SECTION 319 NONPOINT SOURCE POLLUTION CONTROL PROGRAM
WATERSHED PROJECT FINAL REPORT

CENTRAL BIG SIOUX RIVER WATERSHED PROJECT – Segment 1

By

Roger Strom
Watershed Project Coordinator

Project Sponsor
EAST DAKOTA WATER DEVELOPMENT DISTRICT

Jay Gilbertson
District Manager

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This project was conducted in cooperation with the State of South Dakota and the United States Environmental Protection Agency, Region 8.

Grant Numbers: 9998185-00, 9998185-01, 99981185-02, 9998185-03, 9998185-04, 9998185-05, 9998185-06

EXECUTIVE SUMMARY

PROJECT TITLE: CENTRAL BIG SIOUX RIVER WATERSHED PROJECT – Segment 1

Grant Numbers: 9998185-00, 9998185-01, 99981185-02, 9998185-03, 9998185-04, 9998185-05, 9998185-06

PROJECT START DATE:		August 12, 2005
PROJECT COMPLETION DATE:		September 30, 2010
FUNDING: TOTAL BUDGET		$7,032,725.90
TOTAL EPA GRANT 2005 (ORIGINAL)	825,000.00	
TOTAL EPA GRANT 2000	178,200.23	
TOTAL EPA GRANT 2001	33,365.48	
TOTAL EPA GRANT 2002	185,464.93	
TOTAL EPA GRANT 2003	20,694.48	
TOTAL EPA GRANT 2004	176,848.28	
TOTAL EPA GRANT 2006	296,100.00	
TOTAL 319 EXPENDITURES		$1,715,673.40
EPA 319 Grant	$1,705,751.82	
East Dakota Water Development District	294,473.83	
Land Owner Match	517,340.98	
South Dakota Conservation Districts	5,405.97	
Conservation Commission	142.50	
Sioux Falls State Revolving Funds	3,139,371.91	
Total Match		$3,956,735.19
Other Federal		$54,013.00
TOTAL EXPENDITURES		$5,716,500.01

The goal of the Central Big Sioux Watershed Project was:

Restore and protect the beneficial uses of the portion of the Big Sioux River and its tributaries (in South Dakota) between the communities of Watertown and Brandon by implementing and promoting best management practices (BMPs) in the watershed that reduce sediment loading and prevent bacterial contamination.

The work was completed in several areas to include renovation and improvement of existing high-priority animal feeding operations; reduction of livestock access to water bodies; stabilizing banks along critical reaches of Skunk Creek and the Big Sioux River and the restoration of riparian areas. To assist in the effort there was an information and education components and water monitor activities. In the following table is a summary of project accomplishments.

SUMMARY ACCOMPLICHMENTS*

BMP	Unit	Total Expected	Total Implemented
Ag Waste System	AWMSs engineering designs and plans	14	16
Ag Waste System	Constructed AWMS	12	12
Bank Stabilization	Big Sioux Bank Stabilization - LF	1,500	15,400
Bank Stabilization	Skunk Creek Bank Stabilization-LF	10,000	10,000
Grazing Management	Alternative Water sources-Each	10	4
Grazing Management	Rock Crossings -Each	7	4
Information & Education	Field tours of project activities	9	2
Information & Education	Informational meetings and workshops	14	8
Information & Education	Public service announcements	7	8
Information & Education	Quarterly news releases	14	7
Riparian Restoration	Acres enrolled in CRP	150	230.25
Riparian Restoration	rural riparian easements-acres	500	561.52
Riparian Restoration	urban riparian easements-acres	13.1	0
Water Quality Monitoring	QA/QC Samples -each	90	121
Water Quality Monitoring	Water Quality Samples	798	966

*As shown on the Best Management Practices Tracker system.

Annual load reductions achieved due to the installation of the Best Management Practices.

BMP	Nitrogen Lbs/Yr	Phosphorus Lbs/Yr	TSS Tons/Yr
Ag Waste System	121,337	26,968	224
Bank Stabilization – Skunk Creek	190	73	119
Bank Stabilization – Big Sioux River	40,028	15,411	28,146
Riparian Area Management	23,519	5,782	1,032
Conservation Easement	13,169	3,149	1,799
TOTAL	198,242	51,383	31,320

The watershed project achieved most of its goals for BMPs installed but was unsuccessful in achieving the desired load reduction for the segments of the Big Sioux River.

TABLE OF CONTENTS

PAGE

LIST OF TABLES:

LIST OF FIGURES:

APPENDICES

Found at: http://denr.sd.gov/dfta/wp/wqinfo.aspx#Project Under Big Sioux

Appendix A: Animal Waste Management System
Appendix B: Conservation Easements Forms and Evaluation Sheets
Appendix C: Riparian Area Management (RAM) Forms and Evaluation Sheets
Appendix D: East Dakota Water Development District web page
Appendix E: News releases
Appendix F: Central Big Sioux Implementation Grant Final Report Number 2006-CSW-022
Appendix G: Analysis of Bank Stability and Potential Load Reductions
Appendix H: Better Management Practices to Improve Water Quality on Big Sioux
Appendix I: Monitoring Data 2005 thru 2009

INTRODUCTION

The Central Big Sioux River Watershed Project is a 10-year Total Maximum Daily Load, (TMDL) implementation strategy that was to be completed in multiple segments and parts. The project was to restore and/or maintain the water quality of the Big Sioux River and its tributaries to meet the designated beneficial uses. The Central Big Sioux River Watershed Assessment identified various segments of the Big Sioux River and certain tributaries between Watertown and Brandon as failing to meet designated uses due to impairments from total suspended solids (TSS), dissolved oxygen (DO) and/or fecal coliform bacteria (FCB). Twenty-four separate TMDLs were developed for these segments (See Table 1 and Table 2). Activities to improve and/or maintain current sediment and bacterial loadings targeted sub-watersheds within the project area. An information and education campaign was conducted to keep the public informed of project activities and to provide information on BMPs and water quality issues. Water quality samplings were used to monitor and project impacts on impaired water bodies. They were assessed to determine if progress on the TMDLs reductions were achieved.

Table 1: Beneficial Use Impairments Identified for the Central Big Sioux River Watershed.

Segment	Beneficial Use	Impairment
Big Sioux River		
Brookings to I-29	WWFLP[1] LCR[5]	TSS[2]
I-29 to Above Dell Rapids	WWFLP[1]IR[3] LCR[5]	TSS[2]
Above Dell Rapids to Below Baltic	WWFLP[1] IR[3] LCR[5]	FCB[4]
Below Baltic to Skunk Creek	WWFLP[1] IR[3] LCR[5]	TSS[2], FCB[4]
Skunk Creek to Diversion	WWFLP[1] IR[3] LCR[5]	TSS[2], FCB[4]
Diversion to SF WWTF	WWFLP[1] IR[3] LCR[5]	TSS[2], FCB[4]
SF WWTF to Brandon	WWFLP[1] IR[3] LCR[5]	TSS[2], FCB[4]
Tributaries		
Bachelor Creek	WWFLP[1]LCR[5]	FCB[4]
Beaver Creek	WWFLP[1] LCR[5]	TSS[2], FCB[4]
Flandreau Creek	WWFLP[1] LCR[5]	FCB[4]
Jack Moore Creek	WWFLP[1] LCR[5]	FCB[4]
North Deer Creek	WWFLP[1] LCR[5]	FCB[4]
Pipestone Creek	WWFLP[1] IR[3] LCR[5]	FCB[4]
Silver Creek	WWFLP[1]	DO[6]
Six Mile Creel	WWFLP[1] LCR[5]	FCB[4]
Skunk Creek	WWFLP[1] LCR[5]	TSS[2], FCB[4]
Split Rock Creek	WWFLP IR[3] LCR[5]	TSS[2], FCB[4]
Spring Creek	WWFLP[1] LCR[5]	FCB[4]

1 - Warm water fish life propagation (WWFLP) - applicable standard varies with water body;
2 - Total suspended solids; (TSS)
3 - Immersion recreation standard (IR) - 400 colonies per 100 milliliters of water;
4 - Fecal coliform bacteria; (FCB)
5 - Limited contact recreation standard (LCR) - 2,000 colonies per 100 milliliters of water; and
6 - Dissolved oxygen (DO)

Table 2: Beneficial Use Impairments Identified for the North Central Big Sioux River Watershed.

Segment	Beneficial Use	Impairment
BSR Lake Kampeska to Willow Creek	WWFLP[1] LCR[5]	FCB[4]
BSR Willow Creek to Stray Horse Creek	WWSFP[1], LCR[5]	FCB[4]
Willow Creek	WWFLP[1] LCR[5]	FCB[4]
Hidewood Creek	WWMFP[1] LCR[5]	FCB[4]
BSR Stray Horse Creek to near Volga	WWSFP[1] LCR[5]	FCB[4]
Stray Horse Creek	WWMFP[1] LCR[5]	FCB[4]
Peg Munky Run	WWMFP[1] LCR[5]	FCB[4]
East Oakwood Lake	WWSFP[1] IR[3] LCR[5]	TSS[2], Total Phosphorus
West Oakwood	WWSFP[1] IR[3] LCR[5]	TSS[2], Total Phosphorus

1 - Warm water fish life propagation (WWFLP) - applicable standard varies with water body;
2 - Total suspended solids; (TSS)
3 - Immersion recreation standard (IR) - 400 colonies per 100 milliliters of water;
4 - Fecal coliform bacteria; (FCB)
5 - Limited contact recreation standard (LCR) - 2,000 colonies per 100 milliliters of water; and

The two watershed assessments that developed the need for the implementation project are described in the next few paragraphs.

The Central Big Sioux River Watershed Assessment Project began in April of 1999 and lasted through December of 2003 when data analysis and compilation into a final report was completed. The title of the report was: "Phase 1, Watershed Assessment Final Report and TMDL" for the central Big Sioux River in Brookings, Lake, Moody and Minnehaha Counties of South Dakota, dated March, 2004. The assessments were conducted as a result of several segments being placed on the 1998 303(d) list for fecal coliform bacteria (FCB), and total suspended solids (TSS) problems.

An EPA section 319 grant provided the majority of the funding for this project. The Department of Environment and Natural Resources and East Dakota Water Development District provided matching funds for the project.

The North-Central Big Sioux River watershed assessment project began in April of 2001 and continued through December of 2005 when data analysis was completed and published in a final report. The title of the report is: "Phase 1, Watershed Assessment Final Report and TMDLs" for the North-Central Big Sioux River in Brookings, Hamlin, Deuel and Codington Counties of South Dakota, dated December, 2005. The assessment was conducted as a result of this area of the Big Sioux River watershed being placed on the 1998 303(d) list for total suspended solids (TSS) problems.

The long term goal for the assessment projects was to locate and document sources of non-point source pollution in the North-Central Big Sioux River (BSR) watershed and Central Big Sioux River (CBS) watershed and provide feasible restoration alternatives to improve water quality. Through identification of sources of impairment in these goals were accomplished. Water quality monitoring and watershed modeling resulted in the identification of several sources of impairment. These sources were to be addressed through best management practices (BMPs) and the construction of several waste management systems at animal feeding operations.

PROJECT LOCATION: Latitude North 44o 00' 00" Longitude West 096o 45' 00"
HYDROLOGIC CODE: 10170202 -North Central Big Sioux River
10170203 -Central Big Sioux River North and West of Brandon, SD
The south boundary was located in Minnehaha County along county road 38 southeast of Sioux Falls, SD. The North boundary was located in Codington County at the outlet for Lake Kampeska.

The Central Big Sioux River Watershed Project boundaries are within the above seven county area of eastern South Dakota shown in Figure 1. Watertown is located to the north and Sioux Falls and Brandon are located on the south portion.

This did not include the following areas that have been included in other watershed projects: Lake Pelican Watershed, Clear Lake, Lake Poinsett, Lake Campbell, Lakes Herman, Madison and Brant Lake watershed, Bachelor Creek and Wall Lake.

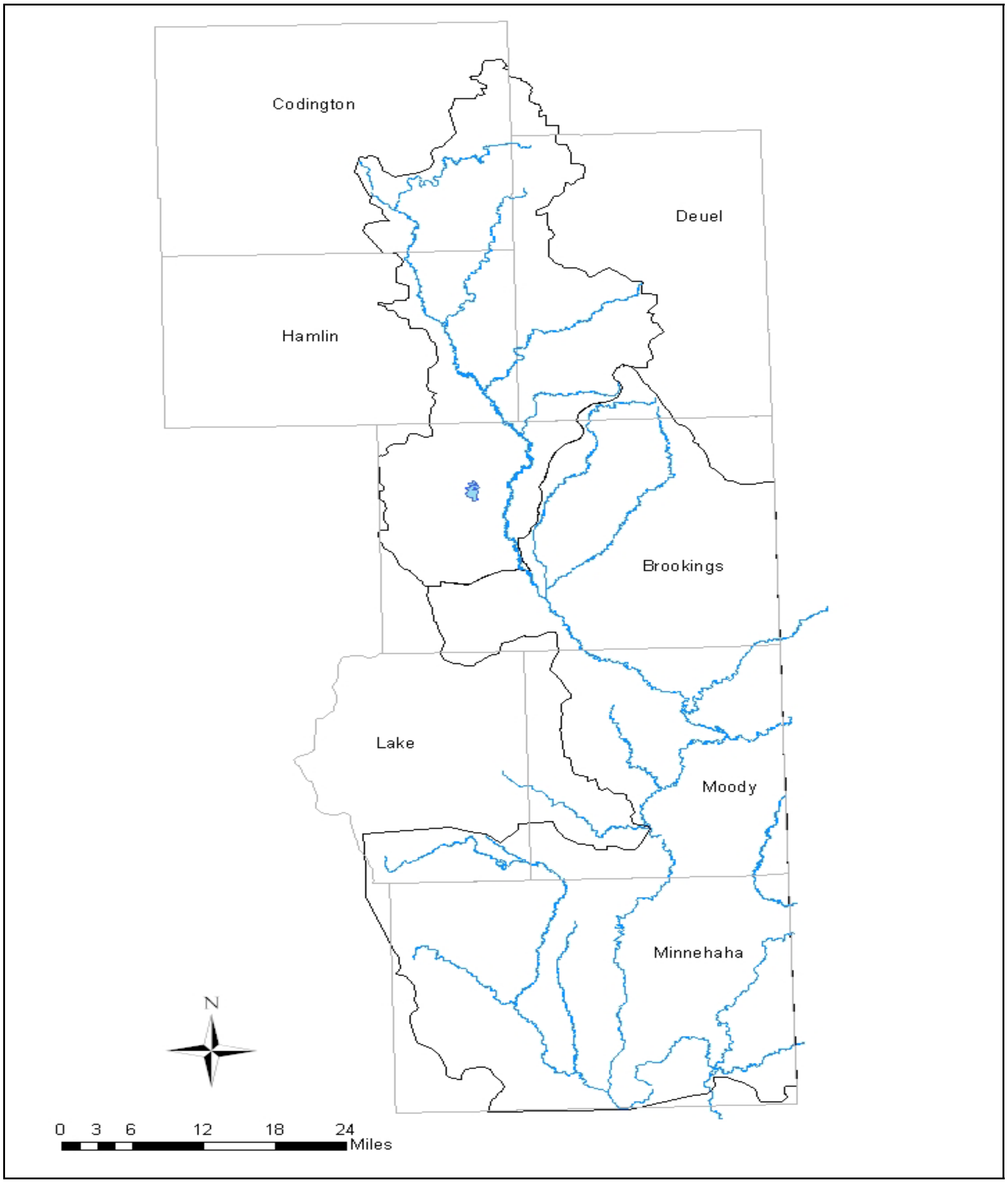


Figure 1: Central Big Sioux River Watershed Project area boundaries.

DESCRIPTION AND LAND USE OF PROJECT AREA:

The surficial character of the watershed can be divided into two parts, relating to the relative age of the landscape. Along the BSR valley, and the eastern tributaries, drainage is well developed and non-drained depressions are rare. To the west of the river, where drainage is poor, there are numerous potholes, sloughs, and lakes. The relief in the area is moderate. Land elevation ranges from nearly 2,000 feet above mean sea level in the northeastern part of the watershed to about 1,265 feet in the southern edge of the project area. Soils within the watershed area are derived from a range of parent materials. Uplands soils are relatively fine-grained and developed over glacial till or thin eolian (loess) deposits. Coarse-grained soils, derived from glacial outwash or alluvial sediments, are found along present or former water courses. In central and eastern

Minnehaha County, in the southern part of the project area, the loess deposits are thick, often in excess of 20 to 30 feet, and the resulting soils are highly erodible. When combined with the relatively high relief, these areas are susceptible to erosion, regardless of land-use practices.

The average annual precipitation in the central BSR watershed is 23.2 inches, of which 76% typically falls April through September. Tornadoes and severe thunderstorms strike occasionally. These storms are often of only local extent and duration, and occasionally produce heavy rainfall events. The average seasonal snowfall is 36.5 inches per year.

The watershed project was confined within the counties of Brookings, Codington, Deuel, Hamlin, Lake, Minnehaha and Moody. Total population in the project area is roughly 280,000.

Land use within this area averaged 73.9 % cropland and the other 26.1% is classed as non-cropland. There is 13.1% of cropland that is not harvested because it is used for pasture, conservation programs, or for other reasons. The non-cropland acres include woodlands, all non-cropland pastures and rangelands, farmsteads, buildings, livestock facilities, ponds, roads, wasteland etc. Corn was the number one crop with an average of 31.5% of the cropland planted to it. Codington County had the lowest percentage of corn with 20% and Moody County was highest with 46.5%. Table 3 provides the crop production figures in 2007 for the major crops.

Table 3: 2007 Cropland Productions by County.

COUNTY	CORN %	WHEAT %	SOYBEANS%	FORAGE %
BROOKINGS	31.6	3.1	22.1	7.1
CODINGTON	20.0	11.0	16.4	8.7
DEUEL	21.6	5.0	14.3	8.2
HAMLIN	31.8	6.9	26.2	4.9
MINNEHAHA	38.2	0	27.3	7.0
MOODY	46.5	04	21.1	5.4
AVERAGE	**31.5**	**4.3**	**21.5**	**7.0**

Cattle production was the primary animal raised with the watershed when comparing AUM's but second by animal numbers. Pigs and hogs are the highest by actual animal numbers. The actual breakdown by animal numbers can be found in Table 4.

Table 4: 2007 Livestock Production Numbers by County.

COUNTY	CATTLE FOR INVENTORY	CATTLE for SALE	PIGS & HOGS	SHEEP
BROOKINGS	73,314	63,292	102,875	7,565
CODINGTON	58,265	38,983	48,707	15,256
DEUEL	50,353	39,012	R*	3,938
HAMLIN	41,650	29,003	61,923	1,203
MINNEHAHA	74,307	52,108	290,027	5,583
MOODY	42,391	39,354	117,517	2,874
AVERAGE	**56,713**	**43,625**	**124,209**	**6,070**

*R indicated that data was not released to the public.

BENEFICIAL USES:

The State of South Dakota has identified 11 beneficial uses that cover all of the bodies of water within the state. The complete list of these uses are listed in the tables below.

Table 5: South Dakota Beneficial Uses.

NUMBER	USE CODE	BENEFICIAL USE
1	DW	Domestic Water Supply
2	CWPFP	Cold Water Permanent Fish Life Propagation
3	CWMFP	Cold Water Marginal Fish Life Propagation
4	WWPFP	Warm Water Permanent Fish Life Propagation
5	WWSFP	Warm Water Semi-permanent Fish Life Propagation
6	WWMFP	Warm Water Marginal Fish Life Propagation
7	IR[3]	Immersion Recreation
8	LCR	Limited Contact Recreation
9	FWP/R/SW	Fish & Wildlife Propagation, Recreation & Stock Watering
10	IRR	Irrigation
11	CIW	Commerce and Industry Waters

Within the watershed the state had assigned the following beneficial uses by segment of the Big Sioux River and its tributaries.

Table 6: South Dakota Beneficial Use of the Big Sioux River Depending on Segment.

SEGMENT NUMBER	USE CODE	BENEFICIAL USE
1	DW	Domestic Water Supply
5	WWSFP	Warm Water Semi-permanent Fish Life Propagation
OR		
6	WWMFP	Warm Water Marginal Fish Life Propagation
7 – Not in all areas	IR[3]	Immersion Recreation
8	LCR	Limited Contact Recreation
9	FWP/R/SW	Fish & Wildlife Propagation, Recreation & Stock Watering
10	IRR	Irrigation

In Tables 7 and 8 the term in brackets in column three refers to the water level (high, medium or low) in the Big Sioux River (BSR) and the creeks or the bank condition (moist or dry).

Table 7: Central Big Sioux River segments with TMDLs and Reduction Needed to Achieve TMDL at the Beginning of the Implementation Project.

Segment	Impairment	Reduction Needed (%)*
Beaver Creek	TSS	79 (high)
Split Rock Creek	TSS	67 (high)
Brookings to I-29	TSS	19 (high)
I-29 to Near Dell Rapids	TSS	14 (high)
BSR SF WWTF to above Brandon	TSS	**
Spring	FCB	45 (overall)
Skunk	FCB	95 (high)
Bachelor	FCB	84 (high/moist)
Beaver	FCB	86 (high/moist)
Flandreau	FCB	91 (high/moist)
Jack Moore Creek	FCB	82 (high/moist)
BSR near Dell Rapids to below Baltic	FCB	29 (high)
North Deer Creek	FCB	34 (high/midrange)
Pipestone Creek	FCB	89 (high/moist), 87 (dry/low)
BSR SF WWTF to above Brandon	FCB	**
Six Mile Creel	FCB	12 (high/moist)
Split Rock Creek	FCB	96 (overall)

* Description of what hydrologic conditions the reduction applies to.

**Impairments were determined but additional study is currently underway and the new values have not been released.

Table 8: North Central Big Sioux River Segments with TMDLs and Reduction Needed to Achieve TMDL at the Beginning of the Implementation Project.

Segment	Impairment	Reduction Needed (%)
BSR Lake Kampeska to Willow Creek	FCB	33 (high)
BSR Willow Creek to Stray Horse Creek	FCB	10 (high)
Willow Creek	FCB	78 (high/moist), 5 (dry)
Hidewood Creek	FCB	59(high)
Stray Horse Creek	FCB	99 (high), 14 (mid range/dry)
Peg Munky Run	FCB	38 (overall)

Since the beginning of the implementation project there have been a number of changes to the TMDL's within the state. Table 9 lists these changes.

Table 9: Current Statuses of North Central and Central Big Sioux River Segments with TMDLs and Reduction Needed to Achieve TMDL.

Segment	Initial Impairment	Action and Date
Split Rock Creek	TSS	TMDL approved May 2008
Brookings to I-29	TSS	Delisted April 2008
Brookings to I-29	FCB	Delisted April 2004
I-29 to Near Dell Rapids	TSS	TMDL Approved May 2008
I-29 to Near Dell Rapids	FCB	Delisted April 2004
SF WWTF to above Brandon	FCB	Assessment Initiated
SF WWTF to above Brandon	TSS	Delisted May 2006
Spring	FCB	TMDL approved May 2008
Skunk	FCB	TMDL approved May 2008
Flandreau	FCB	TMDL approved May 2008
BSR near Dell Rapids to below Baltic	FCB	TMDL Approved May 2008
BSR near Dell Rapids to below Baltic	TSS	Delisted April 2004
North Deer Creek	FCB	TMDL approved May 2008
Pipestone Creek	FCB	TMDL approved May 2008
BSR SF WWTF to above Brandon	FCB	Assessment Initiated
BSR SF WWTF to above Brandon	TSS	Delisted May 2006
Six Mile Creel	FCB	Not Initiated April 2008
Split Rock Creek	FCB	TMDL approved May 2008
BSR Lake Kampeska to Willow Creek	Nitrate/FCB	Not Initiated 2008
BSR Willow Creek to Stray Horse Creek	FCB	TMDL approved June 2008
Willow Creek	FCB	TMDL approved June 2008
Hidewood Creek	FCB	TMDL approved June 2008
BSR Stray Horse Creek to near Volga	FCB	Not Initiated April 2008
Stray Horse Creek	FCB	TMDL approved June 2008
Peg Munky Run	FCB	Not Initiated April 2008
East Oakwood Lake	TSI	TMDL approved June 2008
West Oakwood	TSI	TMDL approved June 2008

*Report is available at this web site: http://denr.sd.gov/dfta/wp/tmdlpage.aspx

PROJECT GOALS, OBJECTIVES AND ACTIVITIES:
The restoration and protection of the beneficial uses of the portion of the Big Sioux River and the South Dakota portion of the tributaries between the communities of Watertown and Brandon by implementing and promoting best management practices (BMPs) in the watershed that would reduce sediment loading and prevent bacterial contamination. Attaining the sediment goal would require reducing total suspended solids (TSS) in the river and selected tributaries by between 20% and 70%. Fecal coliform levels found throughout the study area commonly exceed the water quality standard, particularly in regards to immersion recreation. Attainment of fecal coliform TMDLs would in certain areas require reducing bacterial loads by over 95%. Such targets are beyond the scope of this project segment. The interim targets were measurable and sustainable reductions of TSS (20%) and fecal coliform bacteria (15%) levels, to be met at the completion of the first multi-part segment of the restoration project. Restoration of the beneficial uses of the Big Sioux River and its tributaries, through implementation of BMPs described below and those supported through subsequent projects should lead to attainment of TMDL targets.

Objective 1: Reduce fecal coliform and sediment loadings to the Big Sioux River and its tributaries through the renovation and improvement of existing, high-priority animal feeding operations and limiting the access of livestock to impaired water bodies.

Task 1: Animal Waste Management Systems. Assist livestock producers to install animal waste management systems (AWMS) at critical locations within priority watersheds within the project area to reduce fecal bacteria and sediment loading.

One of the potential sources of fecal coliform bacteria is domestic raised animals. The project focused on a corridor that was two miles wide on either side of the Big Sioux River or the major tributaries within the project boundaries. Project funds could be used to assist animal feeding operations (AFO) or feedlots that house less than one thousand animal units. Operations larger than one thousand animal units are considered to be CAFO's or concentrated animal feeding operations and are subject to other regulations.

The process we follow includes a serious of steps that are followed in the development of an animal waste management system. These include meetings with interested landowners and operators to determine if the operation meets the established criteria and address the questions from the interested party. These include: what design changes that need to be made, how much was it going to cost, how much assistance would be available for the design, construction and permitting of the facility. If this meeting was successful then we would schedule the next meeting to include the engineer that would be tasked with doing a feasibility study for the site to determine if the current location was acceptable or if there was a better site that maybe more suitable for the project. There will be many meeting between that date and a time when there was a completed design and we were ready to start looking for a contractor or go out for bids to build or add improvements to the feedlot. Not all feasibilities study's end with construction. There can be a number of factors that would cause the process to stop. The process often takes two or more years before one had a finished product. Table 10 shows the producers that had project assistance for some phase of the development animal waste management system.

As seen in Table 10, there are a number of projects that are initiated that were never completed. This can be due to a number of factors. This can include a site not being suitable for remodeling, space requirements, owner not having a suitable site to move to, overall cost, and the cost/benefit ratio. Environmentally the new feedlot would make a significant improvement for the watershed but the owner would not make a commitment to alter their operation. One of the major considerations for the landowner was that this was a voluntary program and he was not required to make the changes. The farm economics have also motivated a few operators to discontinue their feeding or dairy operations.

Table 10: Summary of AWMS Participation.

Land Owner Code	Feasibility / Preliminary Design	Finalize Design	Construction
AW-01	X		
AW-04	X		
AW-05	X		
AW-06	X		
AW-07	X		
AW-08	X	X	
AW-09	X		
AW-10	X		
AW-11	X		
AW-C01	X	X	X
AW-C02	X	X	
AW-D01	X	X	X
AW-H01	X		
AW-H02	X	X	X
AW-H03	X		
AW-H04	X	X	X
AW-H05	X	X	X
AW-H06	X	X	X
AW-H07	X	X	
AW-H08	X		
AW-H09	X	X	
AW-H10			X
AW-H11	X	X	
AW-H12	X	X	X
AW-M01	X	X	X
AW-M02	X	X	X
AW-M03	X	X	
AW-M04	X	X	X
AW-M05	X	X	X
TOTAL	27	18	12

A conventional feeding operation with the feedlot on the left, a sediment basin in the middle and the holding pond in the right can be seen in Figure 2.

Figure 2: Conventional feeding operation.

Figure 3 displays a sediment basin which would be located between the feedlot and the holding pond or vegetative treatment area. The basin traps the solid material and allows the liquid to flow into the receiving area.

Figures 3: Feedlot Sediment Basin.

Not all locations are suited to build a conventional feedlot. There are a number of operations that are choosing vegetative treatment areas (VTA) because it does not require building a deep pond. VTAs produce grass that can be used to feed livestock the operator raises. In Figure 4 is a newly constructed VTA that will be planted to grass. Liquid leaving the sediment basin would flow over the grass and provide water and nutrients. VTA's replace the holding pond found in a conventional system.

Figure 4: Newly constructed vegetative treatment area.

Throughout the project, it had been found that many of the producers were more interested in lower cost options. Producers want to significantly reduce the contamination problems and yet did not want to develop a conventional feedlot waste handling system.

The vegetative treatment areas (VTA) have increased in popularity because of the concerns with space needed for holding ponds, the failure rate of the deep holding ponds and the taking of productive land out of production.

Another method that used was to prevent the contamination of the ground water was to divert water away from the feedlot. Figure 5 shows a diversion dike that was built to prevent the water from entering the lot on the right. The dike doubles as a roadway for this operator. In the past water would flow though the feedlot picking up animal waste and depositing it into the Big Sioux River. This less expense option was the logical choice for the some owners.

Figure 5: Clean water diversion adjacent to feedlot in Minnehaha County.

If the current location was not suitable or there were other factors that cause an operator to choice relocation, the old area was required to be abandoned, reclaimed and could not be used as a feedlot in the future. Sites that were abandoned can be seen in Figures 6 and 7.

Figure 6: Feedlot location that was required to be abandoned once the new feedlot was operational.

Figure 7: Previous feedlot that can no longer be managed as a feedlot but is allowed to be grazed.

The Spreadsheet Tool for Estimating Pollutant Load, (StepL) calculated load reductions achieved though the construction of the twelve animal waste management systems are shown in Table 11.

Table 11: Load Reduction Achieved from Construction of Animal Waste Management Systems.

Land Owner Code	Nitrogen Reductions in pounds*	Phosphorus Reductions in pounds*	Sediment Reductions in tons**	Fecal Bacteria Annual Reduction**
AW-C01	3,040.1	684.0	8.35	1.12E+11
AW-D01	15,119.6	3,401.9	22.9	9.43E+10
AW-H02	7,628.5	1,727.0	33.8	8.98E+10
AW-H04	4,540.4	1,021.6	6.5	8.98E+10
AW-H05	6,053.9	1,362.1	8.7	8.98E+10
AW-H06	7,567.4	1,702.7	10.9	8.98E+10
AW-H10	4,540.4	1,021.6	21.8	1.12E+11
AW-H12	22,435.7	2,506.3	21.8	1.12E+11
AW-M01	22,533.8	5,070.1	30.5	8.98E+10
AW-M02	4,979.6	3,430.4	12.0	8.98E+10
AW-M04	6,817.9	1,422.2	24.8	1.12E+11
AW-M05	16,079.5	3,617.9	21.8	8.98E+10
TOTAL	121,336.8	26,967.8	223.9	1.17E+12

*StepL load reductions
**Feedlot and Grazing Reductions Model (FLGR 3) was used to calculate the fecal load reductions

Tasks 2: Reduce livestock access to water bodies. Provide resources to livestock owners to limit or prevent access to impaired water bodies and provide alternative water sources to replace the impaired water bodies.

The approach that was chosen was to offer assistance to operators for the construction of rock crossings or to provide another source of water away from the creek or river. This would limit the livestock contact with the river or creek and yet provide good fresh water to the animals.

During 2006 Moody County Conservation District applied for a Coordinated Soil and Water Conservation Grant from the South Dakota Department of Agriculture. The purpose of this grant was to provide supplemental funds for technical assistance and cost share dollars to establish alternate water sources and rock crossings in the riparian areas of the project. The grant number 2006CSW-022 for $56,800 was to be available from July 1st, 2006 thru June 31st, 2008. The next two tables reflect the budget that was set up for that part of the overall watershed project.

Table 12: Division of Resource Conservation & Forestry Grant Budget.

Activity	Grant Funds	Local Funds	Other Funds	TOTAL
Salary	$18,800		$56,400	$75,200
Alternative Water Sources	$20,000	$20,000		$40,000
Rock Crossings	$16,000	$24,000		$40,000
Fencing			$10,000	$10,000
TOTAL	$54,800	$44,000	$66,400	$165,200

Table 13: Division of Resource Conservation & Forestry Grant Budget Breakdown of Funds.

	CSWC	LANDOWNER	EDWDD	319 EPA	USF&W
Alternate Water Source	$20,000	$10,000	$10,000		
Rock Crossing	$16,000	$16,000	$8,000		
Technical Assistance	$18,800			$56,400	
Fencing					$10,000
TOTAL	$54,800	$26,000	$18,000	$56,400	$10,000

Even though fence was listed as a component to this activity it was handled by the US Fish and Wildlife service and was not tracked within this project. The two components that were tracked were rock crossings and alternate water sources. These two activities were not in great demand during the project. The next two tables reflect the level of participation.

Table 14: The Rock Crossing Expenditures.

	Cost	319 EPA	Landowner
RC 1	$4,557.75	$3418.31	$1139.44
RC 2	$4,557.75	$3418.32	$1139.43
RC 3	$5,923.65	$4442.74	$1480.91
RC 4	$2,867.42	$2150.57	$716.85
RC 5	$4,700.00	$3,525.00	$1,175.00
TOTAL	$22,606.57	$16,954.94	$5,651.63

Table 15: The Alternate Water Source Expenditures.

