. Mr. Anderson signed up to participate in this CIG grant program in 2008. He chose to test it on a small, flood-irrigated, 11-acre alfalfa field near his home. Mr. Anderson, like many of the participants in this program, used a visual indicator to determine when to irrigate. In this case, he lives in an area of very heavy soils with a large shrink/swell capability, so when the cracks in the ground reached a depth of approximately ¾ inch, Mr. Anderson would start irrigating. Using this method, Mr. Anderson needed to apply 2 cfs for approximately 30 hours to ensure the water made it across the entire field. Using a combination of the soil moisture readings and the calculated water balance information provided by the OISC software, Mr. Anderson decreased the time needed to saturate the entire field using 2 cfs from 30 hours to 18 hours—a savings of nearly 40 percent. It is assumed the savings are a result of not allowing the soil to dry to the level where large, deep cracks form. Once they formed, a significant amount of water traveled down the cracks and was lost below the root zone until the crack eventually swelled and sealed, allowing the water to travel further laterally down the field.

4.7 OVERALL

A total of 26 individual irrigators participated in the CIG program during its 3-year existence. The irrigators used the Web application to schedule irrigation timing and depth on approximately 1,500 acres spread throughout the Belle Fourche River Watershed for several different crops, including alfalfa, corn, soybeans, barley, and pinto beans. The current Web application meets the original project goal of being an "easy-to-use means to monitor and schedule irrigations."

5.0 POTENTIAL FOR TRANSFERABILITY

The Web-based OISC developed through this project has excellent potential to be transferred to other regions of the country and to be used by NRCS staff as a management tool. One challenge will be to locate representative weather data and transpose it to the correct format that is compatible with the current database structure. Another challenge, as mentioned earlier, will be to find a cost-effective means of gathering the soil moisture sensor readings, which have proven an invaluable check to the soil water balance being calculated by the OISC software.

6.0 CONCLUSIONS

This project was deemed successful for many reasons. First, it contributed to the BFRWP's goal of improving water quality in the Belle Fourche River and its tributaries. The reach of the river adjacent to the BFID was delisted (no longer impaired) for TSS by the SD DENR in both the 2008 and 2010 South Dakota Integrated Report for Surface Water Quality. Second, the number of irrigators participating exceeded the expectations and goals of the project staff. Originally, the goal was to work with a total of 20 irrigators within the BFID. Because of demand, a total of 26 separate irrigators participated in the project. Third, several of the cooperators reported increased water use efficiency and gains in production. Irrigators within the BFID typically receive about 15 inches of water annually from their storage reservoir with no supplemental groundwater source. The region has from 35–40 inches of ET demand during the typical growing season from April–September. This makes it imperative that they optimize their water application to ensure every drop is being used to its full potential. Finally, cooperating producers were pleased with the Web application and there were several requests to continue the program beyond the current grant period