	Cost	RC&F	USF&W	EDWDD	Landowner
ALW 1	$7,246.27	$1,619.96	$641.21	$1,387.46	$3,597.64
ALW 2	$655.99	$328.00		$164.00	$163.99
ALW 3	$6,150.31	$2,000.00		$1,000.00	$3,150.31
ALW 4	$2,607.53	$1,000.00		$651.88	$955.65
TOTAL	$16,660.10	$4,947.96	$641.21	$3,203.34	$7,867.59

Livestock in the water, similar to Figures 8-9, destroy shoreline vegetation, increase sediment loading, raises water temperature, and increase nutrient levels in the water. Figure 9 shows signs of livestock using this site to cross the creek. This was destroying natural vegetation, increasing turbidity, and degrading the water quality. A rock crossing (Figure 10) was put in place to allow livestock to cross without doing damage as observed in Figure 9. Once built, cows quickly found this crossing, and would use this as the preferred location to cross the creek.

Figure 8: Cattle standing in the water.

Figure 9: Damaged stream due to cattle crossing.

Figure 10: Installed cattle rock crossing.

Objective 2: Reduce sediment loadings to the Big Sioux River and its tributaries through bank stabilization of critical river and tributary segments and by restoration of riparian buffer zones.

Task 3: Stabilize banks along critical reaches of Skunk Creek and the Big Sioux River. The assessment study identified portions of lower Skunk Creek and the Big Sioux River in the Sioux Falls area as contributors of significant sediment loads. Urban reaches of these water bodies generated disproportionate loads of sediment, contributing to the overall TSS impairments. Segments of these water bodies will be targeted for bank stabilization, including both hard (rip-rap) and soft (vegetative) practices.

One of the areas identified as in need of bank stabilization was Skunk Creek and a smaller tributary named Silver Creek. The City of Sioux Falls contracted with Mussetter Engineering, Inc. of Fort Collins, Colorado to develop a plan to stabilize the bank in the area west of Marion Road and south of West 12th Street in the southwest portion of Sioux Falls. The finalized plan was received in June of 2006. The construction contract was awarded to Runge Enterprises with construction administration preformed by Stockwell Engineers, Inc. of Sioux Falls. There was 10,000 linear feet of bank stabilization. About 5,440 feet of the stream banks were stabilized using soft methods of vegetation only treatment. The other 4,110 feet was stabilized using rock riprap and gabion baskets. One segment that was 450 feet in length was stabilized using bend way weirs (Figure 11). The calculated load using StepL (Table 16) resulted in a reduction of 189.7 pounds of nitrogen and 43.2 pounds of phosphorus per year entering the creeks. In addition there is 118.8 tons less sediment entering the creeks. The downstream location is 1.25 miles from the Big Sioux River.

Figure 11: Skunk Creek bank stabilization and rock spurs.

Figure 12: Skunk Creek bank stabilization.

Table 16: Skunk Creek and Silver Creek Bank Stabilization Project.

Segment Number	Length feet	Nitrogen lbs / year	Phosphorus lbs / year	Sediment tons / year
Vegetation Only	5440	10.5	4.1	6.6
M – 1	315 / 315	15.8	6.2	10.0
M – 2	400	10.1	3.9	6.3
M – 3	470	11.8	4.6	7.4
M – 4	440 / 200	16.1	6.2	10.0
M – 5	395	10.0	3.8	6.2
M - 6	375 / 375	18.8	7.2	11.8
M – 7	245	6.2	2.4	3.9
M – 8	410	10.3	4.0	6.5
M – 9	420	54.3	20.9	33.9
M – 10	200	25.8	9.9	16.2
TOTAL	10,000	189.7	73.2	118.8

The Central Big Sioux Watershed Assessment identified and area between Sioux Falls and Baltic as contributing a significant sediment load. It was decided that it would be beneficial to have an outside source conduct an evaluation of the Big Sioux River bank stability.

During August of 2007 a Big Sioux Bank Stability Project was developed and $57,800 was provided to pay for this study. Agricultural Research Service, a branch of U.S. Department of Agriculture was contracted to conduct an “Analysis of Bank Stability and Potential Load Reduction along Reaches of the Big Sioux River, South Dakota” (Appendix G). The main objective of this study was to determine rates and loadings of sediment from stream bank erosion along main stem reaches of the Big Sioux River. This area was 131.36 km upstream of the mouth of the Big Sioux River on the Missouri River to an area 431 km upstream. This activity was to be completed by April of 2008. The analysis was received in January of 2009.

There were five location chosen for the Bank Stability and Toe Erosion Model, (BSTEM) (see Figure 13). They were near Castlewood, Estelline, Brookings, Egan, and Renner. Each site was evaluated for flow levels at the following percentiles: 90th, 75th, 50th, 25th and 10th. According to the executive summary from their report: “The model results showed that predicted eroded volumes of sediment emanating from streambanks decreased non-linearly from the 90th percentile flow year to the 10th percentile year. Predicted volumes of sediment eroded the streambanks at each site ranged from 169 to 1359 cubic meters of sediment per 100meter reach during the 90th percentile year, under existing conditions where the banks have a cover of native grass.” It went on to say that “Bank failures were generally only predicted to occur during the 90th percentile flow year modeled at each site, indicating that during lower percentile flow years, hydraulic scour at the toe was the predominant erosion process, rather than mass wasting of the banks.” Their recommendation went on to state that “The addition of bank-toe protection to the grassed bank resulted in a huge total reduction in average, annual loading...”

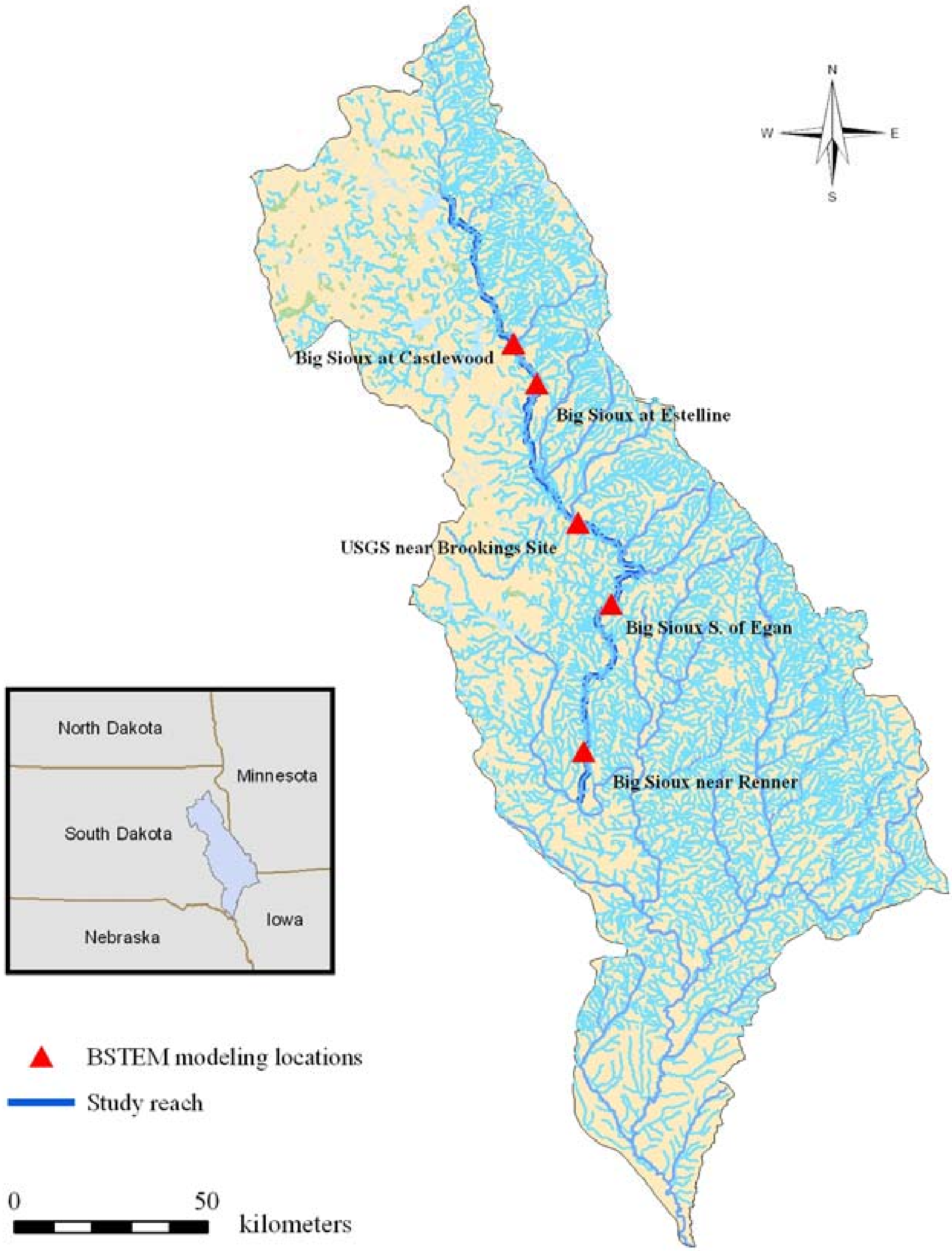


Figure 13: Bank stability and Potential Load Reduction study reach and locations.

After receiving the report, it was decided that a number of locations near Sioux Falls and on the Big Sioux River should be considered for toe stabilization. The City of Sioux Falls had access to about two million dollars in state revolving funds. This would enable work to be completed on a limited number of sites. The Department of Environment and Natural Resources, DENR selected 18 segments of the Big Sioux River in the area from Sioux Falls to Baltic as being potential bank stabilization segments. The City of Sioux Falls also requested DENR investigate seven other sites for potential restoration.

A public meeting was held April 1st, 2009 at the Renner town hall. Twelve local individuals were present representing 10 of 18 selected segments. Permission requests to enter private property were signed by the majority of the owners present and one expressed interest in enrolling in the conservation easement program. Over the summer of 2009, a team of technicians from East Dakota Water Development District and Department of Environment and Natural Resources conducted a rapid geomorphic assessment (RGA) on the sites and assigned them a ranking. DENR then assigned the segments to one of three phases. Phases one and two were designed during the fall of 2009 by City of Sioux Falls engineering staff. Phase one was bid in December and phase two was bid during January, 2010. Construction was completed by the March 31st, 2010 deadline. Conservation District trees were planted on the sites during the spring of 2010. Two more phases are expected during the winter of 2010 through the spring of 2011.

Segment 65 is shown below in Figure 14. This area was losing 3-5 feet of shoreline each year. The operator was planting corn and soybeans to the edge of the 12 foot high bank. Outside rows from previous years could be seen disappearing off the edge of the bank. Rip rap for this site was installed during the winter of 2010 (see Figure 15).

Figure 14: Preconstruction of segment 65.

Figure 15: Rip rap placed on segment 65.

Figure 16: Preconstruction picture of segment 13.

Figure 17: Segment 17 after placement of rip rap during the winter of 2010.

Figure 18: The preconstruction picture of segment 1.

Segment 1 had lost a great deal of shoreline as apparent by the large number of large sod blocks and trees that have fallen into the river. This area had permanent vegetation but it was not sufficient to protect the shoreline from erosion. This was part of the reason that the use of rock was selected for protecting the bank at the toe. The design criterion was that rock rip-rap would go up to the bank full elevation (about the two year flood elevation). These sites are monitored to see how well the sites react with their repairs. They have handled the flooding that occurred during the spring and summer of 2010 very well, and the vegetation is growing very well on the top of the banks.

Phases one and two came in under the anticipated cost thus prompting the City of Sioux Falls and the Department of Environment and Natural Resources to move on to phases three and four.

The Spreadsheet Tool for Estimating Pollutant load, (StepL) was used to determine the load reductions achieved by doing the bank stabilization for this project. The results of these calculations can be seen in table 17 and 18.

Table 17: Big Sioux River Bank Stabilization Project Phase 1 and Reductions Achieved.

Segment Number	Length feet	Nitrogen lbs / year	Phosphorus lbs / year	Sediment tons / year
101	950	1988.4	765.5	1,462.0
103	1,064	1,952.9	1,61.4	1,61.751.84
200	139	164	63.1	89.1
1	778	2,035.5	783.7	1,496.7
9	2013	6,033.9	2,323.0	3,977.7
65	1,316	3,825.6	1,472.9	2,391
6	474	1,157.5	445.6	851.1
TOTAL	6734	17,157.8	6,605.6	11,329

Table 18: Big Sioux River Bank Stabilization Project Phase 2 and Reductions Achieved.

Segment Number	Length feet	Nitrogen lbs / year	Phosphorus lbs / year	Sediment tons / year
2	535	1,306.4	503.0	960.6
17	924	2,578.6	992.8	1,896.0
11	1,063	2,595.7	999.4	1,908.6
4	1,282	3,577.7	1,377.4	2,630.7
15	1,851	5,165.6	1,988.8	3,798.3
13	643	1,993.8	767.6	1,466
104	570	1,193	459.3	877.2
16	998	2,785.1	1,072.3	2,047.9
3	800	1,674.4	644.6	1,231.2
TOTAL	7,866	22,870.3	8,805.2	16,816.5
GRAND TOTAL PHASES 1 AND 2	15,400	40,028	15,411	28,146

See "Analysis of Bank Stability and Potential Load Reduction along Reaches of the Big Sioux River, South Dakota" in the Appendix G.

Task 4: Riparian area restoration in urban and rural settings Critical reaches of the riparian corridor along the Big Sioux River and its tributaries have been lost to urban development. Riparian corridors have been lost to municipal, industrial and agricultural development. In many cases, the riparian areas have been completely eliminated. This task will provide BMPs to restore and preserve critical riparian areas through the acquisition of easements in urban and rural areas. It will also provide additional incentive to landowners interested in enrolling in the USDA Conservation Reserve Program (CRP).

The RAM program was used in conjunction with the continuous conservation reserve program (CCRP), of the conservation reserve program, (CRP). In order to facilitate the enrollment of the CRP acres, the project paid the base rate amount used by CRP to add up to 35% of the acres enrolled in the CP 21, 22 29 and 30 programs.

The following are the guidelines that have followed for this program.

1. If the land under application is eligible for a USDA CRP program, the landowner is encouraged to seek funding from the USDA. This program is only for land which is not eligible for a USDA CRP program.
    a. The land under application must be located on or in close proximity to an impaired river or stream segment. See Figures 24 – 28
    b. Impaired segments which will have a greater priority will be Sioux Falls Waste Water Treatment Facility (SF WWTF) to above Brandon BSR segment, Flandreau Creek, Beaver Creek, Pipestone Creek, and Skunk Creek. These TMDL segments require significantly large reductions in fecal coliform and/or TSS to meet the standard for designated uses.
2. The rental rate as established by the county USDA FSA office for the CRP program will be used for payment under the RAM Program.
    a. Brookings County $60.00 per acre
    b. Codington County $58.00 per acre
    c. Deuel County $58.00 per acre
    d. Hamlin County $58.00 per acre
    e. Minnehaha County $66.00 per acre
    f. Moody County $66.00 per acre
3. There are two ways that land can be enrolled in the RAM Program.
    a. If a landowner has applied for a USDA CRP Program and a small portion of land does not qualify, the landowner may apply for the RAM Program.
    b. Land not eligible for USDA CRP programs may be covered by this program as long as less than 35% of the total amount of land enrolled in both programs is under application for the RAM Program.
        i. The amount of land under application for t5he RAM Program must be adjoining land which is currently under application for a USDA CRP program and must not be more than 35% of the total amount of land under application for a USDA CRP program and the RAM Program.
        ii. The length of time for a RAM contract under this scenario will follow the length of time for the USDA CRP contract.

c. Land which does not qualify for a USDA CRP program because of current condition of the land may be enrolled in the RAM Program.
    i. Example: tree cover
    ii. Cropping history
    iii. Distance from the edge of the waters
4. The landowner will be required to follow a conservation plan for the tract of land enrolled in the RAM Program. This will be provided to the landowner by the conservation district.

Often this makes the difference whether a landowner will enroll in CRP or not. Like CRP, RAM contracts were for either 10 or 15 years.

The watershed project pays the conservation district and then the conservation district will in turn make the payments to the landowner at the end of each year.

Initially East Dakota Water Development District funded the entire amount for the Ram Program. Landowners were paid the annual rental rate times the number of acres enrolled in the RAM contract. During 2008 this payment schedule was changed to the following: one half of the contract value at the end of the first year. In years two thru nine for a ten year contract and two thru 14 for fifteen year contract will receive one half of the annual rental rate times the number of acres enrolled. In the last year of the contract, the landowner will receive the balance of the contract amount. Under this current scenario, EPA 319 funds are being paid during the time period for the watershed project. Any time outside of the project period will be paid by East Dakota Water Development District.

Table 19: Summary for the RAM Program and Resulting Acres Combined with Enrolled CRP.

Contract Number	Acres in RAM	Total with CRP acres	Duration of Agreement
Moody - 02	19.2	98.9	15
MCD -2006-2	16.2	16.2	15
Moody - 01	3.2	3.2	15
MCD -2007 -01	8.5	53.9	10
MCD -2006 -01	4.7	14.3	15
Moody – 03	6.0	15.0	15
Hamlin - 01	29.0	96.8	15
Deuel - 01	15.35	40.45	15
Moody -04	5.7	15.8	15
Brookings - 01	19.2	45.0	10
Moody - 06	46.2	130.2	10
Moody - 07	9.0	9.0	10
Hamlin - 02	12.7	41.0	10
Moody - 08	8.5	26.0	15
Hamlin - 03	6.8	CE	15
Minnehaha 01	20	20	Perpetual
TOTAL	230.25	625.75	10/15 year, 5/10 year

Table 20: Annual Load Reduction Achieved as a Result of the Enrollment in the RAM Program.

Contract Number	Pounds of Nitrogen Reduced*	Pounds of Phosphorus Reduced*	Tons of Sediment Reduced*	Fecal Load Reduced**
Moody - 02	2,140.1	483.6	20.7	1.01E+13
MCD -2006-2	790.5	261.0	184.3	
Moody - 01	360.5	109.4	70.2	
MCD -2007 -01	1,318.1	313.5	13	6.73E+12
MCD -2006 -01	659.9	157.3	7.0	3.36E+125
Moody – 03	2,276	523.9	17.2	5.61E+12
Hamlin - 01 - Load Reductions Are included with Conservation Easements				
Deuel - 01	2,196.8	523.2	13.4	9.89E+12
Moody -04	1,145.2	288.3	20.7	5.61E+12
BCD - 2009 - 01	1,666.8	391.2	14.2	8.41E+12
Moody - 06	5,542.0	1,299.0	26.3	2.86E+13
Moody - 07	1,844.0	574.3	354.2	1.35E+12
Hamlin - 02	1,746.58	410.66	7.5	9.08E+12
Moody - 08	715.9	80.1	26.6	6.73E+12
Hamlin – 03 - Load Reductions are included with Conservation Easements				
Minnehaha 01	1,116.7	366.5	257.1	
TOTALS	**23,519.1**	**5,782.0**	**1,032.4**	**9.54E+13**

*Spreadsheet Tool for Estimating Pollutant Load (StepL) was used
**Feedlot and Grazing Reductions Model (FLGR 3) was used

Conservation Easement Program, CE

Conservation easements were used to restrict or exclude livestock grazing and other farming practices in riparian areas along the BSR and its named tributaries. The program criteria include:

1. Conservation easements will be held by Northern Prairie Land Trust (NPLT).
2. The land under application must be adjacent to or in close proximity to an impaired segment of the Big Sioux River or named tributaries.
    a. Priority area include will be Sioux Falls Waste Water Treatment Facility (SF WWTF) to above Brandon BSR segment, Flandreau Creek, Jack Moore Creek, Bachelor Creek, Split Rock Creek, Beaver Creek, Pipestone Creek, and Skunk Creek. These TMDL segments require significantly large reductions in fecal coliform and/or TSS to meet the standard for designated uses. See Figures 25 – 28
3. The land offered must currently be used as grazing land for livestock or must currently be cropped up to the stream bank. Land which is currently maintained as a riparian area will be considered a lower priority.
4. Easements will be held for a minimum of thirty (30) years or perpetually (permanent).
5. Easements can be placed on lands currently under a USDA CRP contract.
6. Riparian buffers developed by the easement will be a minimum of seventy-five (75) and a maximum of one hundred-fifty (150) feet from the river of stream bank.
7. The landowner will be required to follow a conservation plan which will be provided by NPLT.

Payments were made based on the adjusted assessed land value (AALV), calculated from county taxed assessed value then multiplied by a correction factor that was provided by US Fish and Wildlife that would bring the land value in alignment with the current market value of the land. The payment amount would multiply by the calculated value by using percentage shown in the table below.

Table 21: Shows the Conservation Easement Payment Schedule.

DURATION OF EASEMENT	CRP TIME REMAINING	% OF AALV
30	0	80%
30	<5	75%
30	6 - 9	70%
30	>10	65%
PERPETUAL	0	95%
PERPETUAL	<5	90%
PERPETUAL	6 - 9	85%
PERPETUAL	>10	80%

The Big Sioux River Conservation Easement Program (CE) was the projects other approach to protect land adjacent to the River and its tributaries. The most significant difference between RAM and CE was the duration of the protection that was offered.

Figure 19: Conservation Easement closing for property located Southeast of Castlewood, SD. (Pictured are from left to right Pat Anderson, NPLT, Deb Biord, Dave Gerhold, John Johnson and Doug Feten, both with EDWDD and Dan Gerhold.)

Figure 20: Largest single conservation easement closing. (Front row: Roger Strom, WPC. Carlene Rust and Larry Rust, owners, Curtis Eggers, chairman EDWDD, back row are all board members for EDWDD and they are: Lois Brown, Robert Todd, John Johnson, Kay Kassube, John Weidler, Martin Jarrett, Vincent Flemming and Doug Feten)

The closing seen in Figure 20 was the largest single conservation easement closing. It washeld in conjunction with EDWDD monthly board meeting on April 15th, 2010.

Figure 21: Shows a conservation easement southeast of Castlewood South Dakota.

The watershed project used the StepL model to determine values for nitrogen, phosphorus and sediment reductions. Feedlot and Grazing Reductions Model (FLGR 3) was used for fecal loads found in Table 22.

Table 22: Annual Load Reduction Achieved from Enrollment in Conservation Easements.

Contract Number	Acres	Feet of Shoreline	Pounds of Nitrogen Reduced*	Pounds of Phosphorus Reduced*	Tons of Sediment Reduced*	Fecal Reductions**
B 01	25.7	6,373	237.4	37.0	19.3	8.97E+12
C 01	14.6	3,312	60.8	9.4	4.8	2.99E+12
H 01	28.92	8,354	620.1	139.9	78.4	2.09E+13
H 02	18.2	5,031	485.8	91.1	47.7	3.59E+12
H 03	36.5	7,982	467.4	58.7	23.9	7.47E+12
B 02	27.8	8,646	237.4	37.0	19.3	5.98E+12
H 04	26.4	5,807	246.0	31.8	13.4	4.78E+12
H 05	24.3	9,304	583.2	169.8	103.1	4.78E+12
H 06	18.9	5,650	537.6	156.9	95.5	3.59E+12
H 07	57.1	14,142	739.9	178.0	93.8	1.20E+13
M 01	16.0	5,722	917.1	243.1	161.88	2.22+12
H 09	31.7	8,566	1,328.2	321.0	163.9	5.98E+12
H 10	38.5	11,554	371.8	81.02	45.6	7.47E+12
H 11	46.8	16,978	1,710.3	360.9	173.0	8.97E+12
B 03	14.5	8,033	839.9	210.6	132.7	2.99E+12
H12	103.1	22,236	788.5	121.8	52.5	2.09 E+13
H13	15.4	6,194	2,997.1.0	900.8	570.16.58e+12	
H14	12.8					
H15	4.3					
TOTALS	561.52	147,60	13,168.5	3,149.0	1,798.8	1.30E+14

*Spreadsheet Tool for Estimating Pollutant Load (StepL) was used
**Feedlot and Grazing Reductions Model (FLGR 3) was used

Objective 3: Increase public awareness of water quality issues in general, and project activities and results in particular, throughout the Big Sioux River watershed.

Task 5: Information and Education

The watershed project employed a number of methods to reach the public and create awareness of the watershed project. The web site can be reached at www.eastdakota.org. A portion of the material from the web site is included in Appendix D.

OUTREACH PROGRAM

BROCHURES

"Big Sioux River Watershed Project – Animal Waste Management System"
"Big Sioux River Watershed Project - Riparian Buffer Management"
"Big Sioux River Watershed Project - Conservation Easement Program"
"Big News on the Big Sioux – Your Guide to Water Quality Issues in Eastern South Dakota"
"Time for Clean Water – South Dakota Pollution Prevention Guide"
"Keep the Green out of the Lakes use Zero Phosphorus Fertilizer"
"Conservation Easements – Central Big Sioux River Watershed Program"
"RAM – Riparian Area Management – Central Big Sioux River Watershed Program"
"Conservation Easements – Central Big Sioux River Watershed Program"

VIDEO

"East Dakota Water Development District" – video
"East Dakota Water Development District" – PSA

MAGAZINE ARTICLE

Magazine Title Article Title
Quality on Tap - Big Sioux Community Water System - "Central Big Sioux Watershed Project"
Quality on Tap - Big Sioux Community Water System - "Water Development Districts and Watershed Project"

PUBLIC OPINION SURVEY

2006 Big Sioux River Opinion Survey was conducted by Paulsen Marketing Communications who telephoned 149 respondents were from people owning land along the Big Sioux River (land owner group) and persons randomly selected from the towns of Brookings, Watertown, Brandon and Sioux Falls (urban group). See copy in Appendix H-2 through H-4 at http://denr.sd.gov/dfta/wp/wqinfo.aspx#Project under Big Sioux.

LANDOWNER MEETINGS

Big Sioux Watershed Project Updates:

Location	Attendance Number	Date
Brookings County Extension Office	18	January 16, 2007
Dell Rapids Town Hall	25	February 22nd, 2007
Castlewood Town Hall	24	March 7th, 2007
Brandon Town Hall	17	March 21st, 2007

Figure 22: Public meeting held in Castlewood, South Dakota.

Figure 23: Landowner meeting in Brandon, SD.

DISPLAYS

Sioux Empire Farm Show – Sioux Falls	January 24-27, 2007
Hamlin Conservation hosted Grazing Workshop - Hayti	January 29, 2009
Moody County Farm Show – Flandreau	March 6th, 2009

Meetings attended where Presentations were made

South Dakota Lakes and Streams	September 19th, 2008
	March 6th, 2009
Brookings Conservation District	December 6, 2006
	February 5th, 2009
	May 5th, 2009
Moody Conservation District	December 18th, 2007

Hosted meeting and was an active participant:

Bank Stabilization on the Big Sioux River	April 1st, 2009
Central Big Sioux Watershed Project Steering Committee	December 7th, 2005
	October 6th, 2005
	November 16th, 2005
	February 8th, 2006
	February 21st, 2006
	February 28th, 2008
	October 17th, 2008
Held two Bid Opening –	October 20th, 2008
	August 28th, 2009

Conservation Easement Closing – held 18 meetings to complete easement contracts

East Dakota Water Development District – Presented about 60 Monthly Project updates

Non-point Source Project Coordinators Workshop

North Dakota / South Dakota Non-point Source Project Coordinators Workshop

Aberdeen, SD	February 12-13, 2007
Spoke on Central Big Sioux Project Survey	
Pierre, SD	March 30-31, 2010
Spoke on the Conservation Easement Program and the RAM Program.	

TOURS

Figure 24: Riparian Buffer Conservation Tour – Minnehaha and Moody Counties.

Riparian Buffer Conservation Tour, Co- sponsors	July 31, 2007
EPA/DENR	Sep 21-22, 2010

NEWSPAPER NEWS RELEASES

See Appendix E.

NEWSLETTERS with Articles on the Watershed Project

Sponsor	Date
"For Land's Sake" – Codington Conservation District	Fall, 2006
"Conservation Comments" – Hamlin Co. Conservation District	Fall, 2007

Better Management Practices to Improve Water Quality in the Central and Upper Big Sioux Watershed by SDSU Plant Science Department

An effort was made to provide additional tools to the SDSU Extension Educators in Eastern South Dakota. A project was developed entitled "Better Management Practices to Improve Water Quality in the Central and Upper Big Sioux Watershed". Tables 23 and 24 reflect the acres of land shown in each of the counties maps.

Table 23: Cropland Acres within the Priority Area.

COUNTY	Total Cropland (Acres)	Priority Cropland (Acres)
Brookings	107,015	6,718
Codington	38,674	11,040
Minnehaha	205,334	80,641
Moody	124,347	18,058
Total	475,370	116,457

Data provided by SDSU

Table 24: Rangeland Acres within the Priority Area.

COUNTY	Total Rangeland (Acres)	Priority Rangeland (Acres)
Brookings	21,944	9,273
Codington	14,602	5,777
Minnehaha	44,195	18,166
Moody	31,162	12,396
Total	111,903	45,612

Data provided by SDSU

SDSU produced an Extension Toolbox that contained the following documents:

FS925_E.pdf: Livestock Development and Water Quality
FS 933.pdf: Calibration of Pesticide Spraying Equipment
FS 935.pdf: Recommended Soil Sampling Method
FS 940.pdf: Monitoring Rangeland and Pastures
FS 941.pdf: Nitrogen BMP for Corn in SD
FS 944.pdf: Better Management Practices for Improved Profit… & Water Quality
FS 951.pdf: Issues of Carbon Sequestration
EC 750.pdf: Fertilizer Recommendation Guide
EC 929.pdf: BMP for Corn Production in SD
EDWDD_AW.pdf: Big Sioux River Watershed Project – Animal Waste Management System
EDWDD_EASE.pdf: Big Sioux River Watershed Project – Riparian Buffer Management
EDWDD_RB.pdf: Big Sioux River Watershed Project – Conservation Easement Program
ExEx 1010.pdf: Surface Water Pollution from Livestock Production
ExEx 8091.pdf: Waste Pesticides
ExEx 8166.pdf: Crop Nutrient Consideration for Wet or Flooded Fields

One of the produces was a series on county maps that depicted the priority areas within the Big Sioux Watershed. These maps illustrate where an increased efforts were to be made to implement several best management practices. See the next five figures.

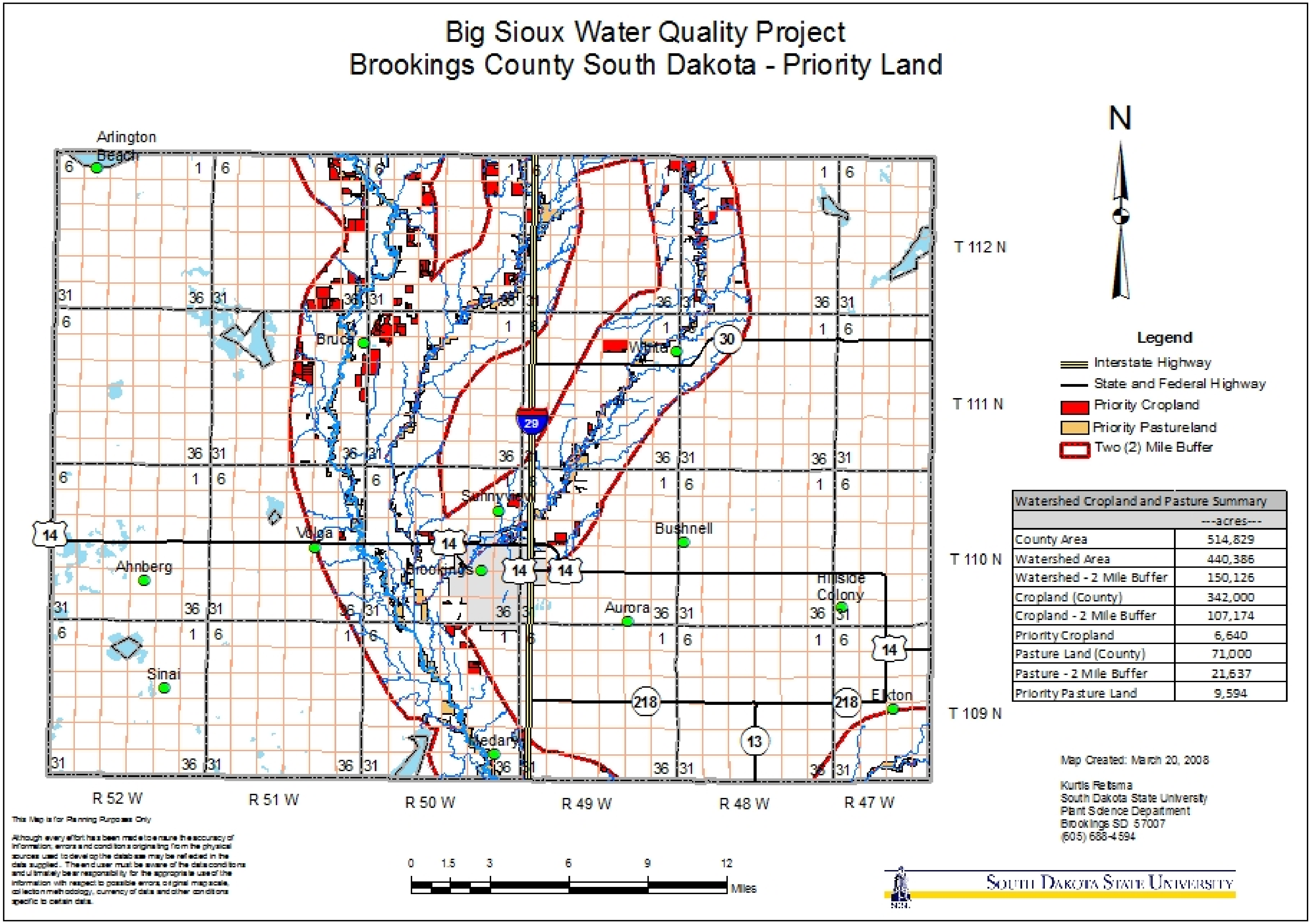


Figure 25: Priority areas in Brookings County.

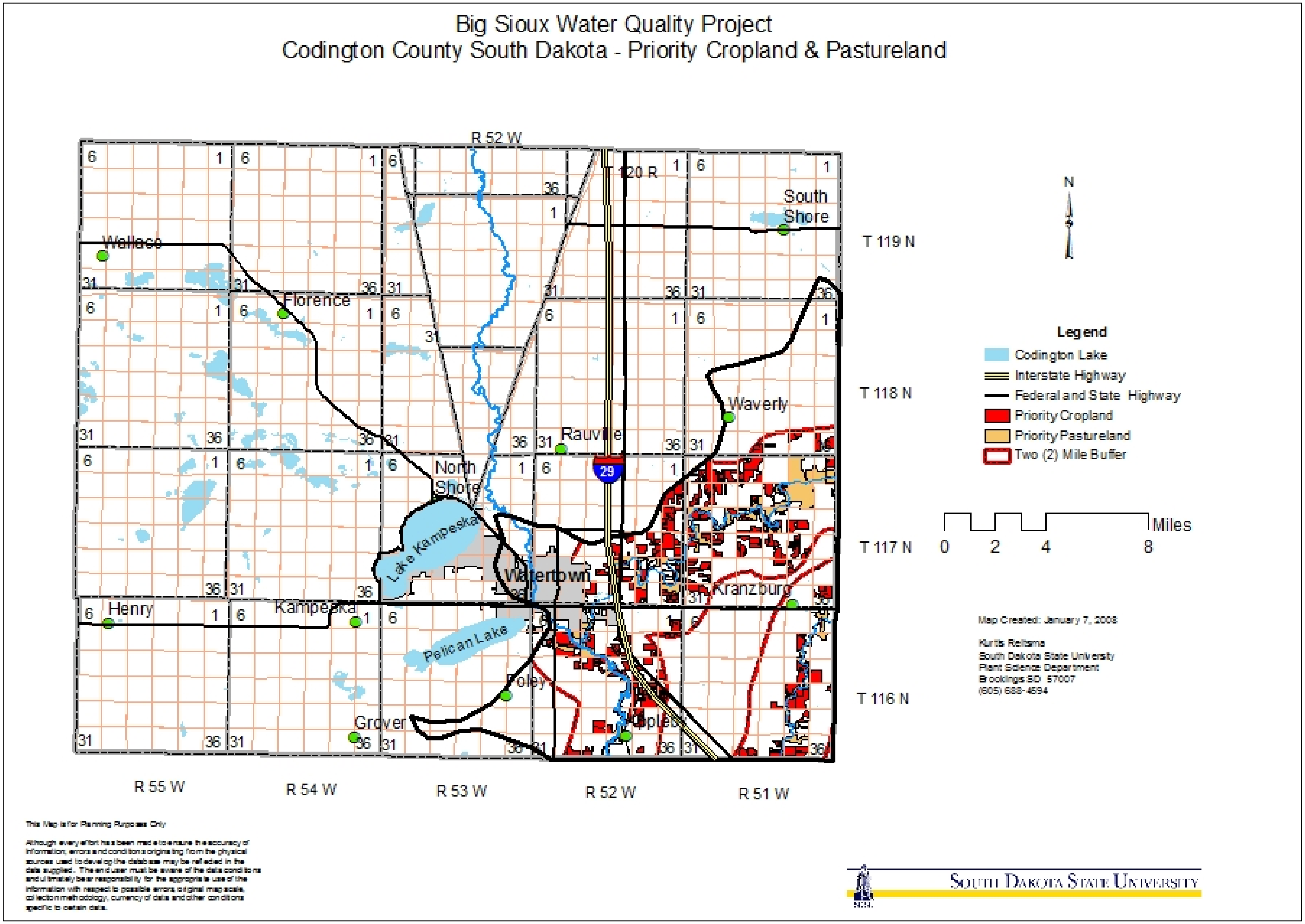


Figure 26: Shows priority areas in Codington County.

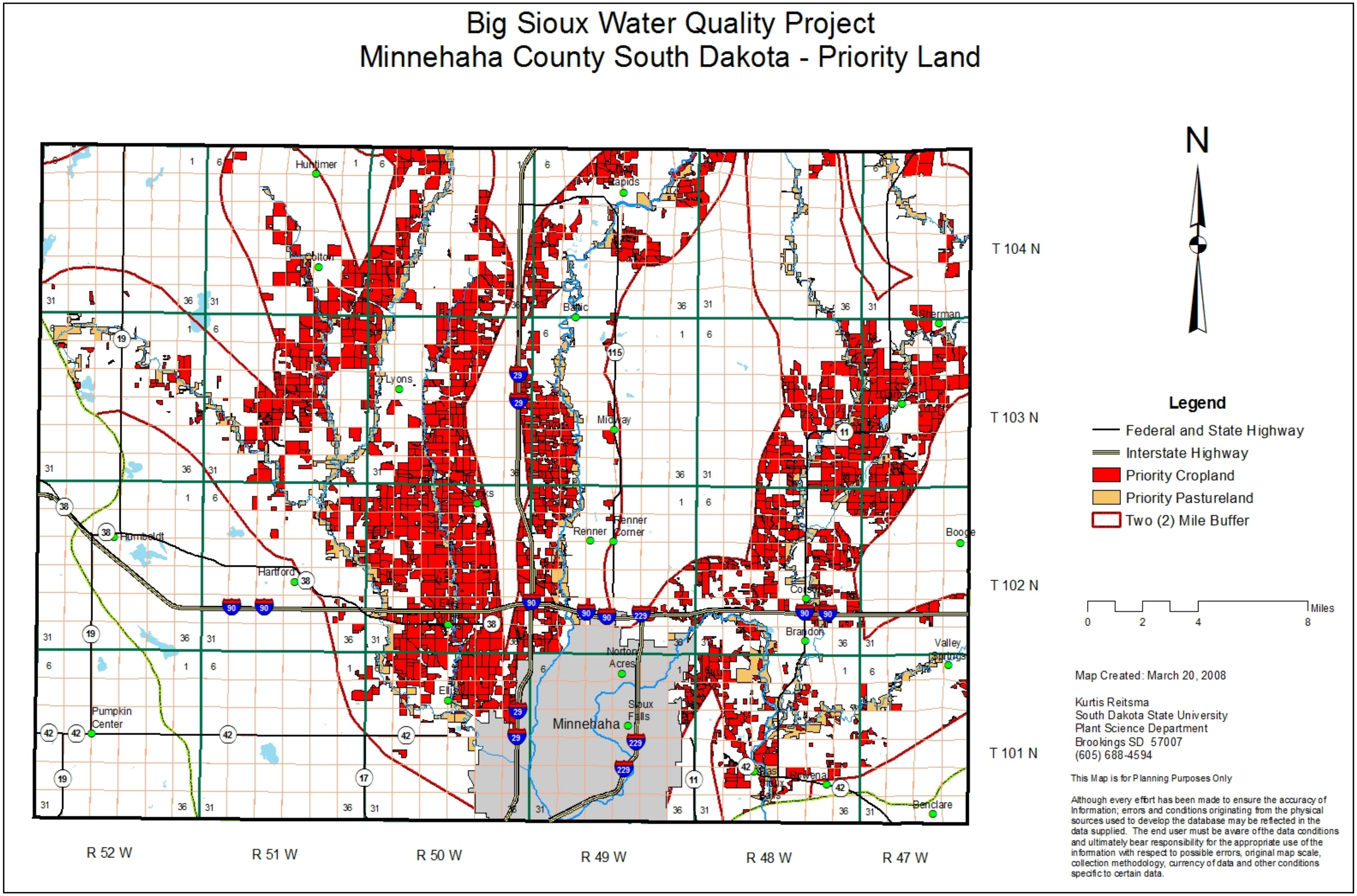


Figure 27: Priority areas in Minnehaha County.

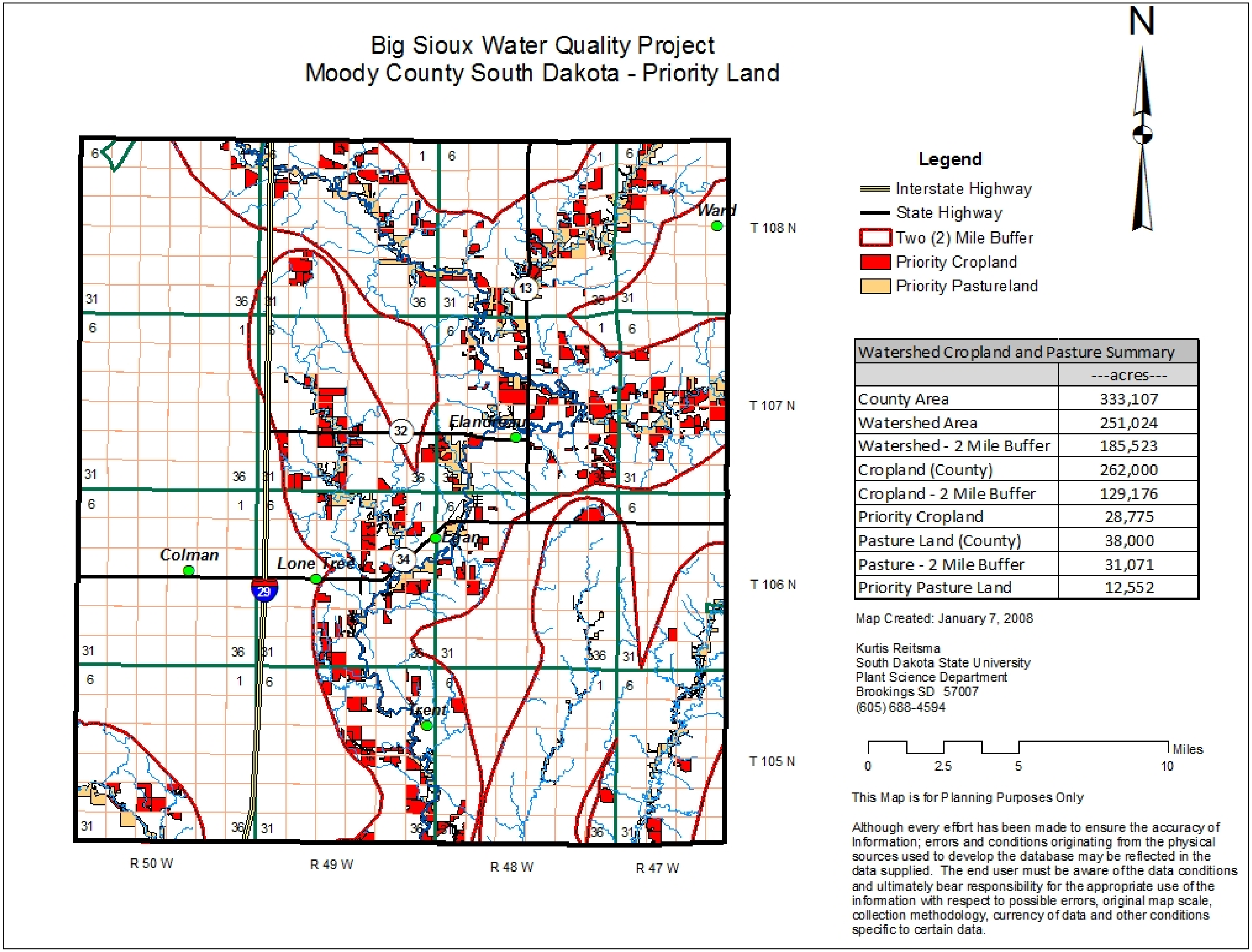


Figure 28: Priority areas in Moody County.

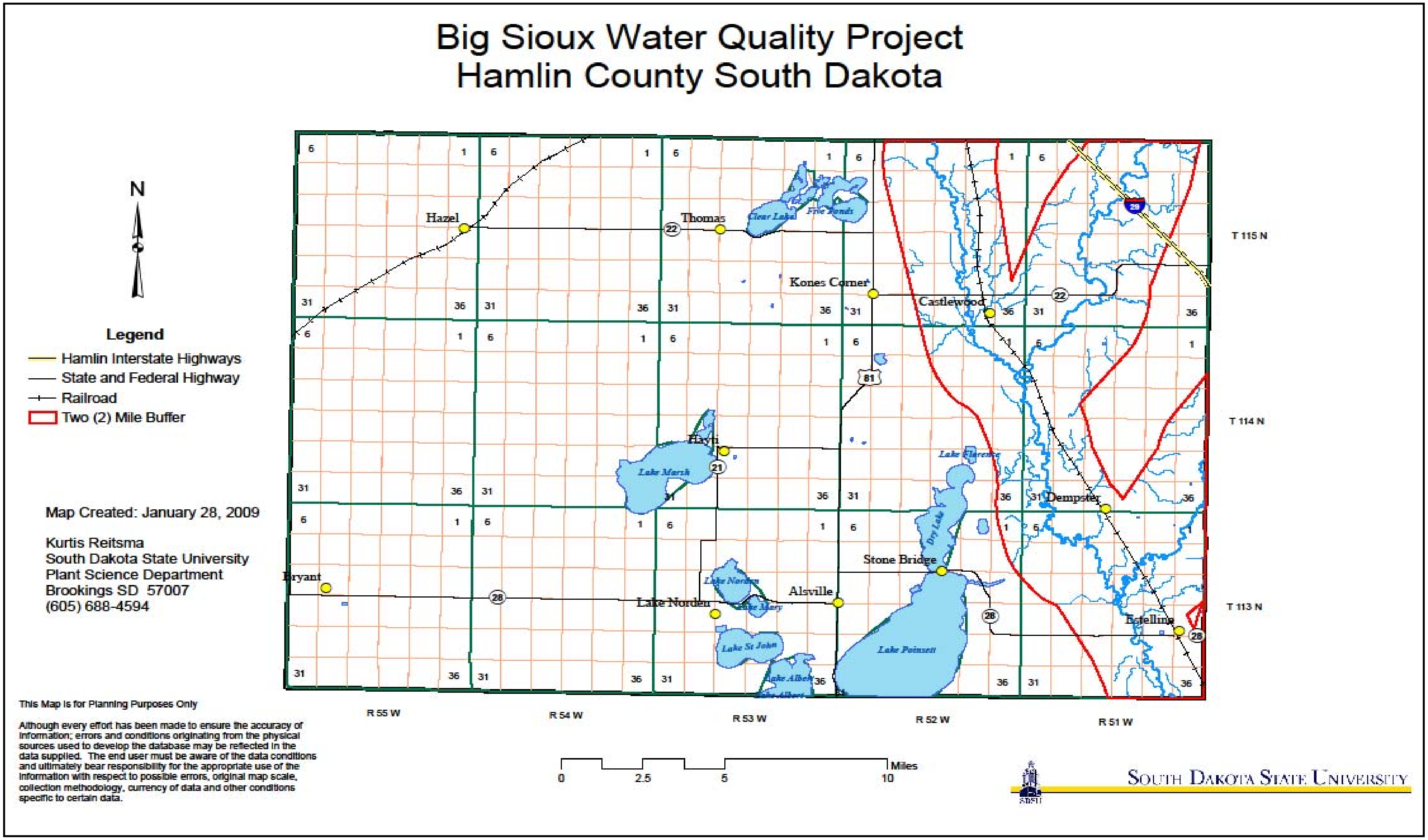
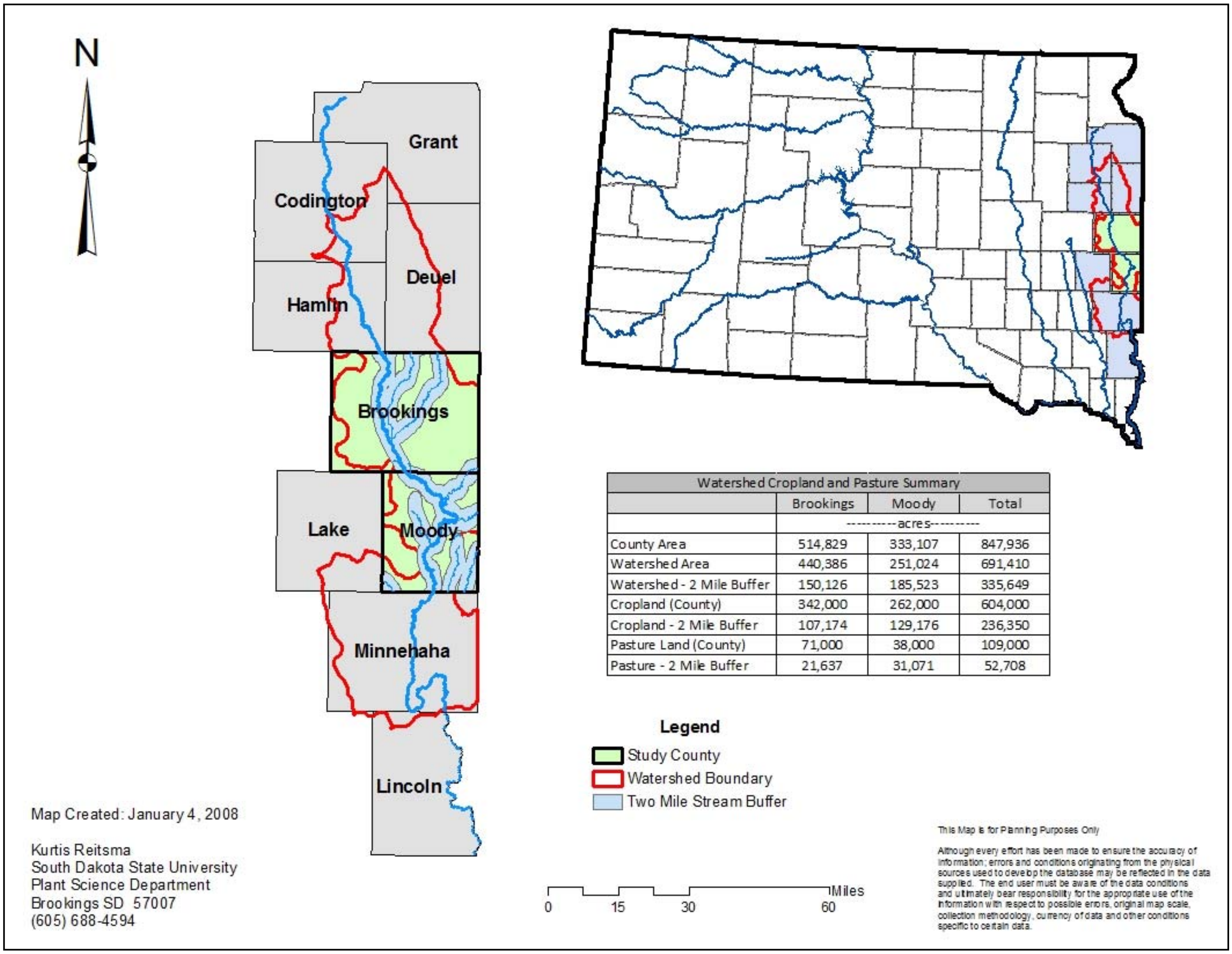


Figure 29: Priority areas in Hamlin County.



Watershed Cropland and Pasture Summary			
	Brookings	Moody	Total
	----------acres----------		
County Area	514,829	333,107	847,936
Watershed Area	440,386	251,024	691,410
Watershed - 2 Mile Buffer	150,126	185,523	335,649
Cropland (County)	342,000	262,000	604,000
Cropland - 2 Mile Buffer	107,174	129,176	236,350
Pasture Land (County)	71,000	38,000	109,000
Pasture - 2 Mile Buffer	21,637	31,071	52,708

Figure 30; Study area use in the Better Management Practices to Improve Water Quality Study.

The Water Quality study was focused on the counties of Brookings and Moody. A copy of the report titled “Better Management Practices to Improve Quality in the Central and Upper Big Sioux Watershed,” produced by SDSU Extension can be found in Appendix H.

Objective 4: Conduct water quality sampling to monitor project impacts on impaired water bodies.

Task 6: Water quality sampling to monitor project impacts Monitor water quality at 24 river and tributary locations.

The fourth objective of the watershed project was to conduct water quality monitoring to assess project impacts on impaired water bodies. To achieve this goal the project worked with a number of monitoring site that are show in Figure 31.

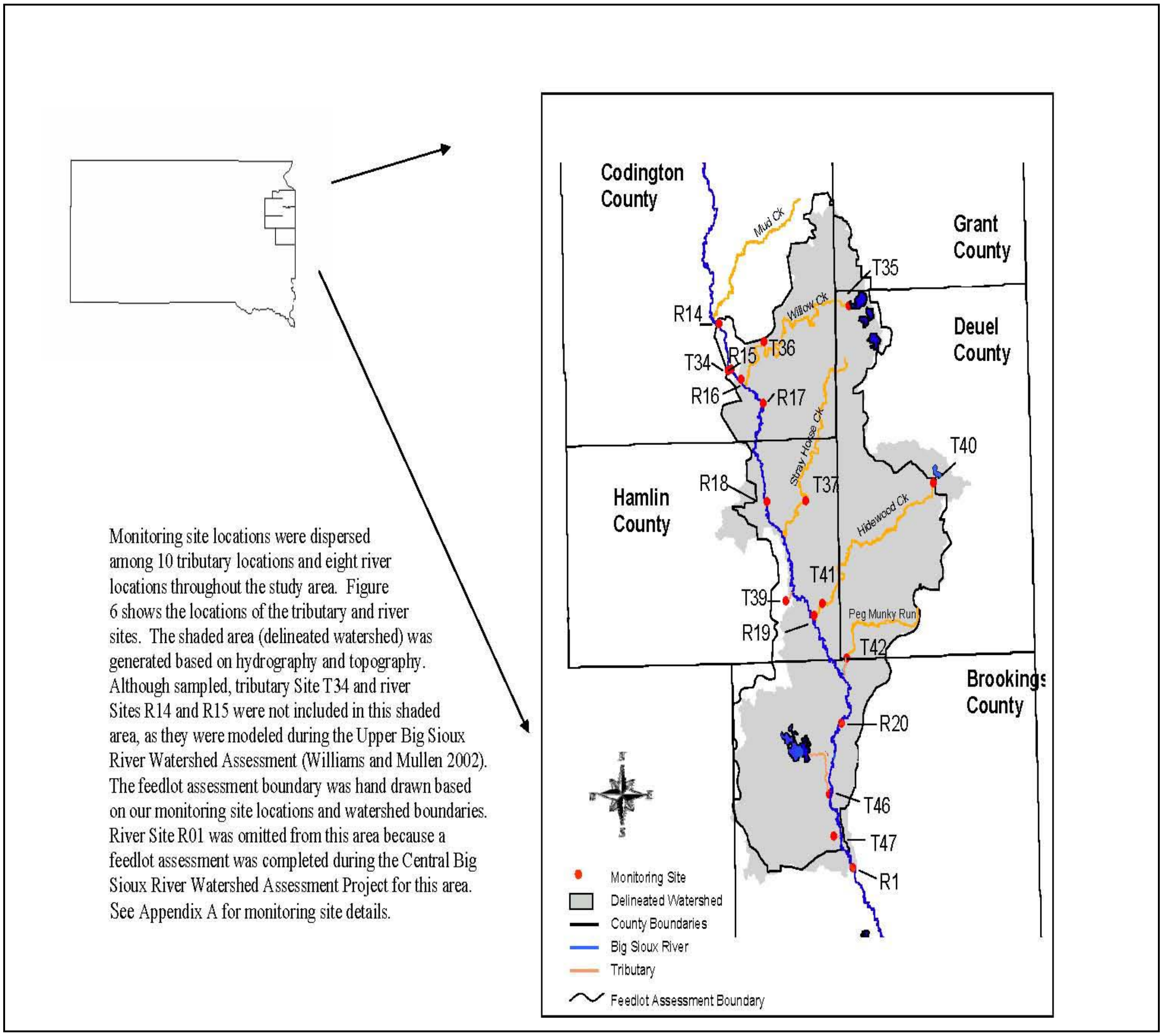


Figure 31: Monitoring Site Locations of the North Central Big Sioux River Watershed Project. **(**Monitoring sites shown are those used during the Assessment Project.)

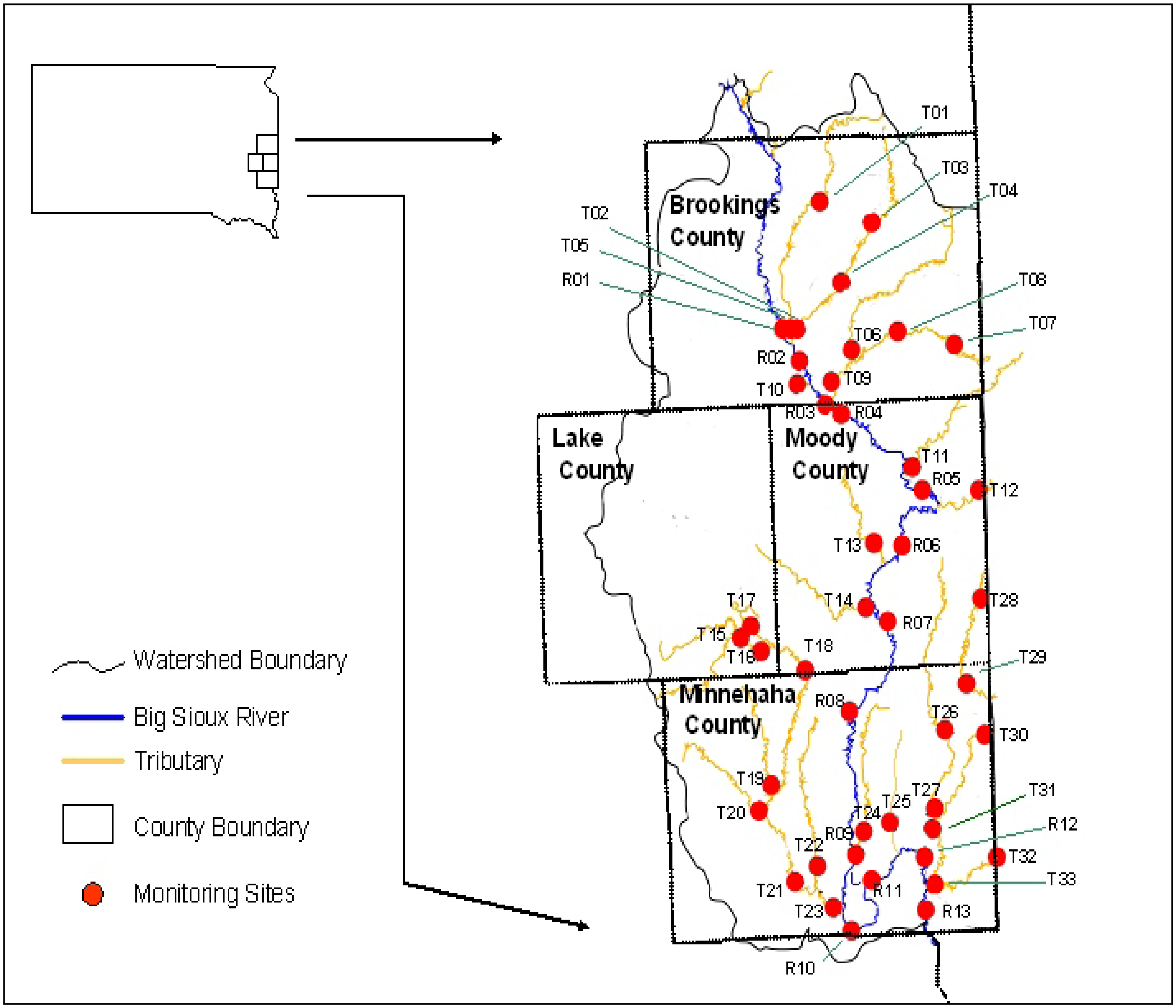


Figure 32: Monitoring Site Locations of the Central Big Sioux River Watershed Project. (Monitoring sites shown are those used during the Assessment Project.)

These areas represent locations that were used during the assessment phases of the watershed project. The following are the site used during the implementation phase. The following tables are the sites and descriptions to the project monitoring.

Table 25: Monitoring Sites along the Big Sioux River.

RIVER SITES 2006-08	SITE NAME	RIVER SITES 2009
R1	Brookings WQM 62	Not Monitored in 2009
R3	Brookings WQM 2	Not Monitored in 2009
R4	Brookings USGS gage	R4
R5	Flandreau –BS 18	Not Monitored in 2009
R6	At Egan	R6
R7	At Trent	R7
R8	Dell Rapids –WQM 3	Not Monitored in 2009
R9	At Diversion (Hwy 38)	Not Monitored in 2009
R10	At Western Avenue	R10
R11	At USGS North Cliff	Not Monitored in 2009
R13	Near Gitchie Manitou	R13
R14	near Watertown	R14
R15	At Broadway	R15
R16	At 20th Avenue	R16
R17	Below Watertown	R17
R18	At Castlewood	R18
R19	At Estelline	R19
R20	At Bruce	R20

Table 26: Monitoring Sites along the Tributaries to the Big Sioux River.

TRIBUTARY SITES 2006-08	SITE NAME	TRIBUTARY SITES IN 2009
T02	Lower North Deer Creek	Not Monitored in 2009
T04	Middle Six Mile Creek	Not Monitored in 2009
T05	Lower Six Mile Creek	Not Monitored in 2009
T11	Spring Creek	Not Monitored in 2009
T12	Flandreau Creek	Not Monitored in 2009
T13	Jack Moore Creek	Not Monitored in 2009
T14	Bachelor Creek	Not Monitored in 2009
T19	Colton Creek	Not Monitored in 2009
T20	West Branch Skunk Creek	Not Monitored in 2009
T21	Middle Skunk Creek	Not Monitored in 2009
T22	Willow Creek (Minnehaha Co.)	Not Monitored in 2009
T23	Skunk Creek	Not Monitored in 2009
T33	Lower Beaver Creek	Not Monitored in 2009
T35	Willow Creek – Waverly	Not Monitored in 2009
T36	Willow Creek - Watertown	Not Monitored in 2009
T37	Stray Horse Creek	Not Monitored in 2009
T40	Hidewood Creek – Clear Lake	Not Monitored in 2009
T41	Hidewood - Estelline	Not Monitored in 2009
T42	Peg Munky Run	Not Monitored in 2009

The next four charts show the results of the monitoring data that was collected. Samples were collected to determine the levels of the suspended solids and fecal coliform bacteria in the water. The samplers determined the water temperature, air temperature, pH, specific conductivity, salinity, dissolved oxygen, turbidity and samples were taken for nitrates testing. The results shown in the chart are divided into the middle Big Sioux River and the Lower Big Sioux River.

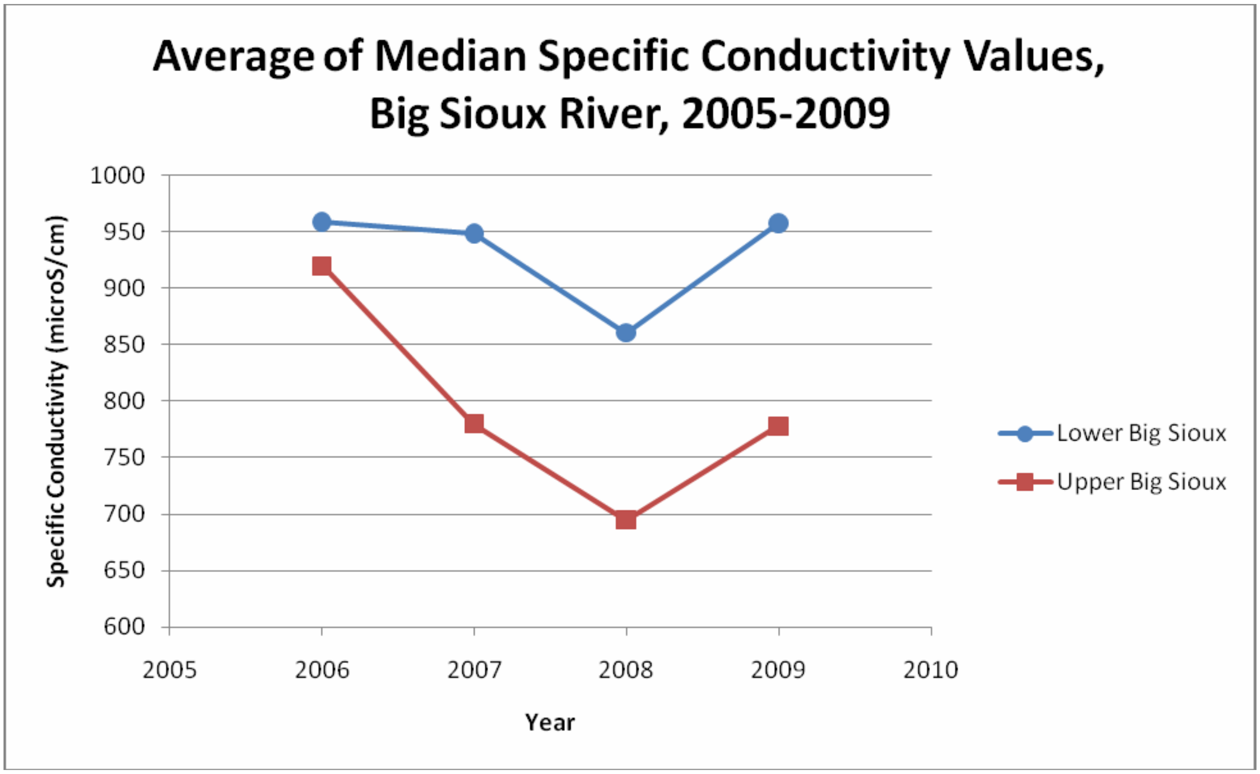


Figure 33: Average of Median Specific Conductivity Values.

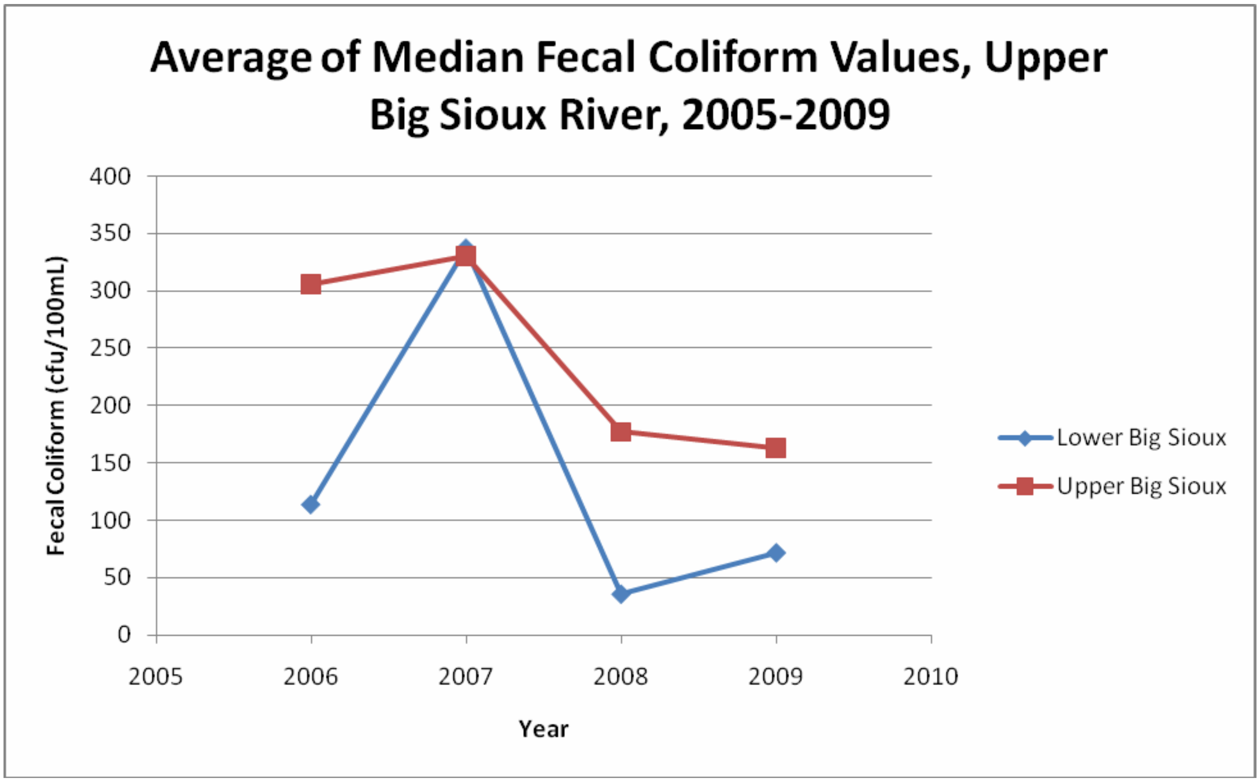


Figure 34: Average of Median Fecal Coliform Values.

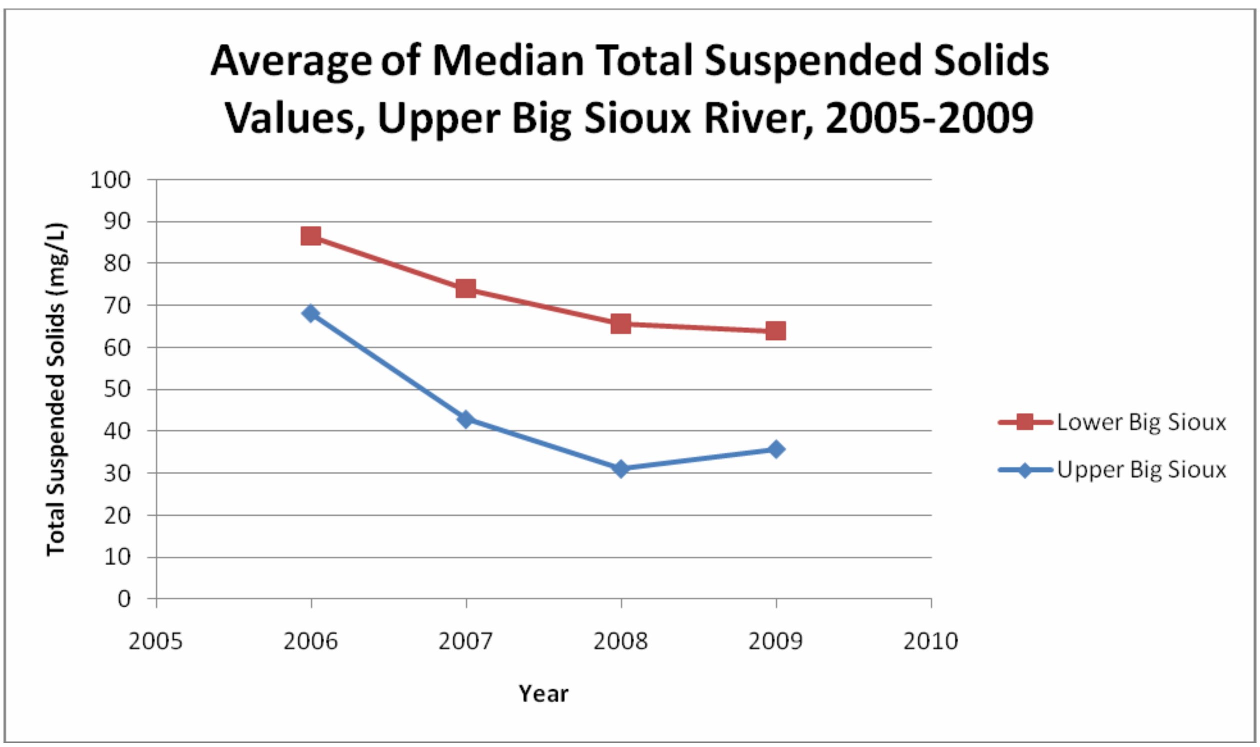


Figure 35: Average of Median Total Suspended Solids Values.

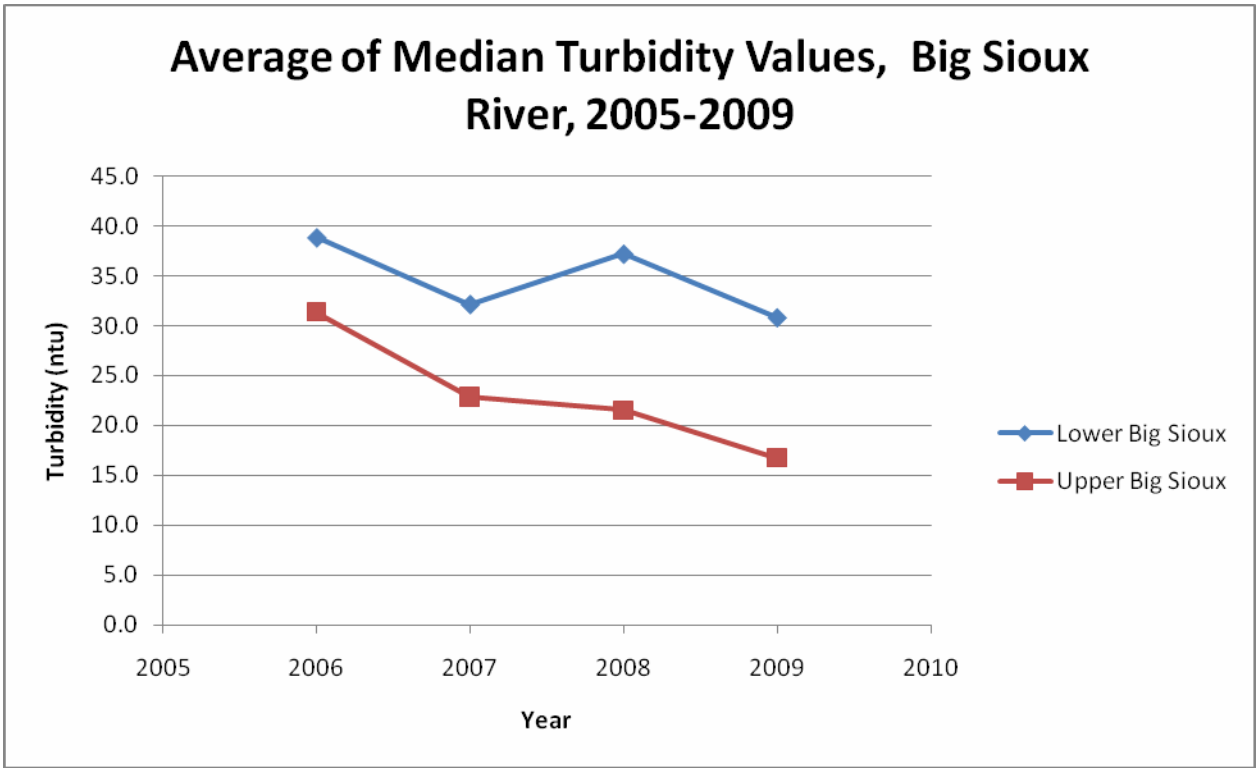


Figure 36: Average of Median Turbidity Values.

Even though the construction activities for the watershed project were completed March of 2010 the East Dakota Water Development District will continue to monitor during 2010. The data that was collected can be found in Appendix I of this report at http://denr.sd.gov/dfta/wp/wqinfo.aspx#Project.

The watershed project used "Step L" for the nitrogen and phosphorus load reduction determinations with the exception of the riparian area management that was used for pasture adjacent to the water body. For these areas we used the average weight for a cow calf pair, number of days in the pasture prior to the enrollment and the number of pounds of nitrogen and phosphorus produced per day and then reduced it by a factor to allow the nutrients that never reached the water way. For our purposes a one thousand pound animal produced the following: N = 0.37 lbs/day and P= 0.09 lbs/day.

Table 27: Pathogen and Phosphorus Reduction Target and Achieved for TMDL Segments.

	Pathogen (Coliform)		Phosphorus LB/Year	
TMDL Segment	Target	Achieved	Target	Achieved
Hidewood Creek	59%	9.43E+10		3,925.1
Stray Horse Creek	99%	8.75E+12		7,624.8
Peg Munky Run	38%	0		0
Spring Creek	45%	0		0
Flandreau Creek	91%	0		0
Jack Moore Creek	82%	0		0
Six Mile Creek	12%	8.41E+12		0
North Deer Creek	34%	0		391.2
Skunk Creek	95%	1.02E+13		1,966.2
Pipestone Creek	87%	8.98E+10		4,101.5
Beaver Creek	86%	0	1,711,539	0
Split Rock Creek	96%	1.01E+13	7,421,467	366.5
Willow Creek	45%	9.85E+13		9.4
BSR- SF WWTF to above Brandon	39%	0	19,948,392	0
BSR – near Dell Rapids to below Baltic	29%	5.03E+13		24,415.6
BSR – I-29 to near Dell Rapids		0	2,458,972	2,875.0
BSR – Brookings to I-29		1.51E+13	1,745,635	247.6
BSR – Stray Horse Creek to near Volga	45%	8.43E+13		1,660.4
BSR – Willow Creek to Stray Horse Creek	30%	2.65E+13		3,115.7
BSR – Lake Kampeska to Willow Creek	33%	1.12E+11		684.0
TOTAL		3.12E+14	31,086,005	51,383

Table 28: Nitrogen and Total Suspended Solid Reduction Target and Achieved for TMDL Segments.

	Nitrogen LB/Year		TSS Tons/Year	
TMDL Segment	Target	Achieved	Target	Achieved
Hidewood Creek		17,316.4		36.3
Stray Horse Creek		44,806.3		273.8
Peg Munky Run		0		0
Spring Creek		0		0
Flandreau Creek		0		0
Jack Moore Creek		0		0
Six Mile Creek		0		0
North Deer Creek		1,666.8		14.2
Skunk Creek		8,985.6		163.6
Pipestone Creek		18,219.6		42.5
Beaver Creek	14,013,904	0	19,613	0
Split Rock Creek	60,949,551	1,116.7	79,207	257.1
Willow Creek		60.8		4.8
BSR- SF WWTF to above Brandon	61,947,219	0	43,722	0
BSR – near Dell Rapids to below Baltic		69,249.0		28,534.6
BSR – I-29 to near Dell Rapids	9,696,928	11,883.6	735,227	515.2
BSR – Brookings to I-29	2,383,821	1,077.3	369	152.0
BSR – Stray Horse Creek to near Volga		7,656.8		636.1
BSR – Willow Creek to Stray Horse Creek		13,163.1		681.3
BSR – Lake Kampeska to Willow Creek		3,040.1		8.4
TOTAL	148,991,423	198,242	878,138	31,320

To evaluate the net impact of the watershed project at various points along the Big Sioux River one needs to include reductions achieved above lower segments and the tributaries. This is covered in the following tables by adding total reductions for each segment plus all those above it.

Table 29: Pollutants for TMDL Segment Big Sioux River Lake Kampeska to Willow Creek.

	Pollution Reduction		Units	TMDL
	Targeted	Achieved		
Pathogen (Coliform)	33%			Yes
Phosphorus		684	Pounds/year	No
Nitrogen		3,040.10	Pounds/year	No
Suspended Solids		8.4	Tons/year	No

Table 30: Pollutants for TMDL Segment Big Sioux River Lake Kampeska to Stray Horse Creek.

	Pollution Reduction		Units	TMDL
	Targeted	Achieved		
Pathogen (Coliform)	30%			Yes
Phosphorus		3,809.1	Pounds/year	No
Nitrogen		16,264.0	Pounds/year	No
Suspended Solids		694.5	Tons/year	No

Table 31: Pollutants for TMDL Segment Big Sioux River Lake Kampeska to I-29.

	Pollution Reduction		Units	TMDL
	Targeted	Achieved		
Pathogen (Coliform)				No
Phosphorus		17,658.2	Pounds/year	No
Nitrogen		88,787.6	Pounds/year	No
Suspended Solids	369	1,806.9	Tons/year	Yes

Table 32: Pollutants for TMDL Segment Big Sioux River Lake Kampeska to near Dell Rapids.

	Pollution Reduction		Units	TMDL
	Targeted	Achieved		
Pathogen (Coliform)				No
Phosphorus		20,533.2	Pounds/year	No
Nitrogen		100,671.2	Pounds/year	No
Suspended Solids	735,227	2,322.1	Tons/year	Yes

Table 33: Pollutants for TMDL Segment Big Sioux River Lake Kampeska to below Baltic.

	Pollution Reduction		Units	TMDL
	Targeted	Achieved		
Pathogen (Coliform)	29%			Yes
Phosphorus		44,948.8	Pounds/year	No
Nitrogen		169,920.2	Pounds/year	No
Suspended Solids		30,856.7	Tons/year	No

Table 34: Pollutants for TMDL Segments Big Sioux River Lake Kampeska to above Brandon.

	Pollution Reduction		Units	TMDL
	Targeted	Achieved		
Pathogen (Coliform)	39%			Yes
Phosphorus		51,383.0	Pounds/year	No
Nitrogen		198,242.1	Pounds/year	No
Suspended Solids	43,722	31,319.9	Tons/year	Yes

BUDGET

There have been a number of adjustments to the budget during the five years of the watershed project. Many of these adjustments have been driven by interest of landowners and operators of the land within the project area. These changes were approved by DENR and EPA prior to the adoptions of the new budget.

Table 35: Initial Budget.

Activity	EPA 319	Land-owner	SRF	Cons. Dist.	EDWDD	Balance
Obj.1/Task 1 AWMS						
Conv. AWMS Engineering	29,250	11,250			4,500	45,000
Conv. AWMS Construction	225,000	75,000				300,000
Alter. AWMS Engineering	19,500	7,500			3,000	30,000
Alter. AWMS Construction	135,000	45,000				180,000
Obj.1/Task 2 Water Access Restrictions						
Riparian Area Fencing		5,000		10,000	5,000	20,000
RWS Pasture Taps		21,875		43,750	21,875	87,500
Shallow Wells		25,000		50,000	25,000	100,000
Bachelor Creek Rock Crossing						
Obj. 2/Task 3 Bank Stabilization						
Skink Creek			2,284,535			2,284,535
Big Sioux River			200,000			200,000
Tributary Streams						
Bank Stabilization						
Obj. 2/Task 4 Riparian Area Protection						
Urban riparian easements			580,000			580,000
Rural riparian easements	199,375		1,304,000		96,625	1,600,000
CRP incentive (RAM)	39,375				13,125	52,500
Obj.3/Task5 Information & Education						
Public Outreach & Education	30,000				20,000	50,000
SDSU Extension						
Obj.4/Task 6 Water Quality Sampling						
WQ Sampling					31,500	31,500
QA/QC Samples						
Project Staffing & Administration						
EDWDD Staff	37,500				37,500	75,000
Contractual Services						
Conservation District Staff	75,000			25,000		100,000
SE Council of Government			150,232			150,232
Travel	20,000					20,000
Supplies & Materials	15,000					15,000
Totals	**825000**	**190625**	**4518767**	**128750**	**258125**	**5921267**

Table 36: Expenditures.

Activity	EPA 319	Land-owner	SRF	Cons. Dist.	EDWDD	Balance
Obj.1/Task 1 AWMS						
Conv. AWMS Engineering	20,143.44	5,518.80			2,091.36	27,753.60
Conv. AWMS Construction	306,839.25	218,817.00	3,801.22			529,457.47
Alter. AWMS Engineering	49,692.09	9,641.30			12,092.85	71,426.24
Alter. AWMS Construction	307,286.23	270,800.50	59,410.74		99,040.06	736,537.53
Obj.1/Task 2 Water Access Restrictions						
Riparian Area Fencing						
RWS Pasture Taps		6,911.94		3,947.96	2,551.46	13,411.36
Shallow Wells						
Bachelor Creek Rock Crossing	16,954.94	5,651.63				22,606.57
Obj. 2/Task 3 Bank Stabilization						
Skunk Creek			1,568,249.04			1,568,249.04
Big Sioux River			40,749.10			40,749.10
Tributary Streams			0			0
Bank Stabilization			1,173,533.26			1,173,533.26
Obj. 2/Task 4 Riparian Area Protection						
Urban riparian easements			0			0
Rural riparian easements	602,449.91		251,343.74		6,668.94	860,462.59
CRP incentive (RAM)	54,231.16				120,315.84	174,547.00
Obj.3/Task5 Information & Education						
Public Outreach & Education	29,054.65			142.5	14,712.19	43,909.34
SDSU Extension	43,755.18				16,234.50	59,989.68
Obj.4/Task 6 Water Quality Sampling						
WQ Sampling	20,000.00				10,530.66	30,530.66
QA/QC Samples						
Project Staffing & Administration						
EDWDD Staff	163,350.85				4,201.74	167,552.59
Contractual Services	58,295.57				1,883.49	60,179.06
Conservation District Staff	4,426.41			1,458.01		5,884.42
SE Council of Government			42,284.81			42,284.81
Travel	20,500.00				4,150.74	24,650.74
Supplies & Materials	8,772.14					8,772.14
Totals	**1,705,751.82**	**517,341.17**	**3,139,371.91**	**5,548.47**	**294,473.83**	**5,662,487.20**

The City of Sioux Falls has requested and received a revised project end date for their project. The plan for the City is to continue to develop the plans for phases 3 and 4 of their Big Sioux River bank stabilization. The completion of the City of Sioux Falls sponsored activity will not be contained in this report.

SUMMARY OF PUBLIC PARTICIPATION

The Central Big Sioux Watershed Project Steering Committee shared in the success of the watershed project. The project was dependent on bring in conservation districts, in each county that comprised the Central Big Sioux Watershed, on board. They needed to have ownership in the project for them to bring it to the landowners and operators in their counties. During 2005 there were a number of meetings with the steering committee that was made up of one board member and the full time employee of each of the conservation districts for the counties of Brookings, Codington, Deuel, Hamlin, Moody, Minnehaha counties. There were two members from the SD Association of Conservation District. Other people that were included were the USDA – NRCS - district conservationist from the participating counties. Staff with Northern Prairies Land Trust was included.

East Dakota Water Development District provided the sponsorship that made the Watershed Implementation project possible. They sponsored the watershed assessment project that demonstrated the need for the implementation project. They provided office space, local match and administrative assistance to the project.

Department of Environment and Natural Resources provided the administration of the Clean Water Act Section 319 Project Grants and the Clean Water State Revolving Funds. Section 319 funds were used throughout the watershed project whereas the State Revolving funds were limited to being used for part of Agricultural Waste Management, Conservation Easements, and Bank Stabilization Projects was funded by the State Revolving Funds.

Department of Agriculture provided the Coordinated Soil and Water Grant funds and its administration. This grant was applied for by the Moody County Conservation District.

South Dakota State University, SDSU, worked on a project to bring SDSU Extension Educators into the project with a study involving the "Better Management Practices to Improve Water Quality in the Central and Upper Big Sioux Watershed.

State Historical Preservation Office, SHPO, was the contact agencies to ensure that Cultural resources were not adversely impacted.

Conservation Districts from Brookings, Codington, Deuel, Hamlin, Minnehaha and Moody Counties provide supported project by providing the local contacts within the communities, served on the steering committee and financial assistance in making landowner payments for the RAM Program.

Northern Prairies Land Trust did much of the work on the conservation easement – site evaluation, document preparation, easement compliance, posting and preliminary survey

City of Sioux Falls applied to DENR for the State Revolving Funds and serve as the intermediary for the securing of these funds. The Bank Stabilization project was handled through the City. Their engineering department completed designs for the bank stabilization.

USDA Natural Resource Conservation Services, NRCS, and Farm Services Agency, FSA, provided technical and financial assistance for BMP installation through the Conservation Reserve Program, CRP, and Environmental Quality Incentives Program (EQIP).

During 2006, a public opinion survey was conducted by the Paulsen Marketing Communications of Sioux Falls, SD. Efforts were made to contact 136 people from a list provided by East Dakota Water Development District. There were 42 people that agreed to participate in the survey. Landowners and operators provided cash and in-kind labor toward the construction of animal waste management systems. They provided the management activities associated with the vegetation on the riparian management areas and conservation easements.

ASPECTS OF THE PROJECT THAT DID NOT WORK WELL

One must remember that the participation of landowners and operators in the watershed is purely voluntary. Thus motivation for the owners and operators come in the form of financial incentives. The conservation easements and the riparian area management, RAM, can work well with this scenario but that is not the case when looking at animal waste management systems. Most of the feedlots are not easily altered to make them environmentally friendly. Many require the owner to relocate his system to a better location. This costs the owner a great deal of money and the operator is going to be faced with the difficulty of trying to feedlot livestock while construction is taking place.

The owner/operators of feedlots are unfamiliar with the process of constructing new or altering old feedlots. They need to have someone that can spend a great deal of time with them to help throughout the building process. The current system does not provide that level of personal attention.

Landowners are faced with an economic challenge of farming and feeding livestock with there current systems. The watershed project tries to motivate these individuals to change their system, and spend at a minimum 25 to 50 percent of project costs out of their own money to make changes. The owners age and if they have family that will continue the feeding operation are also factors. Landowners need to take ownership in the new system and have a financial commitment in the system or it will not be used properly, and increasing the cost share would be a mistake. In many of these cases, without State and Federal pressure to force landowners to either change there system or cease operation, owners are likely not comply with project objectives.

FUTURE ACTIVITY RECOMMENDATIONS

Animal Waste Management Systems to be successful will need state and federal enforcement of the deadline to meet the Clean Water Act goals. The changing of the systems is going to be expensive and there needs to be a large pool of funds available to provide assistance. The primary area of emphasis needs to be place within two miles of the river or major tributaries. The assisting agency needs to be local contacts to effectively be available to provide the level of assistance that they need. Until the owners and operators feel that they need to change their systems or face closure the majority will not make any significant changes to how they are currently operating their systems.

Conservation Easements and Riparian Area Management (RAM the CRP counterpart) can be very effective and reasonable cost ways to provide a buffer system between the sources of non point pollution and the water bodies. The duration of the buffers needs to some flexibility to be able to meet the owner's needs. There should be a range of options from ten years up to a perpetual option available. The payment rates need to be based on the land value, land use history and duration of the contract. There needs to be an organization that is responsible to monitor the land to ensure that the contract is being complied with. This program can be effectively administered on a regional level.

Monitoring program needs to be established to determine if the installation of the best management practices are getting the desired results.

An ongoing information and education program will be needed to create awareness of the needs for water quality improvements and educate the people of the latest technology and programs that are available.

Acronyms and Abbreviations
There are dozens of acronyms and abbreviations used throughout this report. Refer back to this list to help you navigate through the alphabet soup.

AFO: Animal Feeding Operation – facility where animals are confined, fed, or maintained for a total of 45 days in any 12 month period, and where vegetation is not sustained in the normal growing season over any portion of the lot or facility
ARSD: Administrative Rules of South Dakota – legal statutes that specify standards or requirements
AGNPS: Agricultural Non-Point Source – an event-based, watershed-scale model developed to simulate runoff, sediment, chemical oxygen demand, and nutrient transport in surface runoff from ungaged agricultural watersheds
AnnAGNPS: Annualized Agricultural Non-Point Source model
AU: Assessment Unit
BMP: Best Management Practice – an agricultural practice that has been determined to be an effective, practical means of preventing or reducing nonpoint source pollution
BSR: Big Sioux River
CAFO: Concentrated Animal Feeding Operation
CCMP: Comprehensive Conservation and Management Plan
Cfs: Cubic Feet per Second
CFU: Colony Forming Units – a count of the number of active bacterial cells
CNMP: Conservation Nutrient Management Plan
COD: Chemical Oxygen Demand
CREP: Conservation Reserve Enhancement Program
CRM: Crop Residue Management
CRP: Conservation Reserve Program
CSP: Conservation Security Program
CWA: Clean Water Act
DO: Dissolved Oxygen
EDWDD: East Dakota Water Development District
EPA: [U.S.] Environmental Protection Agency
EQIP: Environmental Quality Incentives Program
FCB: Fecal Coliform Bacteria
FLGR 3: Feedlot and Grazing Reductions Model
FSA: Farm Service Agency
GAP: Gap Analysis Project
GIS: Geographic Information System
GPS: Global Positioning System
HUC: Hydrologic Unit Code
I/E: Information/Education
IR: Immersion Recreation
Kg/ha/yr: Kilograms per Hectare per year
Kg/yr: Kilograms per Year
LCR: Limited Contact Recreation
LULC: Land Use/Land Cover
MOS: Margin of Safety
Mg/L: Milligrams per Liter

NPS: Nonpoint Source
NPDES: National Pollution Discharge Elimination System
NRCS: Natural Resources Conservation Service
O&M: Operation and Maintenance
PSA: Public Service Announcement
QA: Quality Analysis
QC: Quality Control
RUSLE: Revised Universal Soil Loss Equation
SCS: Soil Conservation Service
SD: South Dakota
SDDENR: South Dakota Department of Environment and Natural Resources
SDGFP: South Dakota Game Fish and Parks
SDSU: South Dakota State University
SOP: Standard Operating Procedure
SPARROW: Spatially Referenced Regression on Watershed Attributes
SRF: State Revolving Fund
STEPL: Spreadsheet Tool for Estimating Pollutant Load
TDS: Total Dissolved Solids
TKN: Total Kjeldahl Nitrogen
TMDL: Total Maximum Daily Load – a calculation of the maximum amount of a pollutant that a water body can receive and still meet water quality standards, and an allocation of the amount to the pollutant's sources
TP: Total Phosphorus
TSI: Carlson's Tropic Status Index
TSP: Technical Service Provider
TSS: Total Suspended Solids
USDA: U.S. Department of Agriculture
USFWS: U.S. Fish and Wildlife Service
USGS: United States Geologic Survey
USLE: Universal Soil Loss Equation
WHP: Wellhead Protection
WQ: Water Quality – term used to describe the chemical, physical, and biological characteristics of water, usually in respect to its suitability for a particular purpose.
WQS: Water Quality Standard
WPC: Watershed Project Coordinator
WRDA: Water Resources Development Act
WRI: Water Resource Institute
WWFLP: Warm Water Fish Life Propagation
WWTP: Wastewater Treatment Plant

Appendices for the Central Big Sioux River Watershed Project - Segment 1 Final Report

By

Roger Strom
Watershed Project Coordinator

Project Sponsor
EAST DAKOTA WATER DEVELOPMENT DISTRICT

Jay Gilbertson
District Manager

September 30, 2010

APPENDICES

Appendix 1

PRIORITY EVALUATION WORKSHEET
ANIMAL WASTE MANAGEMENT SYSTEMS

Operator Name:________________________________ Phone:__________

Mailing Address:____

Legal Description of Facility:_______________________ County:__________

Nearest TMDL Segment*:__________________________ AGNPS Rating:_____

ANIMALS IN FACILITY: (See Factor Table on Page 4)

TYPE	WEIGHT	NUMBER	FACTOR	NUMBER OF AUs
________	______	______	______	________
________	______	______	______	________
________	______	______	______	________

TOTAL NUMBER OF AU FOR PREDOMINATE ANIMAL TYPE = ________

RATING CRITERIA

RATING POINTS

(1) Operation is: Existing (no expansion)__ Existing (expanding)___ _____ **(1)**
(2) Distance from nearest TMDL segment: _________ **miles** _____ **(2)**
(3) Distance from nearest receiving surface water: _________ **miles** _____ **(3)**
(4) Length of a filter strip immediately adjacent to source: _______ **feet** _____ **(4)**
(5) Depth to a useable, pumpable aquifer: _________ **feet** _____ **(5)**
(6) Watershed Area (including lots): _________ **acres** _____ **(6)**
(7) Total Animal Units (from above): _________ **number** _____ **(7)**
(8) Funding is: Available___ Pending___ Not Identified___ _____ **(8)**
(9) Applying for permit __Yes ___No _____ **(9)**

TOTAL RATING POINTS = _____
(Maximum of 115 points)

***Priority will be given to operations which are located near TMDL segments possessing an immersion recreation designated use by the SD DENR. Those segments include Split Rock Creek, Pipestone Creek, near Dell Rapids to below Baltic segment of the BSR, and SF WWTF to above Brandon segment of the BSR.**

RATING CRITERIA TABLE:

(1) Reply	Points	(2) Distance	Points	(3) Distance	Points
Existing (No Exp)	10	< 1 Mile	25	< 1/4 Mile	15
Existing (Exp)	5	1 to 1.5 Miles	15	1/4 to 1/2 Mile	10
		1.5 to 2 Miles	10	1/2 to 1 Mile	5
		> 2 Miles	5	> 1 Mile	3

(4) Distance (feet)	Points	(5) Depth to Aquifer	Points	(6) Area (acres)	Points
0 - 100	15	0 to 10 feet	10	Over 15	15
101 - 500	10	10 to 50 feet	5	5 to 15	10
501 - 1500	5	> 50 feet	0	< Five	5
>1500	0				

(7) AU #'s	Points	(8) Funding	Points	(9) Permit	Points
500-1000	5	Available	15	Yes	5
< 500	10	Pending	8	No	0
		Not Identified	0		

Form Completed By:______________________________ Date:__________

Applicant Signature:______________________________ Date:__________

ATTACHMENTS TO PRIORITY EVALUATION WORKSHEET

All applicants must include the following which is used in the evaluation process by East Dakota Water Development District:

(1) Completed Priority Evaluation Worksheet

(2) USGS topographic map of the project area

(3) Soil Survey map(s) of the project area

(4) Aerial photo showing location of feedlots, etc.

(5) First Occurrence Map

(6) Wetland Inventory Map(s) showing wetland delineations (landowner can get this from the local NRCS office)

(7) Narrative statement describing background information / justification for the application

Narrative:

Match Documentation Form

____
319 Project

Name:		Tax ID:	
Address:		Phone #:	
City:	SD State Zip	LLD:	

		Practices:
Contract #:		
BMP:		
Completion Date:		

Description of work: ______________________________

Inkind/Cash Match(Use back of sheet if more space is needed.)

Description of work/Item or invoce number	Rate/hour	Quantity	Local Cash/Inkind	Total
				Total

______________________________ ______________
319 Coordinator Date

______________________________ ______________
Owner/Operator Signature Date

*Signing of both parties involved signifies that work described on has been completed to standards setforth in the contract.

CONTRACT FOR RECEIVING EPA 319 COST SHARE

This agreement is made and entered into between the East Dakota Water Development District (hereafter referred to as "EDWDD") and the landowner/operator named below (hereafter referred to as "Owner"). The purpose of this Contract is to establish the requirements of recipients of EPA cost share funds which are disbursed to Owner for the implementation of conservation practices as listed in the attached Conservation Plan Schedule of Operations.

Name of Owner:____
Address: ____
City:__________________________State: __________Zip: ________

CONTRACT REQUIREMENTS

The source of cost shares for implemented conservation practices is the Big Sioux River Watershed 319 Program (Project). Cost share amounts for implemented conservation practices paid pursuant to this Contract will not exceed Seventy-five percent (75%) for identified items and Seventy-five Dollars ($75)/head for the hoop barn and associated dirt and concrete work for the barn for the original number of animal units (800). The owner will have one calendar year (365 days) from the date this Contract is signed by both parties to install all agreed upon items under this Contract.

Cost share funds will be dispersed to the Owner when the conservation practices set forth on Attachment One have been implemented according to the Conservation Plan/Schedule of Operations and have been field checked by EDWDD or a designated representative.

It is agreed the Owner will provide EDWDD copies of receipts and invoices for all labor and materials used to implement the conservation practice(s) which are subject to the cost share.

This Contract can be modified by mutual agreement between the EDWDD and the Owner if the installed practices fail or deteriorate because of conditions beyond the control of the Owner, or if the installed practice unexpectedly causes adverse impacts to significant cultural or environmental resources or significant cultural or environmental resources are discovered during the installation of the conservation practice, or if another more appropriate conservation practice will achieve at least the same level of environmental benefits. Changes to this Contract may also require the concurrence of the South Dakota Department of Environment and Natural Resources (SDDENR). The EDWDD watershed coordinator should be contacted before any changes to this Contract are initiated. A modified Contract will be sent to all participating parties who will have ten days to approve or reject such changes.

EDWDD and the Owner may at any time, by written agreement of the parties hereto, make changes or amendments within the general scope of this Contract concerning the work to be performed, or the manner of performance of the work. If such changes cause an increase or decrease in the cost or time required to perform any services under this Agreement, EDWDD and the Owner shall make equitable adjustments which shall be set forth in a signed written amendment to this Contract.

Producer shall maintain and pay all costs pertaining to Producer's compliance with the requirements of this Agreement.

The terms of this Contract shall commence on ______________________________. The cost of this project is estimated to be Dollars. The items which are eligible for up to a Seventy-five percent (75%) cost share reimbursement and the items which are eligible for a Seventy-five Dollars ($75)/head cost share are provided on Attachment One.

The cost share assistance provided to Owner under this Contract is estimated at Dollars. See Attachment One for more detailed information.

Dated this ____ day of _____________, 2008.

OWNER:

____

Address for Notices to Owner:

Dated this ____ day of _____________, 2008.

GRANTEE:
EAST DAKOTA WATER
DEVELOPMENT DISTRICT

By: ______________________________

Its: ______________________________
Address for Notices:
132B Airport Ave.
Brookings, SD 57006

CONSERVATION PLAN SCHEDULE OF OPERATIONS

ATTACHMENT ONE

Conservation practices included as part of cost share assistance to are as follows:

	Projected cost	cost share rate	cost share assistance
Total			
Margin of Safety			

To receive reimbursement for the items set forth above, the Owner agrees to provide a copy of receipts and invoices for all labor and materials used to implement the foregoing conservation practices. EDWDD or a delegated representative will conduct a field inspection to ensure that the items for which reimbursement has been requested have been installed properly.

ANIMAL WASTE MANAGEMENT SYSTEM PROJECT
PRODUCER AGREEMENT

The East Dakota Water Development District (referred to herein as "EDWDD") and ______________________ of ______________, South Dakota (referred to herein as "Producer"), agree to the following Animal ("Ag") Waste Management System Project Producer Agreement:

1. PURPOSE

The purpose of this Agreement is to develop an animal waste management system for Producer's livestock facilities (the "project"). EDWDD has contracted with an engineer to provide certain architectural and engineering services for this project and will provide these services to the Producer.

2. RESPONSIBILITIES OF EDWDD

A. EDWDD will hire an engineer to provide design, specifications and a comprehensive nutrient management plan for the project.

B. EDWDD will also provide consultation and will work with the engineer and Producer to develop individual work orders for the completion of a site assessment which will result in a final design of an animal waste system for Producer.

C. EDWDD will conduct onsite visits to assess and determine the feasibility of the project, and to provide preliminary layout suggestions. EDWDD will also establish limits for topographic surveys, establish locations for geo-technical explorations and discuss zoning requirements with Producer.

D. EDWDD will consult with Producer to select and approve a site for proposed holding ponds, if applicable.

E. EDWDD will consult with Producer and will review and approve the preliminary design layout prepared by the engineer.

F. EDWDD will consult with Producer to obtain all required design criteria and will approve the final design by the engineer.

G. EDWDD will consult with Producer to obtain necessary data and information for the engineer to prepare a comprehensive nutrient management plan for the animal feeding operation.

3. RESPONSIBILITIES OF PRODUCER

A. Producer agrees to permit EDWDD and the engineer and their agents and employees with access upon Producer's property for the sole purpose of completion of this project and will assist in making appropriate arrangements for access through public and other private property which may be necessary to complete this project.

B. Producer agrees to provide to EDWDD and the engineer with all available information pertinent to the project, including previous reports and any other data relative to the design and construction of the project.

C. Producer shall provide EDWDD all information available which pertains to property ownership, including boundaries, easements, rights-of-way, topographic and utility surveys, zoning, deed and other land use restrictions.

D. Producer shall examine all project documents prepared by the engineer and will obtain such other professional assistance, including attorneys, insurance advisors and others, as Producer deems necessary to evaluate the project documents.

E. Producer shall apply for the necessary approvals and permits from governmental bodies and others as required to complete the project.

F. Producer shall pay all costs pertaining to Producer's compliance with the requirements of this Agreement.

4. PAYMENTS

A. EDWDD will prepare a work order for each individual phase of the project. The cost of engineering services shall be shared by EDWDD and Producer, with Producer responsible for Twenty-five percent (25%) of each individual work order for the engineering services required for the project. Producer shall pay to EDWDD, in advance of performance of the work, Twenty-five percent (25%) of the estimated cost for each work order.

B. It is understood that in the development of this project, changes ("change orders") may be required in the scope of work that may require payment in addition to the original work order. Producer shall pay to EDWDD Producer's share of each additional change order amount within thirty (30) days of notification of the cost of each additional change order.

C. EDWDD will make payments to the engineer for engineer's services as provided in the agreement between EDWDD and engineer.

5. MISCELLANEOUS

A. This Agreement may be terminated by either party upon seven (7) days written notice to the other party, however Producer shall remain responsible for payment for services performed until the notice of termination has been received by the other party.

B. Producer acknowledges that EDWDD's services in connection with this Agreement are to consult with, facilitate and coordinate with others in the fulfillment of the project's objectives. Accordingly, Producer acknowledges that EDWDD is not responsible for the actual services delivered in connection with this Agreement, or the way in which those services are performed by such other individuals or entities.

C. Producer agrees to hold EDWDD harmless and indemnify EDWDD from any liability or claim in connection with this Agreement and the services to be provided hereunder.

D. This Agreement shall be governed by the laws of the State of South Dakota.

E. This Agreement is binding upon the parties, their heirs, successors and assigns.

F. This Agreement constitutes the entire agreement between EDWDD and Producer and supersedes all prior written or oral understandings between the parties concerning the subject matter covered.

G. This Agreement may be amended, supplemented, modified or canceled only by the mutual written Agreement of the parties.

Dated this ____ day of ______________________, 2008.

EDWDD:

By ________________________________ Its __________________________

Producer

By ________________________________ Its __________________________

Appendix 2

Big Sioux River Conservation Easement Program
Application for Conservation Easement

Welcome to the Big Sioux River Conservation Easement Program, and we look forward to working with you. Conservation easements under this program are designed to preserve and protect the water quality of the Big Sioux River or one of its tributaries.

Purpose: The primary purpose of this application is to gather information necessary to determine the appropriate terms of the proposed conservation easement, including a purchase price. It will also be necessary for Northern Prairies Land Trust (Northern Prairies) to contact other sources of information. Payment to the property owner(s) will be made only after a conservation easement has been granted to Northern Prairies under this program. The easement will be filed in the county in which the property is located.

Property Owner(s) Information
Owner(s) #1 Full Legal Name ______________________________
Mailing Address ______________________________
City State Zip Code______________________________
Phone # ______________________________
Percent of Ownership ______________________________

Owner(s) # 2 Full Legal Name ______________________________
Mailing Address ______________________________
City State Zip Code ______________________________
Phone # ______________________________
Percent of Ownership ______________________________

Owner(s) # 3 Full Legal Name ______________________________
Mailing Address ______________________________
City State Zip Code ______________________________
Phone # ______________________________
Percent of Ownership ______________________________

Property Owners' Legal Representative ______________________
Legal Representative's Full Legal Name______________________
Mailing Address ______________________________
City State Zip Code ______________________________
Phone # ______________________________

Property Information ______________________________
Complete Address ______________________________
City, County, State, Zip Code ______________________
Recorded in Deed Book #, and Page # __________________
Plat or Property ID # or Tax Map # __________________

Lien Information (if applicable)
Mortgage Company ____
Loan Account # ____
Mailing Address ____
City, State, Zip Code ____
Area Code and Telephone # ______________________________________

Other Lien Holders (Please list all)
Name ____
Account # ____
Mailing Address ____
City, State, Zip Code ____
Area Code and Telephone # ______________________________________

Name ____
Account # ____
Mailing Address ____
City, State, Zip Code ____
Area Code and Telephone # ______________________________________

Setting: This property is, at some point, adjacent to one or both banks of the Big Sioux River, or a named tributary thereof. **It is understood that recording an easement will place restrictions on the use of this property, and that these restrictions may impact all future owners of the property.**

Terms of this Application: The property owner(s) agree/acknowledge that:

1. Northern Prairies Land Trust (NPLT) or its authorized agent is allowed access to the property for the purpose of completing a site evaluation.

2. Access to the property may include land that is not part of the anticipated easement, but is necessary for a full site evaluation.

3. A future purchase price for the conservation easement will be based percentages of the "Adjusted assessed land value" or "AALV" of the property. The AALV is calculated through multiplying the current assessed value of the land for real-estate taxation purposes, by a specific county multiplier.

4. NPLT will contact the appropriate county office to obtain the property owner(s)' real-estate tax assessment for the property to be placed in the easement.

5. The boundaries of the conservation easement will be established after the site evaluation. Any aerial map or photograph of the property will be made available NPLT to assist in this determination.

6. Generally, one or more of the boundaries will be an agreed-upon distance from the bank(s) of the Big Sioux River, or a tributary.

7. The proposed boundaries will be agreed upon by the property owner(s) and NPLT prior to finalizing the easement.

8. The conservation easement shall be either a perpetual or a thirty-year easement.

9. Because the easement must survive any transfer of title, and have priority over any other property interests, such as mortgages and lien holders, the property owner(s) gives NPLT permission to contact any entity with a legal interest in the property subject to the easement and property owner(s) agree to provide assistance by furnishing names and contact persons for such entities.

10.. If the property to be covered by the conservation easement is, or will be, under any other conservation or land-use program, property owners grant NPLT permission to contact a representative of that program to discuss the Big Sioux River Conservation Easement Program, and obtain any records associated with the program.

11. Property owners are encouraged to consult with whatever counsel they deem appropriate prior to signing this application.

12. This application does not bind property owners, NPLT, or any other entity to finalize the proposed conservation easement at this time. A specific conservation easement will be negotiated if this application is approved.

Signature of Property Owner # 1 Date Signature of Property Owner # 2 Date

Signature of Property Owner # 3 Date

General Description of the Proposed Conservation Easement

This section of the Agreement contains a general description of some of the proposed terms of the conservation easement. The descriptions and terms of this section are not binding at this time, but are intended to inform property owners of the future possibilities.

Easement Restrictions: The primary focus of the conservation easement will be to restrict certain land uses that may have an adverse impact upon the water quality of the Big Sioux River, or a tributary. In most cases, a fence will be placed at the boundary of the easement to restrict these uses.

Other Organizations: There may be other organizations or entities involved in planning financing the proposed conservation easement, and development related activities, such as fencing and providing for an alternative livestock water source(s). However, these organizations or entities will not be parties or signatories to the final conservation easement.

Long-Term Monitoring: NPLT will be committed to monitoring and enforcement of the terms of the conservation easement for the life of the easement. Therefore, the easement will grant NPLT the right to access both the property subject to the easement and other portions of the property, as may be necessary to monitor or enforce the terms of the easement.

Payment Schedule for Conservation Easements: It is anticipated that easements under this program will be permanent easements. However, if a landowner wishes to grant a thirty-year easement instead, the application will be paid at varying percentages of the AALV. Final payments are based on both the length of the easement and whether there are any US Department of Agriculture programs, as shown by the following table:

Duration	Time left on USDA contract (if applicable)	Percentage of AALV
30 Year	0	80
30 year	<5 years	75
30 year	6-9 years	70
30 year	>10 years	65
Perpetual	0	95
Perpetual	<5 years	90
Perpetual	6-9 years	85
Perpetual	>10 years	80

Return mailing: When this Application is completed, please return it to:

Northern Prairies Land Trust

401 E. 8th Street, # 200B

Sioux Falls, SD 57103-7015.

Questions: Please call Northern Prairies Land Trust at (605) 339-3184, or East Dakota Water Development District at (605) 688-6741.

Thank You for your interest in the Big Sioux River Conservation Easement Program.

This Instrument Prepared By:
Northern Prairies Land Trust
401 E. 8th St., #200B
Sioux Falls, SD 57103
(605) 339-3184

DRAFT

DEED OF CONSERVATION EASEMENT
BIG SIOUX RIVER CONSERVATION EASEMENT PROGRAM

ARTICLE I. GRANT OF EASEMENT

THIS CONSERVATION EASEMENT ("Easement") is granted this ____ day of __________, 2006 by ____________________________, ("Grantor") to **Northern Prairies Land Trust**, a South Dakota nonprofit corporation ("Grantee" or "Northern Prairies") subject to the terms and conditions as stated herein:

WHEREAS:

A. The Big Sioux River Conservation Easement Program ("BSRCEP") was established as a portion of the Big Sioux River Watershed Project which is managed by East Dakota Water Development District ("EDWDD").

B. The Grantor owns land consisting of approximately _______ acres, located in _______ County, South Dakota, as described in the attached "Exhibit A", as the "Property".

C. Grantee is a "holder" of conservation easements under SDCL 1-19B-56(2) (b).

D. The Grantor agrees to grant this Conservation Easement to Grantee for the "Easement Area" of the Property, as described in Exhibits A and B.

E. The purpose of this Easement is to preserve and enhance water quality of the Big Sioux River and its named tributaries, and to enhance plant and wildlife habitat, through the establishment and maintenance of riparian buffer easements on land directly adjacent to the river or tributaries.

F. **[Make a general characterization about the Property and Easement Area and describe the general conditions as reflected on attached Exhibit A and B, i.e. farm land, ranch land, riparian land, forest, etc. .]**

G. Grantor grants this Easement in perpetuity (or for a term of thirty years).

H. Grantor will be paid for granting this Easement by EDWDD, based upon the number of acres subject to the easement, the term (years) of the Easement, and the "adjusted assessed land value" of the Property, as agreed to by Grantor and EDWDD. Payment for this easement is the obligation of EDWDD, and Grantee is not liable for said payment, even though Grantee will be the holder of the easement.

DRAFT

I. Grantor, and their successors and assigns, are encouraged to conduct all permitted operations and practices in accordance with good management practices addressing water and soil protection and preservation, erosion control, and habitat protection. Certain land use practices will be required as set forth in a "Conservation Management Plan", attached as Exhibit D.

J. **NOW THEREFORE,** the Grantor hereby grants and conveys to the Grantee this Easement **in perpetuity** on the land described in Exhibit A as the "Easement Area" and the "Property" (the Property easement is only for access to the Easement Area), subject to all terms, covenants, conditions, limitations, restrictions and obligations herein (collectively, the "Terms"). It is the intention of the Grantor and the Grantee that this Easement shall constitute an equitable servitude and restrictive covenant on the Land and shall run with the Land in perpetuity and bind the Grantor, their personal representatives, heirs, successors, assigns and any other person claiming under them.

K. This Easement shall not be interpreted to prohibit or restrict Grantor from participating in any state, federal or local government entity or agency programs designed to promote, preserve or enhance the natural characteristics and potential of the Property and to make any grant of any covenant, restriction, easement or title to the Property for that purpose (a "Public Entity Grant"), provided all of the following conditions are met: (i) any such grant is subject to this Easement; (ii) the grant does not impair, harm or otherwise jeopardize water quality and habitat; and (iii) Grantor shall provide prior notice to Grantee complying with Article V.

L. In reliance upon Grantor's warranties and representations as described below, Grantee hereby accepts grant of this Easement and the responsibility of monitoring and enforcing its terms forever.

ARTICLE II. GRANTOR'S RIGHTS AND WARRANTIES

A. **Retained Rights**. Except as otherwise expressly provided in this Easement, Grantor shall retain all rights, in ownership and possession of the Property including the following:

1. To transfer, lease, mortgage or otherwise encumber the Property, subject and subordinate to this Easement, after compliance with the notice requirements of this Easement in Article V.

2. This Easement shall not be interpreted to prohibit or restrict Grantor from engaging in normal and typical activities on the Property consistent with the current use of the Property as stated in Article I., Paragraph G., provided such activities comply with the Conservation Management Plan and do not threaten or damage water quality or habitat.

[Separately describe in subparagraphs all specifically permitted uses, if any.]

B. **Grantor's Warranties and Representations.**

1. Grantor acknowledges that certain factors, if they were present, would preclude Grantee from accepting this Easement; and Grantee cannot accept this Easement without affirmative assurances that these factors are not present with respect to the Property. Since Grantor is the party most familiar with the Property, Grantor acknowledges the right of Grantee to rely without inquiry on these assurances in the form of Grantor's warranties and representations as described below.

DRAFT

(a) Grantor is the sole owner of the Property, free of all liens, claims, interests and encumbrances, except those permitted in attached Exhibit D. Grantor understands that the Exhibit D parties must consent and subordinate to this Easement. No person has any homestead interest in the Property other than Grantor.

(b) To the best of Grantor's knowledge:

(i) Any handling, transportation, storage, treatment or use of any substance defined, listed, or otherwise classified pursuant to any federal, state or local law, regulation, or requirement as hazardous, toxic, polluting, or otherwise contaminating to the air, water, or soil, or in any way harmful or threatening to human health or the environment, that has occurred on the Property prior to the date of this Easement has been in compliance with all applicable federal, state, and local laws, regulations, and requirements.

(ii) No deposit, disposal, or other release of any hazardous substance or toxic waste has occurred on or from the Easement Area, which is free of all such contamination.

(iii) There are not now any underground storage tanks located on the Property, whether presently in service or closed, abandoned, or decommissioned, and no underground storage tanks have been removed from the Easement Area in a manner not in compliance with applicable federal, state, and local laws, regulations, and requirements.

(iv) Grantor and the Property are in compliance with all federal, state and local laws, regulations, and requirements applicable to the Property and its use.

(v) There is no pending or threatened litigation in any way affecting, involving, or relating to the Property.

(c) No civil or criminal proceedings or investigations have been instigated at any time or are now pending, and no notices, claims, demands, or orders have been received, arising out of any violation or alleged violation of, or failure to comply with, any federal, state, or local law, regulation, or requirement applicable to the Property or its use, nor do there exist any facts or circumstances that Grantor might reasonably expect to form the basis for any such proceedings, investigations, notices, claims, demands, or orders.

(d) In determining to grant this Easement, Grantor has relied solely on the advice of his own legal, tax and valuation advisors and not on any representative of Grantee.

ARTICLE III. GRANTEE'S RIGHTS UNDER THE EASEMENT

A. **General Authority.** Grantee shall have the right and power:

1. To enter upon the Property at reasonable times to monitor compliance with and otherwise to enforce the terms of this Easement as more particularly set forth herein; and
2. To prevent any activity on or use of the Property that is inconsistent with the purpose of this Easement and to require the restoration of such areas or features of the Property that may be damaged by any inconsistent activity or use, pursuant to the remedies set forth in this Article; and
3. Grantee is granted access to the Easement Area on and across any adjoining land of Grantor by the route most convenient to Grantee.

B. **Present Conditions Report.** Exhibit C constitutes a summary of a Present Conditions Report (the "PCR") prepared by Grantee with the cooperation of Grantor, consisting of maps, photographs and other documents and acknowledged by both parties to be complete and accurate as of the date of this conservation Easement. The PCR will be used by Grantee to assure that any future changes in use of the Easement Area will be consistent with the terms of this Easement; but the PCR is not intended to preclude the use of other evidence to establish the present condition of the Easement Area if there is a controversy over its use. A full copy of the PCR is available at Grantee's office.

C. **Conservation Management Plan.** For those parts of the Property designated as the "Easement Area," Grantor agrees to maintain a Conservation Management Plan (Exhibit D) along ____________________ ("Water Body").

1. In the Easement Area only those activities specifically outlined in the Conservation Management Plan will be allowed. Grantor and its successors and assigns are required to conduct all permitted operations and practices in accordance with good management practices addressing soil and water conservation, erosion control, and habitat protection.

2. If the boundaries of the Easement Area are based on the edge of the Water Body and the Water Body moves, then the Grantor shall allow the portions of the Property not formerly in the Easement Area to succeed to the required buffer. All other applicable Terms shall apply. (The Grantor and Grantee may, however, agree to amend the description of the Easement Area.)

D. **Retained and Assumed Responsibilities, Obligations and Liabilities.**

1. **Grantee's Status.** This Easement shall not be construed to create or impose upon Grantee any responsibilities, obligations or liability as, an owner, operator, landlord, tenant or manager of the Property. Grantee's obligations for monitoring and inspection shall be solely for the purpose of preserving water quality and habitat and not for the prevention or mitigation of any damage, injury or other harm to persons or property. This Easement shall not be deemed to create any right of action against Grantee in favor of any third party.

2. **Taxes.** Grantor shall pay before delinquency all taxes, assessment, fees and charges of whatever description levied on or assessed against the Property and/or this Easement; provided, however, that all assessed real estate taxes shall be paid on or before the due date set forth in the county tax statement.

3. **Management.** Grantor shall continue to be solely responsible for the upkeep, maintenance and management of the Easement Area.

4. **Insurance.**

(a) Grantor shall be solely responsible for maintaining all appropriate casualty, property, and liability insurance.

(b) Grantee shall be named an additional insured on all such insurance policies related to the Property.

5. **Compliance with Laws.** Grantor shall remain solely responsible for obtaining all applicable governmental permits and approvals for any construction or other activity or use permitted by this Easement and to conduct the foregoing in accordance with and in observation of all applicable federal, state and local laws, rules, regulations and requirements.

6. **Indemnity.** Grantor shall indemnify, protect, defend with counsel acceptable to Grantee and hold Grantee and its directors, officers, employees, agents, attorneys, volunteers, representatives, successors and assigns ("Indemnified Parties") harmless from and against all claims, actions, administrative proceedings, liabilities, judgments, damages, punitive damages, penalties, fines, costs, remedial action, compliance requirements, enforcement in clean-up actions of any kind, interests or losses, attorney's fees and expenses (including those incurred in enforcing this indemnity), consultant fees and expert fees arising directly or indirectly from or in connection with (i) injury or death of any person, damage to any property or diminution in the value of property resulting from any act, omission, condition or other matter related to or occurring on or about the Property regardless of cause, including injury, death

or other harm to any Indemnified Party; (ii) the presence, suspected presence or release of any hazardous substance whether into the air, soil, surface water or ground water of or at the Property; (iii) any violation or alleged violation of any environmental law affecting the Property, whether occurring prior to or during Grantor's ownership of the Property and whether caused or permitted by Grantor or any person other than Grantor; (iv) any claim or defense by Grantor or any third party that any Indemnified Party is liable as an owner or operator of the Property under any environmental law; or (v) any breach of Grantor's warranties, representations or retained responsibilities, obligations or liabilities hereunder. This indemnity shall not apply if it shall be finally determined that any of the foregoing was caused primarily by the gross negligence or willful misconduct of Grantee.

7. **Remediation.** If, at any time, there occurs, or has occurred, a release in, on, or about the Property of any substance now or hereafter defined, listed, or otherwise classified pursuant to any federal, state, or local law, regulation, or requirement as hazardous, toxic, polluting, or otherwise contaminating to the air, water, or soil, or in any way harmful or threatening to human health or the environment, Grantor shall take all steps necessary to assure its containment and remediation, including any cleanup that may be required, unless the release was caused by Grantee, in which case Grantee shall be responsible therefore.

8. **Assignment.** This Easement is transferable, but Grantee may assign its rights and obligations under this Easement only to an organization that is a qualified "holder" at the time of transfer under SDCL 1-19-56. As a condition of such transfer, Grantee shall require that the purpose that this grant is intended to advance continue to be carried out. Grantee shall give written notice to Grantor of an assignment at least thirty (30) days prior to the effective date of such assignment. The failure of Grantee to give such notice shall not affect the validity of such assignment nor shall it impair the validity of this Easement or limit its enforceability in any way.

9. **Grantee's Remedies.** This Easement has been purchased through the Big Sioux River Conservation Easement Program and the Grantor is to be paid the full amount of the purchase price for the easement either at the time the easement is signed, or upon completion of the requirements of the Conservation Management Plan, as per agreement of the Grantor and Northern Prairies. This Easement is written with the primary purpose of protecting the water quality of the Big Sioux River or its tributaries. As a result, Northern Prairies, as the Grantee, must have substantial enforcement rights for the terms of the Easement. Therefore, the following provisions apply:

(a) **Notice; Corrective Action.** If Grantee determines that a violation of the terms of this Easement has occurred or is threatened, Grantee shall give written notice to Grantor of such violation and require corrective action sufficient to cure the violation be taken. Where the violation involves injury to the Easement Area resulting from any use or activity inconsistent with the purpose of this Easement, the portion of the Easement Area so injured shall be restored to its prior condition in accordance with a plan approved by Grantee.

(b) **Injunctive Relief.** Grantee may bring an action at law or in equity in a court of competent jurisdiction to enforce the terms of this Easement, to enjoin the violation, *ex parte* as necessary, by temporary or permanent injunction, and to require the restoration of the Property to the condition that existed prior to any such injury, if any of the following occur: (i) Grantor fails to cure the violation within thirty (30) days after receipt of notice thereof from Grantee; (ii) under circumstances where the violation cannot reasonably be cured within a thirty (30) day period, Grantor fails to begin curing such violation within the thirty (30) day period; or (iii) Grantor fails to continue diligently to cure such violation until it is finally cured,.

(c) **Damages.** In the event that Grantor does not or cannot cure the noticed violation and effectively restore the Easement Area to its pre-violation state, then Grantee shall be entitled to recover damages for violation of the terms of this Easement or injury to the Easement Area Without limiting Grantor's liability therefore, Grantee, in its sole discretion, may apply any damages recovered to the cost of undertaking any corrective action on the Property.

(d) **Emergency Enforcement.** If Grantee, in its sole discretion, determines that circumstances require immediate action to prevent or mitigate significant damage to the Easement Area which is potentially severe enough so as to make notice impracticable, Grantee may pursue its remedies under this Article without prior notice to Grantor or without waiting for the period provided for cure to expire. In such instance, Grantee shall provide notice as soon as practicable.

(e) **Scope.** Grantee's rights under this Article apply equally in the event of either actual or threatened violations of the terms of this Easement. Grantor agrees that Grantee's remedies at law for any violation of the terms of this Easement are inadequate and that Grantee shall be entitled to the injunctive relief described herein, both prohibitive and mandatory, in addition to such other relief to which Grantee may be entitled, including specific performance of the terms of this Easement, without the necessity of proving either actual damages or the inadequacy of otherwise available legal remedies. Grantee's remedies described in this Article shall be cumulative and shall be in addition to all remedies now or hereafter existing at law or in equity.

(f) **Costs.** All reasonable costs incurred by Grantee in enforcing the terms of this Easement against Grantor, including, without limitation, costs and expenses of suit and reasonable attorney's fees, and any costs of restoration necessitated by Grantor's violation of the terms of this Easement shall be borne by Grantor; provided, however, that if Grantor ultimately prevails in a judicial enforcement action each party shall bear its own costs.

(g) **Forbearance.** Forbearance by Grantee to exercise its rights under this Easement in the event of any breach of any term of this Easement by Grantor shall not be deemed or construed to be a waiver by Grantee of such term or of any subsequent breach of the same or any other term of this Easement or of any of Grantee's rights under this Easement. No delay or omission by Grantee in the exercise of any right or remedy upon any breach by Grantor shall impair such right or remedy or be construed as a waiver.

(h) **Waiver.** Grantor hereby waives any defense of laches, estoppel, or prescription. Add short definitions or examples.

ARTICLE V. GENERAL TERMS AND CONDITIONS

A. Notices and Approvals.

1. **Methods.** Any notice or communication under this Easement shall be in writing and delivered (by hand, telecopy, telegraph, telex or courier) or deposited in the United States mail (first class, registered or certified), postage fully prepaid and addressed as stated below. Either party may, from time to time, specify as its address for purposes of this Easement any other address upon the giving of ten days notice thereof to the other party in the manner required by this paragraph. This paragraph shall not prevent the giving of written notice in any other manner, but such notice shall be deemed effective only when and as of its actual receipt at the proper address and by the proper addressee.

2. **Timing and Substance.** Whenever notice to or approval of Grantee is required, Grantor shall notify Grantee in writing not less than thirty (30) days prior to the date Grantor intends to undertake the activity in question. The notice shall describe the nature, scope, design, location, timetable, and any other material aspect of the proposed activity in sufficient detail to permit Grantee to make an informed judgment as to its consistency with the purpose of this Easement.

3. **Approval.** Where Grantee's approval is required, Grantee shall grant or withhold its approval in writing within thirty (30) days of receipt of Grantor's written request therefore.

Grantee's approval may be withheld only upon a reasonable determination by Grantee that the action as proposed would be inconsistent with the purpose of this Easement. Grantee's approval may be conditioned on reimbursement of costs incurred in, and reasonable fees for, consideration of the request.

B. **Extinguishment and Condemnation.**

1 **Extinguishment.** If circumstances arise in the future that render the purpose of this Easement impossible to accomplish, this Easement can only be terminated or extinguished, whether in whole or in part, by judicial proceedings in a court of competent jurisdiction. The amount of the proceeds to which Grantee and/or EDWDD shall be entitled is the full amount paid for this Easement plus interest, as allowed by applicable law.

2. **Condemnation.** If all or any part of the Property is taken by exercise of the power of eminent domain or acquired by purchase in lieu of condemnation, whether by public, corporate, or other authority, so as to terminate this Easement, in whole or in part, Grantor and Grantee shall act jointly to recover the full value of the interests in the Easement Area subject to the taking or in lieu purchase and all resulting direct or incidental damages. All expenses reasonably incurred by Grantor and Grantee in connection with the taking or in lieu purchase shall be paid out of the amount recovered. Grantee's share of the balance of the amount recovered shall be as stated in this Article.

3. **Application of Proceeds.** Grantee shall use any proceeds received under the circumstances described in this Article in a manner consistent with the Easement purposes, which are exemplified by this grant.

C. **Benefit and Binding Effect.** The Easement created by this instrument shall be a servitude running with the land in perpetuity. Every provision of this Easement that applies to Grantor and Grantee shall also apply to, be binding upon and inure to the benefit of their respective agents, heirs, executors, administrators, other legal representatives, transferees, successors and assigns.

D. The obligations of the Grantors under this Easement shall be joint and several.

E. **Entire Agreement.** This Easement represents the entire and integrated agreement between the parties hereto with respect to the subjects described herein and supersedes all prior negotiations, representations or agreements, oral or written.

F. **Amendment.** This Easement may be amended or modified only in writing, signed by the party to be bound by such amendment or modification, and stating that it is intended as an amendment or modification of this Easement. The parties waive their rights to amend or modify this Easement in any other manner. This Easement may be amended only upon satisfaction of all of the following: (i) written consent of Grantee, which may be granted or withheld in its sole discretion and upon such additional conditions as Grantee may determine to impose in any specific instance; (ii) payment of Grantee's incurred costs and reasonable fees it may impose for the consideration of such amendment; (iii) protection of the Easement Area is improved or not impaired; (iv) the amendment complies with SDCL 1-19B-56(2)(b) et seq. Any such amendment that does not comply with all such requirements shall be void and of no force or effect.

G. **Severability.** If any one or more of the provisions of this Easement shall be determined to be invalid, illegal or unenforceable in any respect for any reason, the validity, legality or enforceability of such provision in every other respect and the remaining provisions of this Easement shall not be in any way impaired.

H. **Nonwaiver.** Failure of a party to insist upon adherence to any term of this Easement on any occasion shall not be considered a waiver or deprive that party of the right thereafter to insist upon adherence to that term or any other term of this Easement.

I. **Governing Law.** This Easement shall be governed by and interpreted under the substantive laws of the State of South Dakota without regard to principles of conflicts of law. This Easement shall not be interpreted to negate, supersede or otherwise modify any law, statute, rule, regulation or ordinance (together a Law) imposing additional or more stringent restrictions, including those related to zoning or land use, unless such Law is permitted to be varied by private agreement and the express terms of this agreement have that effect. No approval of this Easement by any governmental authority shall have the effect of negating, superseding or otherwise modifying such Law, or waiving its enforcement, unless expressly so stated as a part of such approval.

J. **Headings.** The section headings to this Easement are intended solely for the parties' convenience and shall not affect the interpretation or construction of any portion or provision of this Easement.

K. **Recordation; Publicity.** Grantee shall record this instrument in timely fashion in the official records of __________ County, South Dakota and may re-record it at any time as may be required to preserve its rights in this Easement. Grantee may reasonably publicize the grant of this Easement and use photographs and descriptions of the Property on its web site and other informative materials.

L. **Liberal Interpretation.** Any general rule of construction to the contrary notwithstanding, this Easement shall be liberally construed in favor of the grant to effect the purpose of this Easement and preservation of the Easement Area. If any provision in this instrument is found to be ambiguous, an interpretation consistent with the purpose of this Easement that would render the provision valid shall be favored over any interpretation that would render it invalid.

L. **No Forfeiture.** Nothing contained herein will result in a forfeiture by Grantee or reversion of Grantor's title in any respect.

M. **Termination.** A party's rights and obligations under this Easement terminate upon transfer of the party's interest in the Easement or Property, except that liability for acts or omissions occurring prior to transfer shall survive transfer.

N. **Exhibits.** The exhibits attached hereto are incorporated herein by this reference:

Exhibit A - Property and Easement Area Descriptions
Exhibit B - Aerial Map of Easement Area
Exhibit C – Summary of Present Condition Report
Exhibit D - Conservation Management Plan
Exhibit E - Permitted Encumbrances (if applicable)

Appendix 3

PRIORITY EVALUATION WORKSHEET

RIPARIAN AREA MANAGEMENT PROGRAM

Operator Name:______________________________ Phone Number: __________________

Mailing (Physical) Address:___________________________________ Cell Phone__________

Legal Description of Facility:________________________________ County: _____________

Nearest TMDL Segment: __________________________

Acres of Land to be Enrolled________ Is this land under consideration for USDA CRP* _________

*If yes, the land under this application is _____% of the total amount of land under this application and a USDA CRP application.

(For example, if 2 acres are under application for RAM and 7 acres are under application for a USDA CRP contract, the total number of acres under application for both programs is 9. The 2 acres under RAM application is 22% of the total amount of 9 acres under both applications.)

Current management (stocking rate, duration, type of animals, etc.): _________________________

RATING CRITERIA:

RATING POINTS:

(1) Is the land is question on a TMDL segment? ____ Yes ____ No ____(1)

(2) Is the land in question on a direct drainage to a TMDL segment? __ Yes __ No ____(2)

(3) Amount of time land will be enrolled? _______ Years ____(3)

(4) What is the current land management? ____(4)

TOTAL RATING POINTS: ________

(Maximum of 60 points)

RATING CRITERIA TABLE:

(1) TMDL	Points:	(2) Direct Drainage	Points:
Yes	30	Yes	10
NO	10	No	0

(2) TIME	POINTS:	(4) CURRENT MANAGEMENT	POINTS:
15	15	Grazing / Cropping	15
10	5	Currently Idle / unused	5

I authorize East Dakota Water Development District and Conservation District personnel to acquire maps and information from the USDA NRCS / FSA for the purpose of evaluating this application. ____________ Initial

Form Completed By: ______________________________ Date: _____________

Applicant Signature:______________________________ Date: _____________

ATTACHMENTS TO PRIORITY EVALUATION WORKSHEET

All applicants must include the following which is used in the evaluation process by East Dakota Water Development District:

(1) Complete Priority Evaluation Worksheet
(2) USGS topographic map of the project area
(3) Soil Survey map(s) of the project area
(4) Aerial photo of the area
(5) Narrative statement describing background information / justification for the application

NARRATIVE:

GUIDE SHEET FOR PREPARATION OF
PRIORITY EVALUATION WORKSHEET
RIPARIAN AREA MANAGEMENT

HEADING: Complete all requested information to identify the applicant.

LEGAL DESCRIPTION OF FACILITY: Identify the location of the proposed system to the nearest quarter section.

(1) IS THE LAND IN QUESTION ON A TMDL SEGMENT?: If the land in question in draining directly into a TMDL segment, the answer is YES. If the land in question is not draining directly into a TMDL segment, the answer is NO. Refer to the Big Sioux River Watershed Project Guidelines for segments with TMDLs. If NO, then proceed to #2. If YES, skip #2.

(2) IS THE LAND IN QUESTION ON A DIRECT DRAINAGE TO A TMDL SEGMENT?: If the land in question is located on a direct drainage to a TMDL segment, the answer is YES. If the land in question is not located on a direct drainage to a TMDL segment, the answer is NO.

(5) AMOUNT OF TIME LAND WILL BE ENROLLED: How many years is the landowner willing to enroll the land in the riparian buffer protection program?

(4) WHAT IS THE CURRENT MANAGEMENT ON THE PROPERTY?: The purpose of this question is to distinguish between applications that will result in real load reductions.

NOTE: Assign rating points using the rating criteria table on page 1.

BIG SIOUX RIVER WATERSHED RIPARIAN AREA MANAGEMENT (RAM) PROGRAM CONTRACT	1. County	2. Sub-Watershed
6. Conservation District Office	3. Contract Number	4. Acres for Enrollment
	5. Contract Period From To	

This CONTRACT is entered into between the Conservation District and the undersigned owners (who may be referred to as "the Participant"). The Participant agrees to place the designated acreage in the Big Sioux River Watershed Riparian Area Management Contract for the contract period from the date the Contract is executed by the Conservation District. The Participant also agrees to implement on such designated acreage the Conservation Plan developed for such acreage by the Conservation District and the Participant. Additionally, the Participant and the Conservation District agree to comply with the terms and conditions contained in this contract and conservation plan. An annual inspection will occur to ensure that the land is being maintained as specified in the Conservation Plan. Stipulated damages for breach of the Riparian Area Management Contract between the Participant and the Conservation District are:

First Offense: If the land under contract fails to meet contract requirements, the person(s) enrolling land under the Riparian Area Management Contract will be required to repay 125% of the contract rate. The fine will be paid to local Conservation District office.

Second Offense: The contract between the landowner(s) and the Conservation Districts will be terminated and the landowner(s) will be required to repay the Conservation District all annual payments and BMP cost share payments received while the land was enrolled in this program.

Transfer of Land: If a new owner purchases or obtains the right and interest in the land subject to this contract, such new owner will become the participant to the contract under the same terms and conditions. The original contract Participant is responsible for the conditions of the contract until such time a new contract is signed by the new owner and the Conservation District.

By signing this contract, signees agree to the terms and provisions described.

7.	
A. Rental Rate per Acre	$
B. First Year Payment (50% of contract)	$
C. Annual Contract Payment 1/2 rate times arces enrolled	$
D. Last Year Balance of Contract amount	$

8. Identification of BSRW RAM Land

A. USDA Tract No.	B. Field No.	C. Acres	D. Total Estimated Cost Share	
				$

9. PARTICIPANTS

A (1). LANDOWNER'S NAME AND ADDRESS	(3) Social Security Number		
	(2) Share 100%	(4) Signature	Date

B (1). LANDOWNER'S NAME AND ADDRESS	(3) Social Security Number		
	(2) Share %	(4) Signature	Date

10. Official Use Only	11. Signature of Conservation District Rep.	Date

Appendix 4

APPENDICES 4

East Dakota Water Development District has its own web site with the following address:

http://www.eastdakota.org

The Watershed Project could be found within the District web page. One could go directly there with the following address:

http://www.eastdakota.org/BSRSWIP.html

A portion of the contents can be reviewed in the following pages.

Big Sioux River Surface Water Implementation Project: The Central Big Sioux Watershed Project is a 10-year
TMDL implementation strategy that will be completed in multiple segments. The project will restore and/or
maintain the water quality of the Big Sioux River and it's tributaries to meet the designated beneficial uses. The
Central and North-Central Big Sioux River Watershed Assessments identified various segments of the Big Sioux
River and certain tributaries between Watertown and Brandon as failing to meet designated uses due to
impairments from total suspended solids and/or fecal coliform bacteria. Activities to improve and/or maintain
current sediment and bacterial loadings will target sub-watershed within the project area. Water quality
sampling will be used to monitor and assess project impacts on impaired waters bodies so as to meet the
TMDLs. Contact Roger Strom for more information.

The Big Sioux River watershed drains several counties in Southeastern South Dakota and also some in Southwestern Minnesota and Northeastern Iowa (See Figure 1). Do you live in the Big Sioux River watershed? In South Dakota, all or parts of the following counties drain into the Big Sioux River: Roberts, Marshall, Day, Codington, Clark, Hamlin, Deuel, Brookings, Kingsbury, Moody, Lake, Minnehaha, Lincoln, and Union. The Big Sioux River begins in Summit, SD then flows through the towns of Watertown, Brookings, Flandreau, Dell Rapids, and Sioux Falls before emptying into the Missouri River in Sioux City, Iowa.

Several smaller streams feed the Big Sioux River as it winds down Southeastern South Dakota. These smaller streams collect runoff from surrounding farmland and towns. What about lakes? Lakes are also an important part of the Big Sioux River watershed. Some lakes serve as a place for water to drain to when the Big Sioux River has over flown its banks, which helps to save homes downstream from flooding. Major lakes in the Big Sioux River watershed include Lake Kampeska, Lake Pelican, Lake Poinsett, Lake Campbell, Lake Madison, and Wall Lake.

Did you know that many cities along the Big Sioux River use surface or shallow groundwater from the river for drinking purposes. Currently, Sioux Falls is the only city to use surface water for drinking water (roughly two-thirds of their supply), while the other one-third of their drinking water comes from shallow groundwater which is hydraulically connected to the Big Sioux River. Other cities and rural water corporations along the Big Sioux also use shallow groundwater wells which are connected to the Big Sioux for a drinking water source. This means that even though you may reside in rural Moody County, if you eat at a restaurant in Sioux Falls, the water used to make ice for your drink was gotten from the Big Sioux River watershed. This is why it is very important for us to think about what comes in contact with water as it travels down the Big Sioux River. Remember, water in the Big Sioux River empties into the Missouri River and then into the Mississippi River. This means that people downstream of you are using the water that you may have affected. Many cities downstream of us use the Mississippi River for drinking water also.

As of today, portions of the Big Sioux River Watershed between Watertown and Brandon have been identified as unsuitable for fish life propagation, fishing/boating, and/or swimming. The water quality assessment studies completed by our office detail the exact impairments and what the causes of these impairments are.

As a result of the findings in the water quality assessments of the Big Sioux River Watershed, EDWDD has received federal funding to reduce sediment and bacterial loadings into the watershed. The Big Sioux River Watershed Project was designed to reduce non-point source pollution from within the watershed to improve the quality of water in the Big Sioux. By improving animal waste management facilities and returning riparian buffers back to a natural state, we feel that the water quality in the Big Sioux River will improve, resulting in a resource that everyone can enjoy.

EDWDD is the recipient of $1,618,078 in US EPA 319 grant funds to reduce total suspended solid and fecal coliform bacteria loadings into the Big Sioux River Watershed between Watertown and Brandon (includes several major tributaries). These grant funds are being used to install waste management systems at animal feeding operations and to restore riparian buffers along stream banks.

Tuesday, August 14, 2007 marks the closing of the first permanent conservation easements along the Big Sioux River. Two brothers near Estelline, SD have agreed to eliminate livestock grazing and/or crop production within the easement buffer area in perpetuity. The Big Sioux River Conservation Easement program has also acquired a 28 acres buffer strip on the Big Sioux River near Bruce, SD and 14 acres of buffer strip along Willow Creek in Codington County under the 30-year program. A perpetual conservation easement was recently granted on 36.5 acres of buffer strip along the Big Sioux River near Castlewood, SD

Appendix 5

BIG SIOUX RIVER WATERSHED PROJECT

For more information please contact the East Dakota Water Development District in Brookings at 605-688-6471.

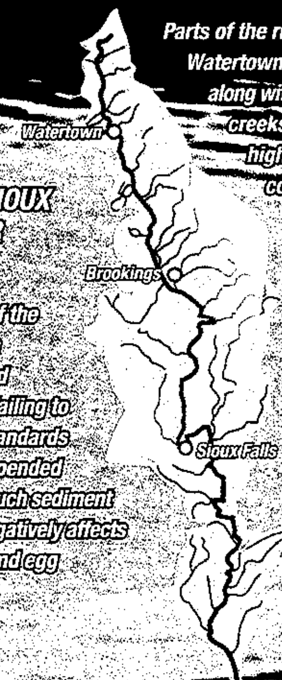
About Us:

The East Dakota Water Development District promotes and supports the sound management and conservation of all water resources. As a political subdivision of the state of South Dakota, it includes all or parts of 11 counties in eastern South Dakota in the Big Sioux River basin.

[illegible]

The Big Sioux River flows peacefully from Roberts County in the northern tip of our state, all the way south to Sioux Falls and Brandon. There it continues on – defining the border between South Dakota and Iowa until it joins the Missouri River at Sioux City, Iowa.

Overall, the 395-mile Big Sioux River is clean and safe. That's the good news. Now the not-so-good news:



Parts of the river between Watertown and Brandon, along with several smaller creeks in the area, have high levels of fecal coliform bacteria. That means the river is at times unsuitable for swimming in those areas. At times, other uses such as fishing and canoeing are also affected.

Other areas of the river between Brookings and Brandon are failing to meet state standards for "total suspended solids." Too much sediment in streams negatively affects fish growth and egg development.

[illegible]

[illegible] specific causes, but scientists can make [illegible]ces. Natural conditions such as heavy rains [illegible]sion play a part. Additionally, poor land management practices along the river in both rural and urban areas can contribute to water quality problems.

What do we do now?

The East Dakota Water Development District (EDWDD) in Brookings has received federal, state and local grant funds to fix the problems. Since it's your money we're using, we wanted you to know how we're addressing these problems:

Step One: Improve Animal Feeding Operations

Overall, area farms and feedlots are doing an excellent job

Big News on the Big Sioux

Your Guide to Water Quality Issues in Eastern South Dakota

Watertown and Brandon.

The money can be used for improvements to animal feeding operations through new construction or engineering. These improvements can be as simple as installing filter strips or as complex as full containment systems.

This program is very important for the continued [illegible] Big Sioux River water quality projects. Farm[illegible] are encouraged to call 605-688-6[illegible] information.

Step Two: [illegible]

The bes[illegible] good defense – especially when you're dea[illegible] nature. That's why, in addition to the feedi[illegible] grants, an additional $1.4 million in funds have been allocated to get back to basics. In other words, help preserve or re-establish the diverse grasslands, woodlands and wetlands along the Big Sioux River.

These "riparian zones" are nature's shield for the river. The natural grasses filter dirt and debris, and help counter the effects of runoff from agricultural fields. They also provide food and shelter for many animals, as well as valuable flood control benefits.

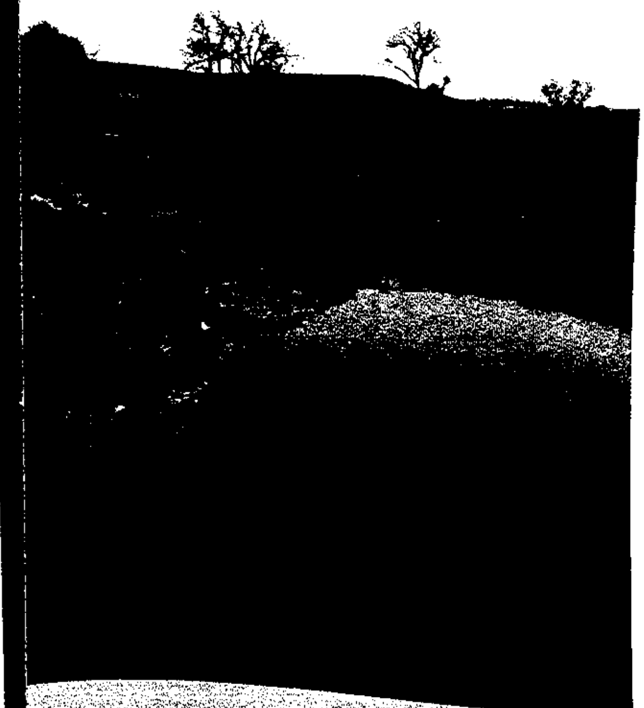
To find out if you're eligible for this program, please call 605-688-6457 for more information.

Step Four: Work Together

You can be assured the Big Sioux River will continue to be monitored by water quality experts. Routine sampling and testing will help us keep an eye on what's happening in the river, good and bad. Here's what you can do:

- *Stay up-to-date on water quality issues where you live, work and play. Let community leaders know you care about the river. Because whatever happens to the Big Sioux in the northern part of the state, good or bad, flows south to affect everyone.*
- *If you farm in the area, use minimum till practices. Avoid plowing fields all the way to the edge of the water, and put up fences to keep cattle away from the banks and streams. Contact your local extension office for more ideas.*
- *If you have a stream, river or lake on your property, maintain the natural shoreline as much as possible. Grass all the way to the edge of the water may look nice, but natural vegetation and rocky edges are essential to stopping harmful pollutants and eroded soil. Local landscapers and extension offices are good resources for reintroducing natural vegetation.*
- *If you own livestock, it's important to keep your animals away from the natural grassy barriers between your farm and the river. A good rule of thumb is to set your fences at least 50 to 100 feet from the water's edge.*

Together, we can keep the Big Sioux River a beautiful, healthy place for generations to come.



Step Three: Focus on Communities

Water quality in the Big Sioux is not just a rural issue. Urban areas have a part to play as well.

For example, the city of Sioux Falls is currently addressing erosion and runoff issues through bank stabilization projects along the Big Sioux River and Skunk Creek. They're getting back to nature, too – with efforts to protect the river by extending conservation easements within the city limits. These easements will help re-establish the natural grasses and banks within the city limits.

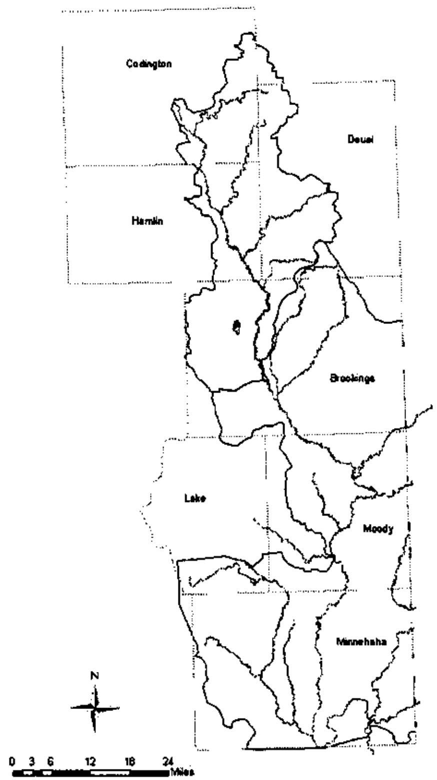
Additionally, Sioux Falls is in the process of fixing storm sewer problems. This should further reduce erosion and runoff into the Big Sioux.

Similar efforts are being explored in other communities along

To learn more about the project please contact either:

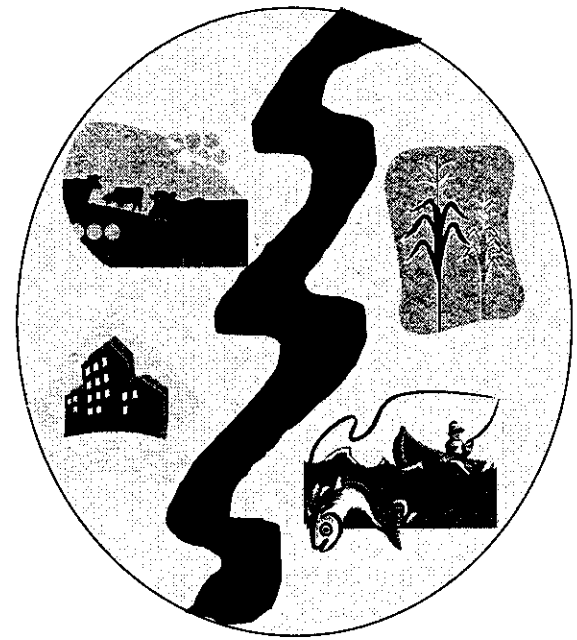
Roger Strom
Project Coordinator
East Dakota
Water Development District
132B Airport Avenue
Brookings, SD 57006
edwdd2@brookings.net
605-688-6457

Patrick Anderson
Executive Director
Northern Prairies Land Trust
401 E. 8th St, Suite 200B
Sioux Falls, SD 57103
info@northernprairies.org
605-339-3184



Impaired segments include the entire stretch of the Big Sioux River between Watertown and Brandon, Willow Creek, Stray Horse Creek, Hidewood Creek, Peg Munky Run, North Deer Creek, Six Mile Creek, Spring Creek, Flandreau Creek, Jack Moore Creek, Pipestone Creek, Split Rock Creek, Beaver Creek and Skunk Creek.

BIG SIOUX RIVER WATERSHED PROJECT



CONSERVATION EASEMENT PROGRAM

BIG SIOUX RIVER CONSERVATION EASEMENT PROGRAM

Goal: Preserve and improve the water quality of the Big Sioux River and its tributaries.

Strategy: Provide substantial financial incentives to landowners who agreed to restrict land-use practices which may impact water quality.

Method: Voluntary conservation easements are utilized to preserve and create natural areas next to the river or tributary by limiting practices which may impact water quality, such as cattle grazing and row cropping along stream banks.

CONSERVATION EASEMENTS

Duration: 30-year or perpetual.

Conservation Management Plan: Outlines the conditions which are needed to maintain the riparian buffer and protect water quality.

Buffer Area: Ranges between 75 and 150 feet, adjacent to the river or tributary.

Easement Area: May be used in any manner consistent with the Conservation Management Plan.

Access: Controlled by the owner.

Transfer: The land may be sold or otherwise transferred, subject to the terms of the easement.

PAYMENTS

Basis: The adjusted assessed land value (AALV) is calculated by multiplying the assessed valuation per acre by a county-wide factor to reflect approximate market value.

Payment Schedule: Prorates the percentage of the AALV offered to the landowner, depending on the duration of the conservation easement, the number of acres involved, and the presence and duration of underlying USDA contracts.

Full Payment Date: Landowners are paid the full purchase price of the conservation easement at the time the easement is signed.

ADDITIONAL PROGRAMS AND FUNDING

Fencing: Available at 100% of the material cost and 75% labor.

Alternate Water Sources: Cost-sharing available at 75% grant and 25% landowner.

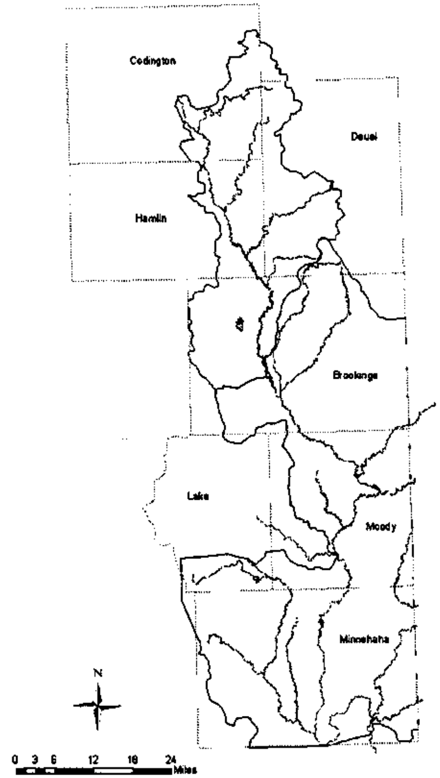
Rock Crossing: Provides a path for cattle to cross the stream from pasture to pasture with minimal damage, and the landowner may be eligible to receive a 75% cost share for a rock crossing.

To learn more about the project please contact:

Roger Strom
Watershed Project Coordinator
East Dakota
Water Development District
edwdd2@brookings.net
605-688-6457

East Dakota
Water Development District
132B Airport Avenue
Brookings, SD 57006

www.eastdakota.org



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BIG SIOUX RIVER WATERSHED PROJECT

RIPARIAN BUFFER MANAGEMENT

Through federal and local funding, the Big Sioux River Watershed Project is striving to restore riparian buffer areas along the Big Sioux River and tributaries between Watertown and Brandon. Activities include fencing cattle out of the stream, removing row cropping along stream banks, and providing alternate watering sources.

BIG SIOUX RIVER CONSERVATION EASEMENT PROGRAM

The Big Sioux River Conservation Easement Program (BSRCEP) is designed to provide a financial incentive to landowners to restrict cattle grazing and row cropping along stream banks. Terms of the conservation easement can be either 30-year or perpetual. A conservation management plan will be provided to provide information to the landowner regarding maintaining the riparian buffer. Buffer widths range between 75 and 150 feet depending on many factors. Payment for the conservation easement will be determined by the adjusted assessed land value (AALV). The AALV is determined by multiplying the assessed valuation per acre by a county wide factor to reflect true market value. A pay schedule has been developed to prorate the percentage of the AALV offered depending on the term of the conservation easement and the presence or absence of any underlying contracts.

RIPARIAN AREA MANAGEMENT

The Riparian Area Management (RAM) program is designed to: (A) accompany an existing USDA buffer management program or (B) accommodate those areas not qualifying for a USDA buffer management program because of canopy cover. A landowner enrolling acreage along a stream bank into a USDA program such as CP-30 may apply for the RAM program to help square up an areas along the stream. If for reasons such as too little or not enough canopy cover, a landowner can apply for the RAM program to enroll a riparian buffer along an impaired stream. The annual rental rate for the RAM is the Farm Service Agency county rental rate for CP-30. The local conservation district office will administer the yearly rental rate to the landowner. Contact your local conservation district office or East Dakota Water Development District for more information.

FENCING AND ALTERNATE WATERING SOURCES

Fencing materials for the BSRCEP and RAM programs are available at 100% of the material cost. Alternate water sources can be cost shared at 75% grant and 25% landowner.

ROCK CROSSINGS

For situations where a landowner owns property on both side of a stream and has enrolled land into a riparian buffer program, the landowner can apply for assistance installing rock crossings. The purpose of a rock crossing is to provide a path for cattle to cross the stream from pasture to pasture with minimal damage to the stream bank. The landowner may be eligible to receive a 75% cost share for a rock crossing.

www.argusleader.com

SIOUX EMPIRE

CONTACT US
▶ Jeff Martin: Metro editor, 331-2373
or jemartin@argusleader.com
▶ Newsroom fax: 605-331-2294

SECTION B

ARGUS LEADER, SIOUX FALLS, S.D. ◆ SUNDAY ◆ MAY 21, 2006

Big Sioux mildly cleaner

River contains less sediment than two years ago

POLLUTION CHANGES

IMPROVEMENTS: The Big Sioux no longer exceeds limits on sediment between Brookings and Dell Rapids, and between Sioux Falls and Fairview.

PERSISTENT PROBLEM: The river still exceeds limits on fecal coliform bacteria between Dell Rapids and Sioux City.

– DENR

BY BEN SHOUSE
bshouse@argusleader.com

The Big Sioux River is slightly cleaner than it was two years ago, but that might be a largely technical achievement rather than a victory over pollution.

The state Department of Environment and Natural Resources recently finalized a report on water quality required every two years by the Clean Water Act. The report compiles a list of "impaired" water bodies based on water samples from 137 monitoring stations across the state, plus additional samples from sites of interest.

Most of the Big Sioux south of Brookings violated the limit for sediment in the 2004 report, but not in the new report. The sediment limit is meant to protect warm-water fish.

But a leading explanation is that the new report covers a drier period than the old report, which incorporated flood events in the late 1990s. The new report covered periods of lower river levels, which scientists refer to as "base flows."

"If you have base flows, you're typically not going to have a lot of suspended solids," said Gene Stueven, environmental senior scientist at DENR in Pierre. On the other hand, "the concentrations are less, so that's an improvement."

He said the finding will not change the department's plan for voluntary programs to improve agricultural practices along the river. Those practices also target fecal coliform bacteria, an indicator of manure pollution still found in most of the river south of Dell Rapids.

The cleanup means grants for farmers and livestock producers to reduce manure runoff and erosion. The East

See RIVER, page 8B

40

River

Continued from 1B

Dakota Water Development District in Brookings is starting to portion out $1 million in grants, and about half a dozen livestock producers have shown interest so far.

Jay Gilbertson, manager of the district, says he agrees with the DENR explanation.

"The river's probably a little bit better off. The question is why, and I suspect part of it is simply the flow. There hasn't been enough of a land use change to explain that," he said.

But Jarrod Johnson, a farmer and cattleman near Brandon, says the river and its tributaries are getting cleaner every year.

"I think that we're just seeing a lot better farming methods because we've been able to have a lot better weed control," he said. Farmers now till their fields less in fall and leave stubble in the fields, reducing erosion, he said.

Johnson and Gilbertson do agree that more progress is desirable, and Johnson said he and other producers are open to some of the improvements that East Dakota recommends.

But water quality is a moving target, and it can take years to even understand if a change in the landscape is causing any change in rivers and streams.

Asked how long before more improvements might become obvious, Stueven said, "There are so many unknowns, I have no idea."

Reach Ben Shouse at 331-2318.

ARGUS LEADER, SIOUX FALLS, S.D. ◆ **SUNDAY** ◆ JUNE 25, 2006

Residents misinformed about Big Sioux pollution

BY BEN SHOUSE
bshouse@argusleader.com

Residents of the Big Sioux basin are open to cleaning up the river using new taxes and regulations, but many are unclear on exactly why the river is polluted.

A new survey of 149 residents of Sioux Falls and other communities along the Big Sioux River says 65 percent are willing to pay higher taxes to protect water quality. Seventy percent are open to regulations on the use of private land, and 45 percent of land owners said they are willing to submit to them.

But when asked what they think is polluting the river, the most common answer was pesticides. In fact, researchers and state officials say, the biggest problem is bacteria from livestock manure, which can cause illness in people who come in contact with untreated river water.

"They know there is a problem, they're willing to do something. Sometimes they don't know exactly what it is," said Angela Guidry of East Dakota Water Development District in Brookings, which commissioned the survey.

The survey of 42 land owners and 107 residents of Sioux Falls, Brandon, Brookings and Watertown was conducted in April and May by Ag Media Research of Sioux Falls, Guidry said.

The district plans to tackle the problem with about $1 million in grants for livestock producers to contain manure and limit their animals' access to streams. Guidry said the sur-

See **RIVER**, page 3B

▶ **INSIDE: See a list of survey results from residents along the Big Sioux River, page 3B.**

River: Livestock pollution might be main problem

Continued from 1B

vey also points to a need for education.

"I think our job now is to inform the people exactly what the problems are," she said.

She has a possible explanation for why people erroneously believed that pesticides are a bigger problem than manure pollution. She said they have gotten a lot of negative press, so people may overestimate the dangers.

"A lot of people are scared of chemicals, and they don't fully understand the chemical world.

"If you look at fecal coliform bacteria, which is what our problem is," she said, "it's not going to give me cancer, it's not going to make me grow a third eye."

A study by East Dakota of the location and timing of bacterial pollution showed that by far the most likely culprit is livestock pollution from small feedlots and pastured animals. It did not implicate large feedlots, though some activists say they are a bigger threat than small operations.

Some landowners are skeptical of the claim that livestock are the main culprit. Quintin Nemmers, 81, who lives along the river near Dell Rapids, cites a different line of evidence.

"In my younger days, we used to do a lot of swimming in the Big Sioux River," he said. "It was a lot more clear than what it is now, and, I might add, along the river practically every farm had a pasture."

He said that more cattle are kept away from the river now, but that farmers plow right up to the river bank, causing more erosion.

He is correct that erosion causes sediment problems on the river. But Guidry said there are no data to compare whether bacterial pollution has changed since the days when he swam there.

Lynn Boadwine, a dairy owner near Baltic, said he hopes livestock owners will take advantage of East Dakota's grants.

"Anytime a producer gets regulated or has a new set of rules," he said, "it takes a little bit of prodding and a little bit of time, and I think we've really just started that process.

"I think it's a good thing, and I think it's something producers shouldn't be afraid of. They just need to adapt to it."

He said voluntary cleanup programs are preferable for now. The alternative – forcing smaller operations to make major improvements – could put some of them out of business.

"This has some real economic consequences. I mean, you can't take somebody that maybe netted $25,000 in their farm operation and give them $200,000 more of debt."

Reach Ben Shouse at 331-2318.

SURVEY RESULTS

Here are some results from a survey of 107 urban residents and 42 landowners along the Big Sioux River.

▶ In your opinion, is the Big Sioux River worth protecting?
YES 99.3%
NO 1% (one person)

▶ Are you willing to have regulations on the use of private property to protect the water quality in the Big Sioux River?
URBAN 79% yes
LANDOWNERS 45% yes, 24% undecided, 31% no

▶ Which of the following represents the greatest threat (within the category of agricultural pollution)?
PESTICIDES/ HERBICIDES (incorrect answer) 39%
ANIMAL FEEDING OPERATIONS (correct answer) 23%

tertown PUBLIC OPINION

Vol. 120 No. 152 Serving the Glacial Lakes Region of South Dakota and Minnesota since 1887 Pric

Water survey shows mixed conclusions

By Terry O'Keefe
Public Opinion Staff Writer

BROOKINGS — A survey of people living in the Big Sioux River watershed between Watertown and Brandon shows most agree the river needs to be cleaned up, but it also shows that most are unaware of how or where to start.

The survey, conducted by Ag Media Research of Sioux Falls for the Brookings-based East Dakota Water Development District (EDWDD), telephone interviews with 150 residents between April 18 and May 25. Those contacted included two separate groups — those who own property along the Big Sioux and a second of adults 25 years or older in the four largest cities along the river, including Watertown.

EDWDD Manager Jay Gilbertson said although programs have been in place for some time to address water quality issues, many of those contacted in the survey were not aware they existed. He said people contacted in the Watertown area were the exception to that.

"Those with awareness of efforts to address water quality issues was very small in percentage, but people in Watertown had a much higher awareness," Gilbertson said. "That's thanks to the efforts of Mike Williams and the Upper Big Sioux Watershed Project.

"But, in general, the responses weren't what we had wanted to see."

Angela Guidry of the EDWDD compiled the results of the survey into a report that was

Please see WATER, Back Page

■ WATER

Continued from Front Page

presented to the S.D. Board of Water and Natural Resources last Friday. She said the intent of the survey was to gauge people's knowledge of the river's condition and their willingness to participate in programs aimed at improving it.

"The reason we did it was to get a feeling for how the people living along the Big Sioux felt of the resource," Guidry said. "Part of our job is going to be to educate the public.

"The survey is going to help us do that. Get the word out to people as to what the problems are."

According to the report, 88 percent of those surveyed feel they have a "significant obligation" to protect water quality for the future and a high percentage would also support stricter regulations and more enforcement as part of the improvement plan.

Gilbertson attended Friday's meeting of Water Board in Pierre and said there were a few surprises in the responses and some that weren't so surprising.

"It was no surprise to anybody that people were interested in the Big Sioux River and were willing to do something about it," Gilbertson said. "They said they would also support additional regulations if voluntary efforts were unsuccessful.

"That was encouraging to me and certainly to the board."

The survey was funded by EDWDD using money from a $1 million grant the organization received for water quality improvement. It addressed the area between Watertown and Brandon, including Sioux Falls, because those in the watershed north of Watertown have already been more involved in existing programs, Gilbertson said.

"In the northern part of the watershed, there have been quite a number who have taken advantage of the programs," he said. "The lack of understanding or the lack of education is something were going to work with.

"We're working with a public relations firm to put together a package to present to the public. We need to get the word out through services clubs and ag commodity groups."

Both Gilbertson and Guidry said the apparent lack of understanding or awareness of existing cost share programs available to land owners is a major concern.

"We will be meeting with groups over the winter," Guidry said. "We will hold town hall meetings where people can come and find out what we're doing with the grant money and how we plan to make the river better.

"Some projects are already under way and we're making plans for the future."

Gilbertson said the responsibility for improving water quality in the Big Sioux River lies with both rural and urban residents and most apparently support stricter regulations and better enforcement of the those regulations.

"We're also going to be talking about enforcement," he said. "When we find people who are not complying with the rules, we need to enforce that.

"We need more resources to enforce the rules. There is not a great record of enforcement, whether it's federal, state or local."

Over $1 million ready for nutrient management

Press Release #1

BROOKINGS — Grant money is now available to farmers living along the Big Sioux River between Watertown and Brandon to be used for riparian restoration and nutrient management planning of animal feeding operations.

The funds have recently been made available as part of the Central Big Sioux River Watershed Project and will be administered by the East Dakota Water Development District (EDWDD).

Totaling over one million dollars, the funds are a mix of local, state and U.S. Environmental Protection Agency dollars and are available on a 75 percent or greater cost-share basis. These funds are part of the Central Big Sioux River Watershed Project and are targeted for improvements to animal feeding operations in the engineering and construction of appropriate nutrient management systems. The grant money is also available for riparian restoration through land set aside programs available for qualified farmers.

Water quality studies in the Big Sioux River watershed have identified persistent problems with suspended sediment and/or fecal coliform bacteria. These impairments affect how and when people can use the river as a recreational resource. This pollution is derived from many sources, but livestock and land-use practices along the river are the major contributors. EDWDD, through its Central Big Sioux River Watershed Project, wants to find farmers willing to upgrade their operations and management practices to ensure that dirty water doesn't run into creeks and eventually the Big Sioux River.

Jay Gilbertson, EDWDD Manager, said that his organization wants to work with farmers through a volunteer program like the Big Sioux River Watershed Project on finding sound environmental solutions to assure that waters attain and then maintain water quality standards.

"A key to this program is that the grant money allows farmers to make improvements to their facilities while also helping restore impaired waters and protect unimpaired water bodies," he said. "This cost-share program helps farmers make these improvements through best management practices without having to shoulder the lion's share of the financial burden."

"The grant money allows farmers and local, state and federal government agencies to work together. Keeping family farmers in business and making sure that we have a clean water supply along the Big Sioux is a win for all of us."

EDWDD will be working formally and informally with a variety of entities to encourage best management practices that both promote sound land use and improve water quality.

43

ARGUS LEADER, SIOUX FALLS, S.D. ◆ WEDNESDAY ◆ APRIL 5, 2006

BROOKINGS

Money available to stop manure runoff

About $1 million now is available to livestock producers for projects that reduce manure runoff into the Big Sioux River.

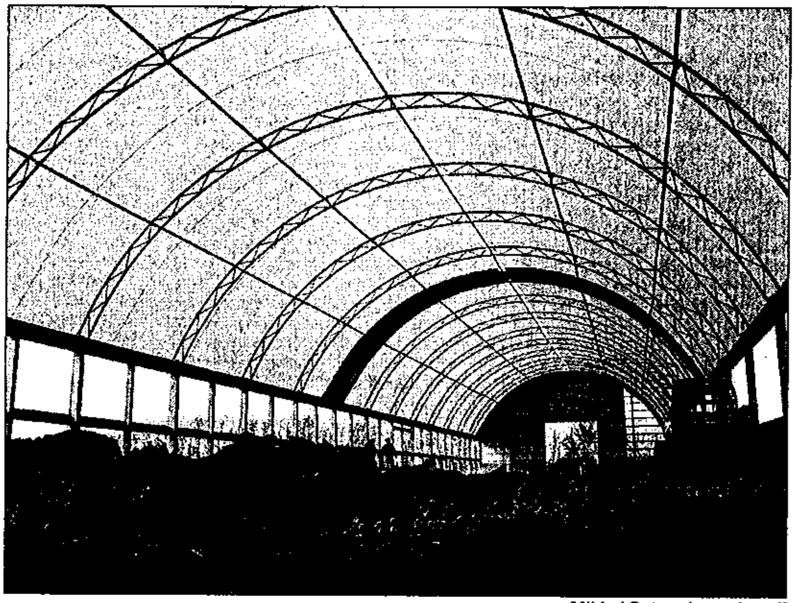
The East Dakota Water Development District in Brookings announced it is looking for producers willing to reduce runoff from their feedlots or reduce access of livestock to the river.

Up to $90,000 per project is available from the U.S. Environmental Protection Agency's fund for nonpoint-source pollution.

The project should be near the river between Watertown and Brandon, and owners must pay 25 percent of the cost, said Angela Guidry, an environmental scientist for the district.

Interested producers may contact Guidry at 605-688-6741.

– From staff reports



▶ **A hoop roof will protect the feeding area and manure from runoff at the Craig Wiste bull calf feeding operation south of Summit, S.D. A concrete feed slab has been installed.**

Mikkel Pates, Agweek staff

Enthusiasm for manure plans

▪ '319' cost-shares help cover stock expansion

By Mikkel Pates
Agweek Staff Writer

SUMMIT, S.D. — That big, red-and-white hoop structure on the Craig Wiste farm south of Summit, S.D., is all about one thing — manure containment.

But it's also about cattle feeding profitability, says Roger Foote, an engineer technician with the Upper Big Sioux River Watershed Project in Watertown, S.D., who says his organization's grant helped cost-share the project.

Foote

Wiste, 50, is a former dairyman and now is head herdsman at the NorSwiss Dairy, an 1,100-head dairy nearby Summit. For about five years, Wiste has had a side enterprise raising bull calves from dairy operations.

He and his wife, Gretchen, who also works at a bank in Summit, typically take the calves from birth to about 700 pounds and then market them through a sale barn in Watertown. Calves are bottle fed for about two weeks and put on pails for another four weeks. After another eight months on feed, they're sold.

The bull calf operation has been in a set of outdoor pens on a farm that has been in their family since 1981.

But the fact is, the farmstead is on the banks of Indian Creek, a tributary to the Upper Big Sioux River.

In the 1990s, the Natural Resources Conservation Service had scored the Wiste farm as one of its highest priority areas in the watershed, because of its proximity to the creek.

The UBSRWP got involved about three years ago.

Mikkel Pates, Agweek staff

▲ **Roger Foote is an engineer technician for the Upper Big Sioux River Watershed Project, based in Watertown, S.D. Among other things, the project offers cost-sharing on manure management facilities and structures.**

Grant program

It's a "319 grant program," which gets funds from the Environmental Protection Agency as part of the Clean Water Act implementation. In existence for about 12 years, UBSRWP provides cost-share assistance for landowners and farm operators to install surface water quality projects. The programs are available through watersheds across the region and often are important to farmers looking to expand livestock operations as affordable feed — including distiller's grains — become more affordable.

The UBSRWP touches four counties — Codington, Grant, Roberts and Day — in northeast South Dakota.

"Work on anything that drains into the Upper Big Sioux River above Watertown," Foote says.

The Wiste project is typical of smaller livestock operations that often have been planned without regard to manure containment.

The structure will replace outside pens, initially designed for dairy cows, on the farm and will contain all of the feeding and house a composting operation. It will cut Wiste's manure output by a third and keep clean water out.

Manure will be emptied once a year. Wiste puts some of the manure on 70 acres of his own adjoining land, but in the past year has obtained easements to put manure on another 200 acres.

Foote says traditional feeding operations of this type often have their environmental impacts.

"Mother nature pulls the handle in the spring and flushes it all out," Foote says.

Plan A, Plan B

About three years ago, the UBSRWP got involved in Wiste's situation.

"Originally, we were looking at doing a lagoon separation basin and evaporation pond," Foote says. "We designed it for a 25-year storm for flood routing. Generally, the NRCS design standards are for 25-year events."

Plan A would have cost about $130,000, for which the producer would have had to pay 25 percent.

"However, during a 100-year event, there's a possibility of the pond being over-topped, and that's a risk we didn't want to take. The creek flows through the property so the evaporation pond would be up against it," Foote says. "Logic says you don't put something in the way that you don't want to get wiped out."

Wiste and the UBSRWP developed a second plan.

Plan B — a manure stacking facility, covered by the hoop structure — carried a $120,000 price tag, of which Wiste will pay about 30 percent to 35 percent.

Once the hoop structure is fully installed, the Wistes' existing pens will be abandoned and replaced with a hoop structure. The new facility will house feeding and collecting manure for up to 400 animals — up from the 150 a year they've been running so far.

Wiste says the bull calves are becoming more available with the expansion of dairies in the region, led by low feed costs.

The Wistes' structure was supplied Whetstone Valley Ag Supply in Wilmot, S.D., and was made by Cover-All and measures 224 feet long by 50 feet wide at the base. It will have a compacted, dirt clay floor. There will be three or four small pens inside for sorting and working, as well as a concrete feeding pad.

"The composting system is not unique, but it's new for this type of feeding," Foote says. "It's not common for beef cattle, but you see it hogs and dairy dry cow."

Wiste had worked with a composting system at NorSwiss, in a structure that holds some 120 cows. The bull calf structure has younger animals, so it handles more animals.

"I try to make it worthwhile to the cooperator," Foote says. "Not only is he doing right by the environment, he's making more money. Cleaner cattle gain better. The nutrients are controlled better for fertilizer applications. The stuff is worth at least $60 a ton, with fertilizer prices going up."

Foote says there isn't really a waiting list for the UBSRWP projects. There were three projects in process in late September.

A jump on mandates

Wiste sees the building as getting a jump on mandates.

"I'm thinking it isn't going to be very long and we're going to have to be responsible for the runoff of the manure," Wiste says. "For the type of situation I'm in, the cattle have to be under a roof."

Foote agrees about the inevitability of mandates.

"When that happens, we don't know," he says. "But a person might as well get the (cost-share) assistance while it's available."

UBSRWP has spent more than $4 million during the past 10 years, covering some 320 projects. Most are stock dams, grassed waterways and riparian area improvements — stream bank shoreline and ag waste systems.

The underlying funding is through the Environmental Protection Agency. The UBSRWP then uses local matches on a 60-40 ratio. The city of Watertown, municipal utilities, conservation districts are among them. The Lake Kampeska Water Project District is one of them.

The project is different than the Natural Resources Conservation Service in some respects.

The UBSRWP can cost-share some things — including some dugouts — that the NRCS can't.

"They do manure systems, but they don't do them at the percent cost-share that we do," Foote says.

Sometimes the UBSRWP cost-share can be piggybacked on the NRCS projects. The NRCS often will cost-share a portion of the project, while the UBSRWP cost-shares an entire project cost.

There's no such thing as a "typical" project, Foote says.

"The more people who want to sign up, the better. We can go to EPA for more grant money." ◻

Contacts:
Angela Guidry- Project Manager
East Dakota Water Development District
Phone: (605)-688-6457
Fax: (605)-688-6744

Patrick Anderson- Project Director
Northern Prairies Land Trust
Phone: (605)-339-3184
Fax: (605)-339-3184

Date: January 10, 2007

FOR IMMEDIATE RELEASE

Landowner Meetings Announced

Brookings, South Dakota -- There will be a series of meetings for landowners with land along the Big Sioux River and major tributaries, which will outline project funding for improving animal waste management systems and establishing protective buffer zones along the waterways.

"The goal of these programs is to improve and preserve water quality in the Big Sioux River and major tributaries" states Angela Guidry, Project Manager. The programs are sponsored by East Dakota Water Development District and funded through an Environmental Protection Agency 319 Grant.

The meetings are scheduled as follows: Brookings, South Dakota - Swiftel Center, January 16; Dell Rapids, South Dakota – Pizza Ranch, February 22; Castlewood, South Dakota – Ida's Café, March 1; and Brandon, South Dakota – Sioux Valley Energy, March 21. The meetings will start at 10 a.m. and lunch will be provided afterwards. Interested landowners should contact East Dakota Water Development District at 605-688-6457 at least three days in advance to pre-register for each meeting.

The meetings are cosponsored by East Dakota Water Development District, Northern Prairies Land Trust, and South Dakota Farm Bureau.

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Landowner meetings to be held to discuss Big Sioux issues

A recent water quality assessment of the Big Sioux River Watershed identified more than 20 segments of the Big Sioux River and major tributaries as not meeting one or more of their uses designated by the South Dakota Department of Environment and Natural Resources.

While an excessive amount of suspended sediment was observed in seven segments of the Big Sioux River between Brookings and Brandon, six river segments and 14 tributaries were observed to have over the state standard of fecal coliform bacteria.

Excessive suspended solids in the water column have a negative effect on fish reproduction. The state water quality standard for fecal coliform bacteria is set to prot[illegible] human health. While po[illegible] of the Big Sioux River [illegible] ignated as limited contact recreation (boating, fishing), other portions of the Big Sioux River are designated as immersion recreation (swimming).

Some portions of the watershed require more than a 90 percent reduction in fecal coliform bacteria to be considered safe for human contact.

In response to the results of the water quality assessment, more than $1.5 million in grant funds have been awarded to East Dakota Water Development District (EDWDD) to reduce sediment and fecal coliform bacteria loadings into the Big Sioux River Watershed.

While many factors affect the loading of sediment and fecal coliform bacteria into the waterways, EDWDD has prioritized the grant funds to restoring a riparian buffer zone along streams and improving animal waste management systems in the watershed.

Riparian buffer zones are critical to protect water quality in the Big Sioux River.

There will be a series of meetings for landowners with land along the Big Sioux River and major tributaries, which will outline project funding for improving animal waste management systems and establishing protective buffer zones along the waterways.

"The goal of these programs is to improve and preserve water quality in the Big Sioux River and major tributaries" said Angela Guidry, project manager in a release. The programs are sponsored by East Dakota Water Development [illegible] funded through [illegible] Protection [illegible] meetings are scheduled as follows:

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- Castlewood - Ida's Cafe, March 1
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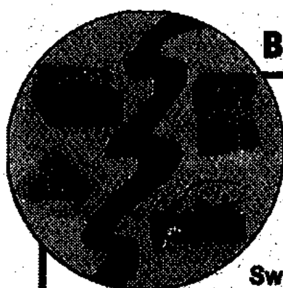
The meetings are cosponsored by East Dakota Water Development District, Northern Prairies Land Trust, and South Dakota Farm Bureau.

– From Staff Reports



Big Sioux River Watershed Project

Plan to attend the Big Sioux River Watershed Project Public Informational Meeting to find out how you can use cost share assistance to improve natural resource conservation practices on your farm.

January 16, 2007 in Brookings at the Swiftel Center - Room D beginning at 10:00 am

This meeting is being co-sponsored by East Dakota Water Development District, Northern Prairies Land Trust, and SD Farm Bureau.

Contact EDWDD at 605-688-6457 with questions, or for more information. Lunch will be provided.

Landowner meetings will cover river pollution

BROOKINGS – The first of four landowner meetings aimed at curbing pollution in the Big Sioux River will be held at 10 a.m. Tuesday at the Swiftel Center.

Landowners can learn how to get money to improve animal waste management or plant buffer strips along waterways. Grants from the East Dakota Water Development District would pay 75 percent of the cost.

Later meetings will be:

■ Feb. 22 at the Pizza Ranch in Dell Rapids.

■ March 1 at Ida's Cafe in Castlewood.

■ March 21 at Sioux Valley Energy in Brandon.

All meetings are at 10 a.m. and include free lunch. To preregister, call 605-688-6457 at least three days in advance.

– From staff reports

SIOUX FALLS
BUSINESS JOURNAL
March 28-April 3, 2007 www.siouxfallsbusinessjournal.com Vol. 5, No. 13 • $2

Programs help landowners protect water

Agencies offer voluntary options for reducing pollutants in Big Sioux River

By Randy Hascall
Sioux Falls Business Journal

AGRIBUSINESS

Pollutants in the Big Sioux River between Watertown and Sioux Falls are such a concern that two organizations are offering financial incentives to landowners who take steps to reduce runoff from feedlots and fields.

The East Dakota Water Development District and the Northern Prairies Land Trust have partnered in a program whose mission is to improve and preserve water quality with steps that include a buffer strip along the river and its tributaries.

The agencies held a series of landowner meetings during the past three months. Landowners could work with either one of the organizations or enter a cooperative venture with both.

Water tests show that fecal coliform bacteria is a big problem in many segments of the river, said Angela Guidry, project manager with East Dakota. Sediment content also is high in many areas and is threatening the fish population.

Guidry told nearly 20 citizens at a March 21 meeting in Brandon that money is available to help livestock producers upgrade their feedlots. The cost-sharing program includes three types of systems: a conventional one with a sediment basin and holding pond; a roofed facility; and a vegetative treatment system.

"Those are the three biggies we can do," she said.

Tests and studies of the river and creeks in the basin show that less than 20 percent of the fecal coliform contamination could have come from septic systems, less than 5 percent from wildlife and less than 0.1 percent from municipal treatment plants, Guidry said.

That leaves more than 74 percent that's believed to be attributable to livestock. More than 1,150 feedlots operate between Watertown and Sioux Falls, said Jay Gilbertson, manager of the East Dakota Water Development District.

BIG SIOUX RIVER

Problems

• Parts of the river and several creeks between Watertown and Brandon have high levels of fecal coliform bacteria.

• Areas between [illegible] and Brandon have high levels of sediment that affect fish growth and egg development.

Proposed solutions

• Improve animal-feeding operations

• Create a buffer strip along the river

• Keep livestock away from banks and streams

• Re-establish grasses and riverbanks within city limits and fix storm sewer problems

Submitted photo
Mark Klein, a feedlot operator near Dell Rapids, talks with Angela Guidry of East Dakota Water Development District. East Dakota is going to pay Klein for installing a holding pond system at his operation.

"Probably 10 percent of those animals are the problem," Gilbertson said.

The Big Sioux provides drinking water to many communities and thousands of rural residents. It also is used

See **WATER**, page 8

WATER: Incentives offered

Continued from page 6

for recreation, irrigation and stock watering.

The agencies' conservation easement program includes financial incentives to reduce runoff by creating and maintaining grassy buffer strips along waterways. In many instances, farmers would have to take that land out of crop production to create the buffers.

Buffer strips usually are 75 to 150 feet wide, said Pat Anderson, executive director of Northern Prairies Land Trust, a nonprofit corporation funded by private foundations and investors to help preserve land. The program would pay most of the cost of fences to keep livestock off the grass buffers. Farmers would be responsible for weed control.

Pat Anderson

Anderson said it's possible that farmers would be allowed to graze their livestock on the buffers for a short time early in the season or to harvest the grass for hay.

The cost-sharing plan uses a formula to determine payment levels to landowners. Payments will be made either in a lump sum or over 30 years.

One benefit to landowners is that they would retain ownership and control of the property, Anderson said. All citizens would benefit through having cleaner water.

Jed Olbertson, who lives near Norway Center in Lincoln County, attended the Brandon meeting and said it's good to see efforts being made to improve conservation.

"I like their approach. They're not as heavy-handed as some federal programs," Olbertson said. "It seems like there's a real desire to work with people."

Olbertson said 90 percent of his farming operation is in the Big Sioux River watershed. He serves on the Lincoln Conservation District board of directors and said that board will play a part in how the Big Sioux program is implemented in Lincoln County.

"I think it's better to be proactive," Olbertson said. "It's better to do what you can than do what you have to do."

Gilbertson stressed that the conservation programs are voluntary. At some point, if the water problems aren't corrected, landowners will have to make changes without being compensated, he said.

"Someone with authority will come in," he said. "We're a long ways from that."

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Argus Leader

Project pays producers to help keep river clean

Saturday, April 14, 2007

LLOYD B. CUNNINGHAM / ARGUS LEADER

Lee Vande Weerd and his son James overlook the Big Sioux on a piece of their land that they have agreed to keep free from cattle and crops in an effort to protect the river. The goal of the Big Sioux Watershed Project is to improve water quality. The land will be used for hunting.

Levi Chiodi / Argus Leader

Goal: Improve water quality in next decade

BY BEN SHOUSE
bshouse@argusleader.com

BRUCE – On these 26 acres, with this one farm family, a long-awaited effort to clean up the Big Sioux River is finally getting its feet on the ground.

There have been tests and studies since the 1990s, including a thorough assessment in 2004. But it was not until last week that a key program focused on the river launched its comprehensive effort to reduce erosion and manure pollution.

On April 6, Lee Vande Weerd's family signed the Big Sioux Watershed Project's first easement, an agreement to exclude cattle and crops from this parcel that straddles the Big Sioux. It is the first step in a two-pronged, $2.8 million effort that could ultimately reach hundreds of landowners and livestock producers.

The project is entirely voluntary, an approach that could falter because of landowner skepticism. But despite that, and despite the full-time staff of just one person, it still has an ambitious goal.

"We'd like to see the water quality dramatically better in 10 years," said Angela Guidry, who runs the project for the East Dakota Water Development District in Brookings.

For Lee Vande Weerd and his sons, Justin and James, the easement program is a great deal.

"This money we have here almost came out of the blue for us," Lee Vande Weerd said.

The $27,510 they got for the 30-year easement beats what they could get from the federal Conservation Reserve Program. And under the agreement, the land retains its primary useful purpose.

"That land will be worth most to hunters, and they don't care what kind of easement you got on it," James Vande Weerd said. He is an ag business student at South Dakota State University and plans to join the family operation full time when he graduates.

See **RIVER**, Page 6A

@ARGUSLEADER.COM: Watch James Vande Weerd talk about the easement he received for hunting as long as he keeps livestock and crops away from the river.

River

Continued from 1A

The easement also is a win for water quality. Studies show these vegetated buffer strips along stream banks prevent the vast majority of sediment and fecal coliform bacteria from reaching the river.

Fecal coliform bacteria are microbes that indicate the potential for untreated water to cause disease in humans who come in contact with it.

"I wasn't aware that it was probably one of the dirtiest stretches of river there is between Sioux Falls and Codington," Lee Vande Weerd said.

There is $1.5 million for the program, from the Environmental Protection Agency, East Dakota and the City of Sioux Falls. Invitations have gone out to 700 landowners between Watertown and Brandon, Guidry said. But so far, only six have signed on.

"The easement program has been slow coming. I guess we were hoping it would be a little more popular," Guidry said.

Vande Weerd says the program might not work for everyone's operation. Land by the river often is valuable for grazing because of fertility and easy access to the water.

But cattle with access to water also are a major source of bacterial pollution, according to the 2004 study by East Dakota. The evidence for that is the fact that many creeks are polluted even in late summer, when there is very little runoff from beyond the river banks.

This pattern of "low-flow" pollution is found in Pipestone and Split Rock creeks in Minnehaha County and in Stray Horse Creek, 20 miles north of the Vande Weerds, Guidry said.

Researchers have detected another type of pollution, one that shows up primarily during heavy rain or rapid snowmelt.

The fecal coliform pollution in Skunk Creek, for example, is 20 times the acceptable level during "high-flow" conditions. And Stray Horse Creek hits 100 times the limit set in the Clean Water Act, Guidry said.

Buffers around streams can intercept some pollution. But according to the East Dakota study, the root of the problem is small and medium-sized livestock operations where water can contact manure and then run into a creek.

So the project also has $1.3 million to help those operations redesign or relocate to prevent manure runoff.

One obstacle to that cleanup effort in Minnehaha County is, perhaps surprisingly, neighbors with concerns about water quality.

Scott Swanson is participating in the East Dakota program, which will help him build a new feedlot closer to his home. He will bring all his cattle under a barn so no rain can fall on the feedlot.

But neighbors went before a county commission hearing in February to oppose his permit. They argued that Swanson has made mistakes on his existing feedlot and should not be allowed to build a new one.

The commission granted the permit, but Swanson said others might be discouraged from joining in the cleanup.

"I think everybody's probably running scared half to death, the way my neighbors came after me," he said.

Guidry said the opposition is understandable, given the number of people moving from Sioux Falls into rural Minnehaha County. But she hopes to work with neighbors to minimize the obstacle.

There might be a bigger barrier to the feedlot program, said Mark Klein of Dell Rapids, the first producer to sign on.

"Everybody's holdup is cost," he said.

He said his bottom line might suffer because he had to share the cost of his waste system to get the $46,000 grant from East Dakota.

But those who do not join the program could face some sort of regulation in the future, and nobody knows what sort of grants will be available then.

"I think everybody's got it in the back of their head that they should be doing something," Klein said. "Everybody knows it's the talk."

The state Department of Environment and Natural Resources would have to take the lead on any mandatory pollution controls. The current feedlot permit does not apply to feedlots with fewer than 1,000 beef cattle.

Dave Templeton of DENR in Pierre said he is optimistic the voluntary approach can work.

"I'm hopeful that once some of the landowners sign up," Templeton said, "that success breeds more success."

Guidry said producers stand to benefit financially in the long run; most feedlot overhauls include a nutrient management plan, which helps maximize the value of the manure used to fertilize crops.

Ten producers already are in the feedlot program, and about 15 others have expressed interest. She hopes the grapevine will accelerate the easement program too.

"Hopefully, once we get some of these done and the word out, people will realize that it can really help them."

Reach Ben Shouse at 331-2318.

THE BROOKINGS
REGISTER

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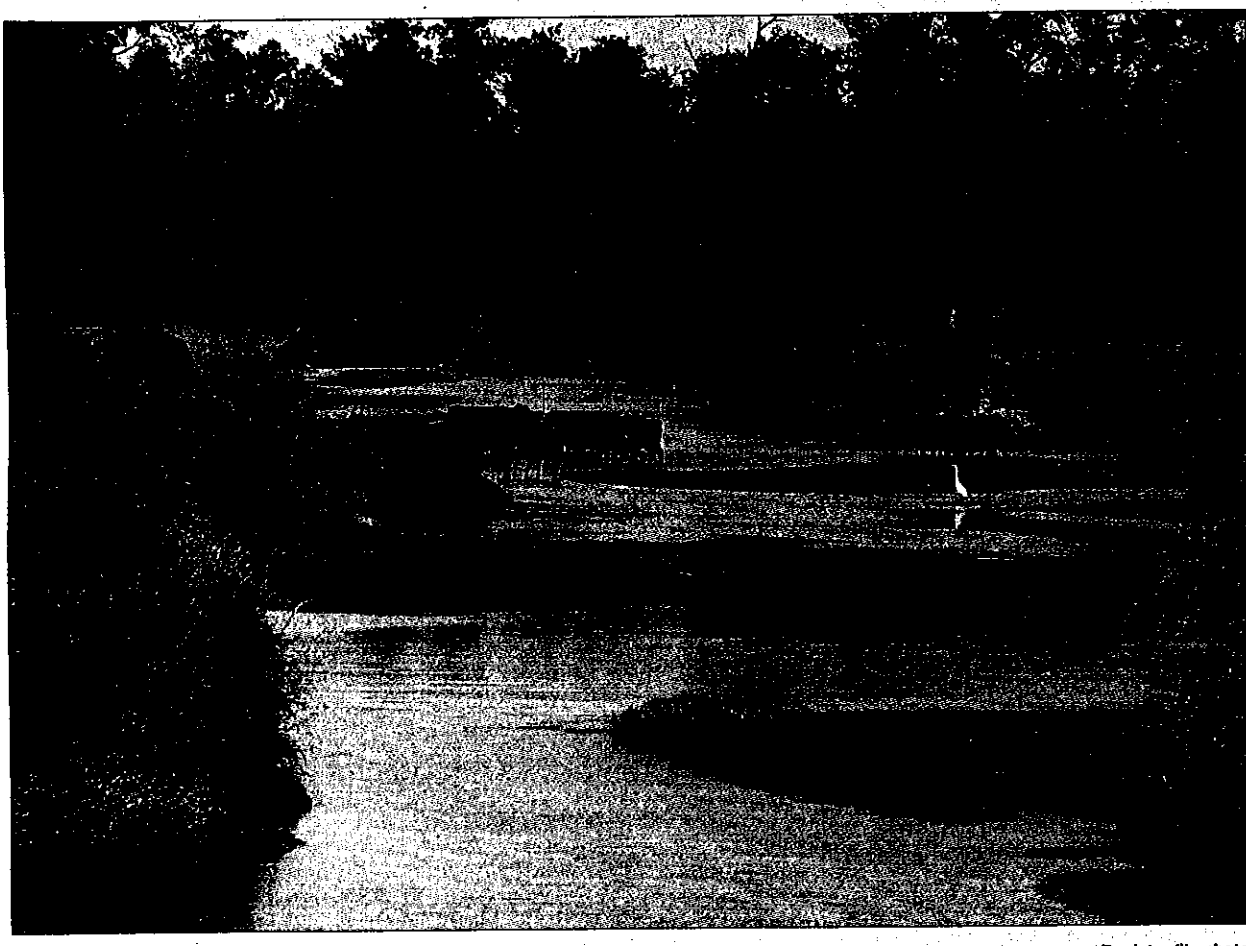


Register file photo

These cattle were wading in one of the Big Sioux's tributaries west of Brookings last spring. A local easement program is providing financial incentives for landowners who agree to protect property around the river and prevent situations like this.

How polluted is Big Sioux?

■ State study details Big Sioux contamination here, area landowners join local easement program

While pollution from sediment and fecal coliform bacteria (sewage contamination) has long been detected in the Big Sioux River, the state just this month released a report that could speed up its cleanup.

Efforts in parts of the 14-county Big Sioux Watershed, of which Brookings is a part of, are already well under way, though.

The Central Big Sioux River watershed assessment project says that numerous studies between 1999 and 2003 measured pollution in the river and its tributaries.

According to the draft report from the state Department of Environment and Natural Resources, the North Deer/Six Mile Creek subwatershed is meeting all water quality and field parameters except for fecal coliform bacteria. In

See RIVER, page A2

RIVER: Program helps producers to take part in Big Sioux cleanup

Continued from page A1

Courtesy photo

James Tesch (right) signed 29 acres of his land in Hamlin County that borders the Big Sioux River into a permanent easement Aug. 14. He will retain access rights to the land and also was financially compensated by East Dakota Water Development District for the easement.

the Big Sioux from Brookings to Interstate I-29, suspended solids are not meeting standards. (Suspended solids include silt and clay particles, plankton, algae, fine organic debris, and other particulate matter.)

Cities along the Big Sioux Watershed use surface or shallow groundwater from the river for drinking purposes. Water coming from portions of the watershed between Watertown and Brandon were found to be unsuitable for sustaining fish populations, swimming and for fishing and boating.

The report says that the Big Sioux's pollution is mostly the result of small and medium feedlot runoff and erosion in stream banks.

As a result of the findings, East Dakota Water Development District received federal funding to improve animal waste management along the river and to restore buffer areas in seven counties in the watershed - Codington, Hamlin, Deuel, Brookings, Moody, Lake, and Minnehaha counties.

The Big Sioux River Conservation Easement Program (BSRCEP) provides a financial incentive to landowners for creating the easements that protect water quality and livestock health. EDWDD has partnered with Northern Prairies Land Trust (NPLT) to make the BSRCEP available to landowners.

Hamlin landowners sign

Two Hamlin County landowners have already placed 50 acres of former pastureland in permanent easements to help protect the boundaries of the Sioux River from contamination.

James Tesch received $34,213 for placing an easement on 29 acres of his Hamlin County property. Russell and Cheryl Tesch of Estelline received $17,643 for placing 18 acres of their land in a permanent easement.

Beyond the obvious financial benefits of the easements, both families had conservation and the health of their own livestock in mind when they made the decision to create the easements.

Protecting the river water and making running cattle on their property easier were his main concerns, Russell Tesch said. Keeping the fences intact there had become "kind of a hassle."

Jim Tesch said his cattle drink rural water, which is healthier than what they would get from the river if they were grazed right up to the banks. Diseases are transmitted through the river water and cattle can develop foot rot and other health problems from walking around in the muddy water. They gain better if they drink the rural water, Tesch said, and keeping them away from the river prevents their waste from polluting the river.

The Tesch easement will create a 125-foot area next to the river that is fenced off and won't be grazed or used for crop farming. Landowners who put their land in an easement still have full access to that property and retain hunting and fishing rights, said Jim Madsen, a private lands biologist with the Northern Prairies Land Trust. One of the main benefits of the easements, he said, is keeping livestock out of the river, which also allows vegetation to grow on the banks preventing erosion.

The East Dakota Water Development District and Northern Prairies Land Trust are working together to create as many easements as possible between Watertown and Brandon including some of the river's main tributaries.

The Northern Prairies Land Trust is a local non-profit land trust that works with landowners to reach conservation goals, Executive Director Pat Anderson said. The easements will be protective of water quality, he said. His organization can hold the easements in perpetuity and work with landowners to further their conservation goals.

Residents hear plan

East Dakota held four meetings last winter that were attended by 100 landowners, Angela Guidry, an environmental scientist with East Dakota, said. The district received applications from the Tesch family before the meetings began. Theirs are the first permanent easements created along the Sioux River. Another 30-year easement of 28 acres was closed near Bruce in April.

"It's a good program," Madsen said. "One thing about this one – it provides the money up front."

Along with helping to create the easements, Northern Prairies and East Dakota work with the South Dakota Department of Game, Fish and Parks and the United States Fish and Wildlife Service to plant vegetation in the easements if necessary, Madsen said.

Jim Tesch plans to put more native grasses in his easement. He said that would make the land a better environment for wildlife. People claim there used to be trees all along the river, he said, but "now there are hardly any because the cattle have rubbed them down."

"It would be nice if the whole river was that way," Tesch said of the easements.

– From staff reports

Tuesday

August 21, 2007

Wednesday
August 29, 2007

Easement program is under way

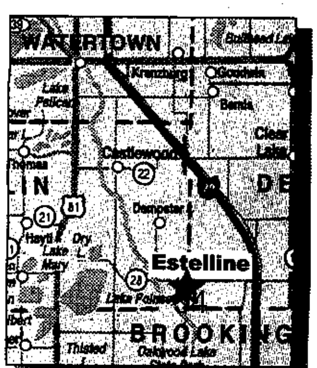
By Michelle Sihrer
Public Opinion Staff Writer

ESTELLINE — In an effort to restore water quality in the Big Sioux River, the Big Sioux River Conservation Easement Program (BSRCEP) — which offers permanent and 30 year conservation easements to landowners next to the river — was started.

The East Dakota Water Development District (EDWD) took water samples from the Big Sioux from 1999 to 2003 and concluded that there were high levels of fecal coliform bacteria in the water. By purchasing easements of land around the river, conservation practices can be used to reduce bacteria and other sediment in the water.

"If we keep cattle out of the water, we can reduce sediment loading and fecal bacteria loading into the river,"

Please see SIOUX, Back Page



Watertown
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SIOUX

Continued from Front Page

Angela Guldry, EDWD Environmental Scientist, said.

Two brothers in Hamlin County are the first participants to sign permanent conservation easements along the Big Sioux River. James Tesch received $34,213 for 29 acres and Russell and his wife Cheryl Tesch received $17,643 for 18 acres. The brothers live on adjacent property near Estelline.

"With the permanent easement, we purchase landowner's right to graze or grow crop in an easement area," Guldry said.

Landowners who sign easements can still hunt and fish the land in the easement, they just can't grow crop or allow cattle to graze in it, Jim Madsen, Northern Prairies Land Trust Biologist, said.

The BSRCEP is funded by three sources: funds from a 319 EPA Grant distributed by the S.D. Department of Environment and Natural Resources, funds from EDWD and funds from the city of Sioux Falls.

The city of Sioux Falls uses surface water from the Big Sioux, so the city received federal grants to help pay for clean up of the river, Guldry said.

Funding for the program was received in 2005, but the program didn't officially start until 2006, Guldry said.

According to provisions in the easements, the landowner is responsible to pay for insurance and taxes on the land included in the easement. The landowner is also responsible for maintaining the grass and soil in the easement area.

The easements are held by the Northern Prairies Land Trust (NPLT), a non-profit group. The permanent easement is attached to the property, so if the property is sold, the easement would remain, Guldry said.

To ensure the provisions in an easement are being followed, representatives with the NPLT check the land.

"Northern Prairies makes a commitment to the landowner and fund providers to make sure restrictions put against the property are followed... the land will be checked at least once a year," Madsen said.

The 30 year term easements have the same restrictions as the permanent ones, but end after 30 years. There is currently one landowner who has signed a 30 year easement for 28 acres near Bruce and there are six others who have applied for it. There is one landowner who has applied for a permanent easement, Guldry said.

The only way to remove the permanent easement is to go to court, according to provisions in the easements.

Landowners interested in an easement fill out an application that gives general information on the location of the land. Then the land is assessed and an estimate of the land's value is made.

"Once an agreement is reached, we set a closing date and it becomes final," Guldry said.

Landowners with easements can also qualify for other federally funded conservation programs, Guldry said.

Anyone interested in participating in this program can contact the East Dakota Water Development District.

Water quality subject of Moody County tour

Agricultural practices to improve water quality are the subject of a tour in Moody County today.

The tour is free, and starts with registration at 9 a.m. at the Moody County Extension Office, 500 W. 1st Ave., Flandreau.

It then will visit "best management practices" along Pipestone Creek, Bachelor Creek, and the Big Sioux River. Lunch will be provided, followed by a visit to rotational grazing systems, riparian forest buffer systems and wildlife habitat plantings.

One of the tour sponsors is the East Dakota Water Development District, which offers producer grants for projects aimed at improving water quality.

For information, call Angela at 605-688-6457 or John at 605-997-2949 ext. 3.

– From staff reports

Farm country feels urban push

Minnehaha tries to stave off conflict in managing growth

By Jonnie Taté Finn
jtatefinn@argusleader.com
Published: November 14, 2007

CROOKS - Scott Swanson sees the change all around: gravel roads being paved, new homes cropping up where corn and soybeans used to be, and neighbors in those new homes wondering where Swanson can keep his cows from mooing or manure from smelling.

It's all a part of being a modern-day farmer in one of the fastest growing counties in the Midwest, said Swanson, a fifth-generation farmer on his property two miles northwest of Crooks.

Swanson is building a 999-head cattle feedlot on his property. Minnehaha County commissioners approved the operation in February, less than a year after rejecting the same plan because of concerns from neighbors, many of whom Swanson said are non-farmers.

Planning officials point to Swanson's case as an example of the county ensuring a future for ag operations in the state's most populated region.

Yet those who study population issues and those who work closely with the farming community say the county will see only more growth in the future. They predict agricultural operations eventually will be pushed to the state's inner rural regions.

Swanson's case of complaints from neighbors represents a conflict with which commissioners here know well.

"I think the county works very hard to maintain a balance. But houses don't make good crop rotations," said Steve Dick, executive director of Agriculture United for South Dakota, a nonprofit group that supports the growth of family farms and ranches in the state.

The county's focus is based on the simple fact that more land in Minnehaha County is zoned for agricultural use. Roughly 85 percent of the county's 521,000 acres is zoned as such, according to the Minnehaha County Planning and Zoning Department.

"Minnehaha County will always have an emphasis on ag production," said Scott Anderson, county planning director. "We'll certainly never be a complete metro area, at least not in the next 40 to 50 years. But there's no way we can plan that far out."

Of the county's 68,000 taxed land parcels, about 4,080 are classified for agricultural purposes, according to Minnehaha County's Equalization Office. Across the state, there are about 31,000 farms, according to the South Dakota Department of Agriculture.

Planners such as Anderson insist a balance is possible despite the ever-expanding boundaries of cities such as Sioux Falls, Brandon and Hartford, which have propelled county population figures from 124,000 in 1990, to 148,000 in 2000, to more than an estimated 170,000 today, according to the U.S. Census Bureau.

Factors portend more nonfarm rural growth

But despite Anderson's assertion that you can't plan 40 or 50 years ahead, Charles "Fritz" Gritzner, a professor at SDSU who teaches population geography, says you can - to some extent.

He sees a growing metro population pushing agriculture to more rural counties.

"As long as the catalysts of growth are there, a population will continue to grow," Gritzner said.

The catalysts he referred to include proximity to interstate highways and the construction of successful industries such as health care systems.

"Sioux Falls will continue to grow, and may do so exponentially at an ever-increasing rate."

That growth will mean the growth of neighboring towns, which would decrease the amount of agricultural land in the county.

But metropolitan growth and the loss of agricultural land use in Minnehaha County wouldn't necessarily be a bad thing, since it would drive agricultural industries to the state's rural areas, Gritzner said

Agriculture accounts for 90 percent of South Dakota's 48.57 million acres, according to the state Department of Agriculture.

Long-term plan devised in 1998 guides county

Planning for growth is something that must be done in steady increments, Anderson said.

When that happens, planning for the county's future isn't a difficult task.

In fact, his department still uses the Minnehaha County Comprehensive Development Plan adopted in 1998 to carry out planning needs and goals. With it came a map outlining the county's transition areas: thousands of acres surrounding hubs such as Sioux Falls, Brandon and Hartford. Those acres are identified by planners as land that can be developed into future urban areas.

"It's sort of our blueprint for the county, and it works very well," Anderson said of the transition map.

"It allows people to know where we want growth to occur, places we feel are appropriate for growth. You can't put a 60-home subdivision in the middle of nowhere."

Preparing for possible use by wind farms

Anderson said the transition areas eventually might be developed, "but we're coming up with ways now to ensure enough land is available to agriculture in the future."

For instance, he said the county recently made major revisions to the county zoning ordinance dealing with wind generation for better use of land for wind farms.

"We can't predict what will happen in nine to 10 years, but we're hoping wind farms will make a huge boom in this county," Anderson said. "And there can be agriculture underneath a wind farm. You can grow crops under a wind turbine, so the plan is to blend those two land uses together."

County tries to prepare residents for rural life

In addition, Minnehaha County has a Right to Farm Notice Covenant, which tries to ease the strains between rural residents and newcomers.

When a homeowner obtains a building permit for a rural home, he or she is asked to sign a form that says they understand what to expect from living in the country. That form includes references to gravel roads, farm noises, smells and the hours of operation. A booklet also is given to them to outline what they should expect, and it can be found online.

"It's all part of the zoning dance we do, blending land uses together," Anderson said. "It's security for farmers ... and also helps (farmers) be good neighbors, too."

That's what Swanson is striving for by participating in the East Dakota Water Development District. The program not only is helping him build his new feedlot closer to his home, but will bring all his cattle under a barn so no rain can fall on the feedlot and pollute nearby water systems.

"My experience with the county planning and zoning board is that they're in favor of agriculture," Swanson said, surveying the progress on his feedlot. "When a property like mine is zoned ag, they try to use it for what it's intended for. And I think it's the intent of Minnehaha County to have a bright and flourishing ag community."

Reach Jonnie Taté Finn at 331-2320.

PUBLIC OPINION

WEEKEND EDITION

ol. 122, No. 296 — Serving the Glacial Lakes Region of South Dakota and Minnesota since 1887

December 13 - 14, 2008

Easements will protect waters near Castlewood

BY JOE O'SULLIVAN
Public Opinion Staff Writer

The Gerhold family has won the lottery. The environmental lottery, that is.

The family was paid between $30,000 and $40,000 for each of two easements that will help protect waters flowing into the Big Sioux River near Castlewood.

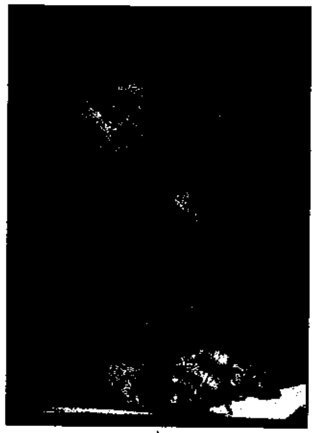
. "Usually when we sign this many things it's because we're taking out a loan," Dan Gerhold said as he leafed through a sheaf of legal documents Friday morning at the Watertown Regional Library.

Non-profit organization Northern Prairies Land Trust and the East Dakota Water Development District purchased the perpetual easements, totaling approximately 43 acres, along a 1.75 mile stretch of Stray Horse Creek, just south of Castlewood.

The easements, 100 foot swaths of land on either bank of the creek, cannot be used for grazing or agriculture in most cases, though most of the land is currently not used for such purposes.

One of the easements is

Please see WATERS, Back Page



Public Opinion photo by Joe O'Sullivan

Deb Biord, Dave Gerhold and Dan Gerhold (not pictured) sign contracts Friday morning to provide perpetual easements on their rural Castlewood property. The easements on each bank of the Stray Horse Creek will help filter water entering the Big Sioux River.

WATERS

Continued from Front Page

located on a dairy, while the other is part of a land trust. Both parcels are owned by the Gerhold family.

Patrick Anderson, executive director of Northern Prairies Land Trust, said the easement allows the NPLT to make sure good environmental practices are being met.

"In this program people are paid up front for easements," Anderson said.

The finalizing of the sale involved a conference table and plenty of fancy documents.

Anderson and Jim Madsen, another NPLT member, explained the agreement one last time as the papers were signed and stamped.

"No tilling, breaking up grass, storage of machinery ... if there's grazing nearby there needs to be a fence," Anderson read from the contract.

Two thirds through the happening, the Gerhold's pastor stood up from the small audience and interjected: "On behalf of God and creation and everything, thank you."

Roger Strom, watershed project coordinator of the East Dakota Water Development District, said the easements help filter water that ends up in the river.

In a rain event, any water that leaves the crop or dairy land will pass through the easement's grass, which will filter nutrients that affect water quality, Strom said.

Strom said both groups are actively seeking to buy more easements from area landowners.

Anybody interested in creating a conservation easement can contact his office at (605) 688-6741 or the NPLT at (605) 882-5250.

FERTILIZER LABEL

Look for the Zero in the middle, 27- 0 - 4 the middle number represents the percent of phosphorus that is contained in the bag of fertilizer. The first number is the percent of nitrogen and the last number is the percent of potassium.

When You're Fertilizing the Lawn Remember You're NOT just Fertilizing the Lawn. A cooperative venture with the Water Quality Consortium

EAST DAKOTA WATER DEVELOPMENT DISTRICT

132 B AIRPORT AVENUE
BROOKINGS, SD 57006

Phone: 605-692-6741
email: edwdd2@brookings.net

KEEP THE GREEN OUT OF THE LAKES

USE ZERO PHOSPHOROUS FERTILIZER

ZERO PHOSPHORUS FERTILIZER - A SMALL STEP TO IMPROVE LAKE WATER QUALITY

Excessive algae can degrade lake use

Why is Phosphorus Bad for the Lakes? Phosphorus is a nutrient that stimulates plant growth. In a lake, excess phosphorus encourages algae growth. Too much algae causes scum to form on the lake's surface and harms water quality. As algae dies and decays, it looks and smells bad. It also uses up oxygen in the water that fish and other wildlife needs.

PHOSPHORUS (P)–Is an essential nutrient for grass growth. Quite often, lawns do NOT need supplemental phosphorus. In South Dakota the soil test result from the South Dakota State University Soil Testing Laboratory for 2004-2006 has the average going from 13 to 16 parts per million which is considered to be at a high range. In 2006 the average lawn sample had a reading of 28 ppm. Anything above 16 is considered in the very high range. At these levels supplemental P is a waste.

Algae Growth

Phosphorus often is the least plentiful nutrient in surface water supplies. According to different sources one pound of phosphorus can produce 500 pounds of algae. The potential for surface water pollution is high because of sources of phosphorus such as eroding soil particles, grass clippings and other organic matter can be carried into surface water supplies. It becomes apparent that we need to limit the amount of phosphorus.

How does "P" get into Lakes

Storm water and ground water carry phosphorus into the lake from a number of sources including:

-fertilizers from lawns, gardens or farming

-detergents

-failing septic tanks

-pet and livestock waste

-soil that erodes from bare ground—gardening, landscaping, farming and commercial development

Storm drains flow into creeks, rivers or lakes without any processing.

Clean Water Tips

-Before you apply fertilizer have soil tested. Follow the recommendations provided. Usually you can use ZERO PHOSPHORUS fertilizer without having any negative impacts. New grass seeding require higher nutrient levels and should be the only time when one should consider phosphorus fertilizer.

-Sweep up the leaves and grass clippings and put them in a compost bin or trash container.

Do not fertile before a storm.

-When fertilizing use a slow release or organic fertilizer.

-Sweep up spilled fertilizer or pesticides and apply them to the lawn. Never wash them into the street.

Read and follow the label instructions exactly.

-Pick up pet waste and flush it down the toilet or bag it and place it in the garbage.

-After washing your car or boat pour the bucket of soapy water down the drain NOT in the street. Or better yet go to the commercial car wash.

-Plant native plants - they often require less fertilizer and water.

East Dakota Water Development District

132 B AIRPORT AVENUE

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Payment Schedule

Payment will be a percentage of the Adjusted Assessed Land Value (AALV). An assessed value of the property will be obtained and corrected with a multiplier unique to each county.

Duration Years	CRP Time Remaining	% of AALV
30	0	80%
30	<5	75%
30	6-9	70%
30	>10	65
Perpetual	0	95%
Perpetual	<5	90%
Perpetual	6-9	85%
Perpetual	>10	80%

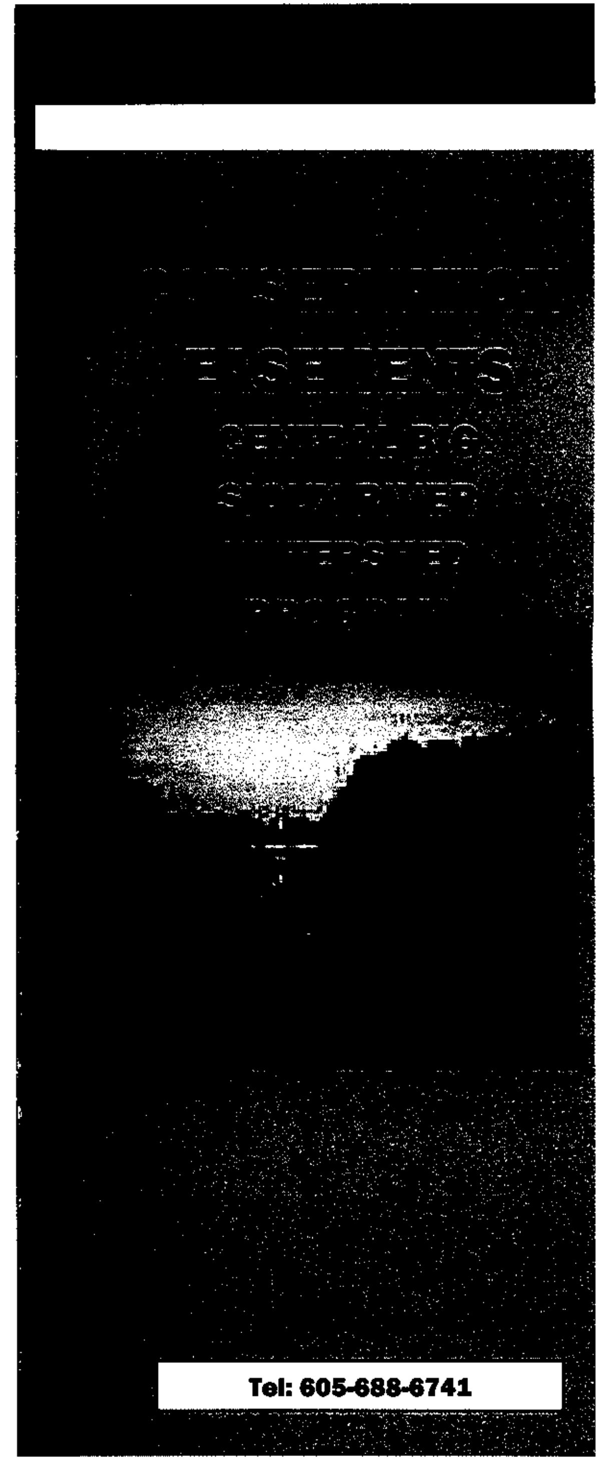
NORTHERN PRAIRIES LAND TRUST
401 e 8TH St. Suite 200B
Sioux Falls, SD 57103-7015
605-339-3184

NORTHERN PRAIRIES LAND TRUST

605 Third Avenue NW
Watertown, SD 57201
605-882-5250
www.northernpraries.org

EAST DAKOTA WATER DEVELOPMENT DISTRICT
132 B Airport Avenue
Brookings, SD 57006
Www.eastdakota.org

Phone: 605-692-6741
email: edwdd2@brookings.net



CONSERVATION EASEMENTS - CENTRAL BIG SIOUX WATERSHED PROGRAM

An example of damage done by cattle

The Big Sioux River Conservation Easement Program is designed to reduce Total Suspended Solids, TSS, and Fecal Coliform Bacteria, FCB, loading in the project area. Conservation Easements will be used to restrict or exclude livestock grazing and other farming practices in the riparian area along the Big Sioux River, BSR, and it's named tributaries.

-Land can be currently enrolled in the USDA Conservation Reserve Program (CRP).

-Easement duration: Thirty (30) years or Perpetual (permanent).

-Conservation Easements will be sought along the main stem of the Big Sioux River and named tributaries which are currently impaired.

-Priority Area: Big Sioux River, Jack Moore Creek, Flandreau Creek, Bachelor Creek, Split Rock Creek, Beaver Creek, Pipestone Creek and Skunk Creek.

-The land offered must currently be used as grazing land for livestock or cropped up to stream bank. Land which is currently maintained as a good riparian area will be considered a lower priority.

-The Riparian buffers developed by the easement will be a minimum of seventy-five (75) and a maximum of one hundred-fifty (150) feet from the river or stream bank.

-The landowner will be required to follow a conservation plan which will be provided by NPLT.

-Under the conservation plan, management of the land under the conservation easement will be outlined. Some type of maintenance on the vegetation will be required.

-Northern Prairies Land Trust (NPLT) will hold the easement.

An example of a protected stream bank

-If the adjacent land is being grazed by livestock then the landowner will be required to fence the area to prevent destruction of the grass cover. Fencing material may be provided by South Dakota Game Fish and Parks and a portion of the cost of construction will be reimbursed by the project. This will be addressed on an individual bases.

132 B Airport Avenue
Brookings, SD 57006

Phone: 605-692-6741
email: edwdd2@brookings.net

Rental Rates Used

Brookings—$60.00

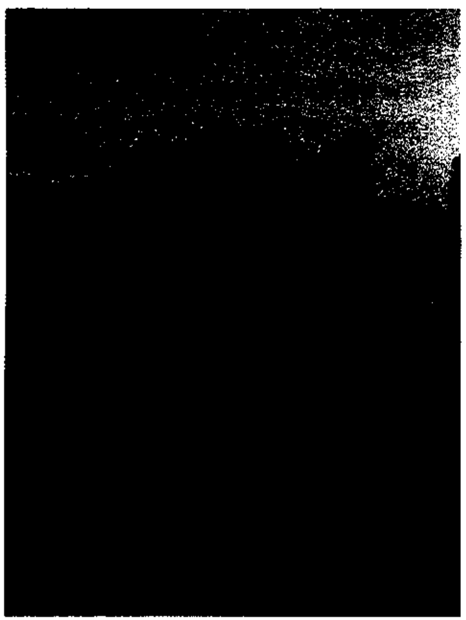
Codington—$58.00

Deuel—$58.00

Hamlin—$58.00

Minnehaha—$66.00

Moody—$66.00



Contact the office where the property is located or EDWDD

Brookings Conservation District
605-692-8003 X 3
Codington Conservation District
605-882-4989
Deuel County Conservation District
605-874-8225 X 3
Hamlin County Conservation District
605-783-3353
Minnehaha Conservation District
605-882-5250 X 3
Moody County Conservation District
605-997-2949 X 3

EDWDD
EAST DAKOTA WATER DEVELOPMENT DISTRICT
132 B Airport Avenue
Brookings, SD 57006
www.eastdakota.org

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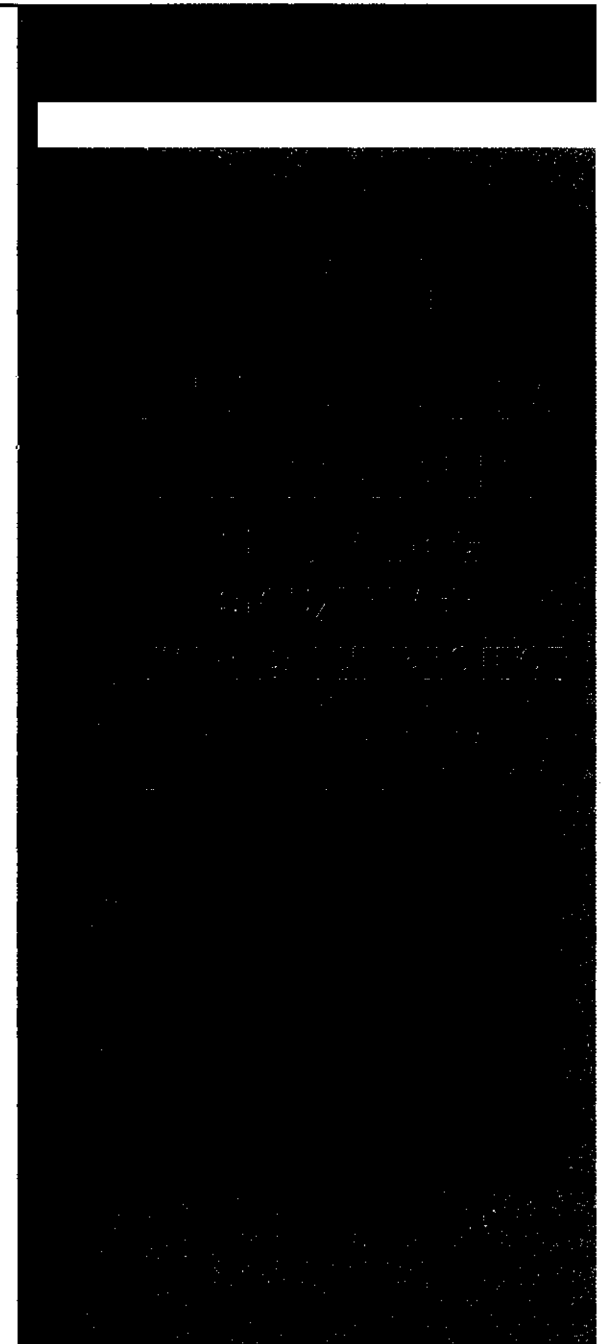

Tel: 605-688-6741

RIPARIAN AREA MANAGEMENT (RAM) - CENTRAL BIG SIOUX WATERSHED PROGRAM

An example of damage done by cattle.

The Big Sioux River Riparian Area Management Program (RAM) is designed to reduce Total Suspended Solids, TSS, and Fecal Coliform Bacteria, FCB, loading in the project area by ensuring that tracts of land not eligible for a USDA Conservation Reserve Program (CRP) program become protected as riparian buffer areas

-Priority Area: Big Sioux River, Bachelor Creek, Beaver Creek, Flandreau Creek, Jack Moore Creek, Pipestone Creek, Split Rock Creek, and Skunk Creek.

-Current land use: The area is actively grazed or cropped adjacent to the stream bank.

-The landowner is encouraged to seek funding from the USDA CRP. This program is only for land which is not eligible for a USDA program.

An example of a protected stream bank.

-This program can be used to round out a field when a small portion of the land does not qualify to be enrolled in CRP.

-RAM contract duration: Ten (10) to fifteen (15) years depending on the length of the current CRP contract.

-If the field does not qualify for CRP but fits the other criteria it may be enrolled. The maximum length of the contract will be fifteen (15) years.

-The landowner will be requires to follow a conservation plan for the tract of land enrolled in the RAM Program. This will be provided to the landowner by the conservation district.

-The landowner will be assessed penalties by the holder of the RAM contracts if the landowner is found to be not following the conservation plan for the land under contract.

-If the adjacent land is being grazed by livestock then the landowner will be required to fence the area to prevent destruction of the grass cover. Fencing material may be provided by South Dakota Game Fish and Parks and a portion of the cost of construction will be reimbursed by the project. This will be addressed on an individual bases.

-Financial assistance may be provided for watering the livestock. This to will be determined on each individual project.

-The landowner will be paid fifty percent of the contract amount at the end of the first year. The following years they will receive one half of the rental rate times the number of acres. The last year of the contract they will receive the balance of the contract.

East Dakota Water Development District

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Brookings, SD 57006

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email: edwdd2@brookings.net

@ARGUSLEADER.COM
Argus Leader
FRIDAY, SEPT. 4, 2009 SIOUX FALLS, SOUTH DAKOTA

Easements aim to raise quality of river water

Renner couple first in county to put land in Big Sioux program

BY THOM GABRUKIEWICZ
tgabrukiew@argusleader.com

A Renner couple are the first people to grant a conservation easement on land they own in Minnehaha County to protect the shoreline and improve water quality along the Big Sioux River.

Jerry and Carol Ward of rural Renner granted a 16-acre easement to Sioux Falls-based Northern Prairies Land Trust under the Big Sioux River Conservation Easement Program.

The Wards agreed to limit certain uses on the land, including tilling crops or allowing livestock access to the river, which can affect water quality.

In return, they'll get paid to leave the land in a natural state, with trees and native grasses.

MORE ONLINE

For more information on the easement program, visit Northern Prairies Land Trust at www.northernprairies.org/tools.htm.

"This was the right thing to do for our children and grandchildren," said Jerry Ward.

The hope is to get all the landowners who border the Big Sioux and its major tributaries to sign on as well, said Roger Strom, watershed project coordinator with the East Dakota Water Development District. That would create miles of grassy buffer so that when erosion happens, silt and soils get trapped in the grass, leaving the

See **EASEMENTS**, Page 4A

Easements: Hamlin County sets pace

Continued from 1A

water clean as it enters the river.

The Big Sioux suffers greatly from two water quality problems that can limit the waterway's beneficial uses such as swimming or paddling, said Pat Anderson, executive director of the Northern Prairies Land Trust. Suspended solids, including dirt from tilling too close to the shore and fecal coliform contamination from animal waste, can lead to water issues downstream. Sioux Falls taps the Big Sioux for its municipal water supply.

"In some cases, it can apply to feedlots that are too close to the bank as well," Anderson said. "Doing these deeds adds to the water quality of the Big Sioux."

The voluntary program uses federal money distributed by the South Dakota Department of Environment and Natural Resources to local sponsors. East Dakota Water Development District is the primary sponsor for the Big Sioux Watershed.

WHAT IT IS

LEGAL TOOL: An easement is a tool used by landowners to preserve natural and open space values on their land. It is a voluntary, legal agreement between a landowner and an organization that spells out what land-use practices are consistent with the landowners' wishes. To get favorable tax treatment, easements usually are granted in perpetuity.

The money is used to buy perpetual and 30-year easements. The amount a landowner receives is based on a standard formula based on the assessed value of the land plus a county-by-county multiplier.

"It's a standard formula set by the U.S. Fish and Wildlife Service, and I believe it's worth it for farmers to deed these strips of land," Anderson said. "We're not talking about big blocks of land here."

The easements are limited to a band of land that's about 100 feet wide, adjacent to the river or its major tributaries. This allows farmers and ranchers to keep working their land, yet improve water quality by not disturbing the shoreline with livestock or allowing silt to enter the waterway through erosion.

The program started in 2005, and the Trust locked up its first easement in 2007 outside of Minnehaha County, Anderson said.

"It took us some time to work the bugs out," he said.

It's been very popular in Hamlin County, where seven Big Sioux River conservation easements are in place and several other applications are waiting to be processed.

"I think there will be more and more interest as we move forward," Anderson said. "Farmers are certainly talking about it."

Reach Thom Gabrukiewicz at 331-2320.

Watertown Public Opinion <www.thepublicopinion.com> Saturday, September 5, 2009

Easement program expands

• Minnehaha County is giving it a try

SIOUX FALLS, S.D. (AP) — A conservation easement program along the Big Sioux River is moving into Minnehaha County.

The program has been popular in Hamlin County, where seven easements are in place and several others are waiting to be processed. Now, a Renner couple has become the first in Minnehaha County to grant an easement.

The easements are aimed at protecting the shoreline and improving water quality along the Big Sioux. Landowners are paid to limit certain uses of the land such as crop tillage and to prevent livestock from having access to the river. The easements are limited to a strip of land that is about 100 feet wide.

The voluntary program uses federal money distributed by the South Dakota Department of Environment and Natural Resources. The East Dakota Water Development District is the primary sponsor for the Big Sioux Watershed.

Property owners sign easements

• They'll help keep the Big Sioux River clean

By Joe O'Sullivan
Public Opinion Staff Writer

BROOKINGS — Three more property owners in December sold shoreline into easements that should help keep the Big Sioux River clean.

The properties are all in Hamlin County, according to Roger Strom, watershed project coordinator for the East Dakota Water Development District (EDWDD).

The easements add 120 acres and over seven miles of buffer to the Big Sioux River and some of its tributaries. It also proves a boon to the sellers. Strom said about $200,000 was paid to the three families.

It works like this: strips of land between 100 and 120 feet along the river or its tributaries are purchased with a lump sum under a 30-year or lifetime plan. For the most part, the grassland cannot be altered. The payoff is that the strips work like a buffer, filtering water that runs off from farms.

"If you go out there after a heavy rain, you see a corn field and a bean field and you get a two-inch rain," he said. "There's a lot of water and dirt and material moving with that water ... that grass strip serves as a filter system."

What the easements are filtering is nutrients like phosphorous, found naturally and in fertilizer that can turn water green and create algae blooms, which in extreme cases kill fish.

Courtesy Photo

From left are Roger Strom, watershed development director of the East Dakota Water Development District; Curtis Eggers, chairman EDWDD board; Carolyn Johnson, trustee of the Robert E. Johnson Family Bypass Trust; and Jim Madsen, Northern Prairies Land Trust in Brookings on Tuesday. Johnson put a tract of Hamlin County shoreline into easement to help protect waters flowing into the Big Sioux River.

The thin parcels of land add up to a chunk of shoreline. One of the new easements contributes over 8,500 feet of shoreline in a 32-acre tract.

Two of the new easements are located on tributaries of the Big Sioux River, one on Stray Horse Creek, another on the tributary that runs between the river and Lake Poinsett, where the set of contentious flood gates lies. The third easement is on a stretch of the river, just south of Castlewood.

The transactions bring five new easements for a total of over 420 acres into the protection program, according to Strom. The project's goal is 500 acres, and he said another easement in the works will bring EDWDD close to its goal.

"Within the time period of our project, we're going to be reaching or exceeding our goal of 500 acres," Strom said.

The EDWDD develops the easements with the Northern Prairies Land Trust. The former group provides funding, both their own as well as federal dollars, while the latter surveys the land, works out the legal aspect and performs the annual inspection of the easement lands.

Easements help Big Sioux water

Program pays landowners to limit use

BY THOM GABRUKIEWICZ
tgabrukiew@argusleader.com

Three easements secured in Hamlin County will help improve water quality in the Big Sioux River and preserve the land surrounding it.

The easements are with the Sioux Falls-based Northern Prairies Land Trust under the Big Sioux River Conservation Easement Program. They add 117 acres and more than 3,700 feet of river and creek bank protection along the Big Sioux River.

The parcels include the Richard Beare Estate between Lake Poinsett and the Big Sioux River; property owned by Randy and Mary Hanson on Stray Horse Creek and the Big Sioux River; and the Robert Johnson Family Bypass Trust on the big Sioux River southwest of Castlewood.

The families agreed to limit certain uses on the land, including tilling crops or allowing livestock access to the river, which can affect water quality.

In return, they'll get paid to leave the land in a natural state, with trees and native grasses.

"I wanted to make sure it lasted forever," said Ronald Beare, who put his land into a perpetual easement. "It's good for wildlife, we'll be planting trees on part of it, we can still hunt on it and I can picture what it'll look like 10 years from now. It was a way for us to help protect our water quality."

The latest easements were secured in December and raise the number of protected parcels along the Big Sioux to 14.

"I think there's a need to protect water quality," said Pat Anderson, executive director of the Northern Prairies Land Trust. "We would like to see more activity all along the watershed."

The hope is to get all landowners along the Big Sioux and its major tributaries to sign easements as well, said Roger Strom, watershed project coordinator with the East Dakota Water Development District. That would create a grassy buffer so that when erosion happens, silt and soils get trapped in the grass and leave the water clean when it enters the river.

"We're not opposed to farmers producing crops or livestock," Strom said. "It's a compromise. It allows them to reduce impacts of tillage, of livestock on the water."

The voluntary program uses federal money that is distributed by the South Dakota Department of Environment and Natural Resources to local sponsors. East Dakota Water Development District is the primary sponsor for the Big Sioux Watershed.

The money is used to buy either perpetual or 30-year easements. The amount a landowner receives is based on the assessed value of the land plus a county-by-county multiplier.

"It's a way to protect the environment and get paid something to do so," Beare said. "It's not a windfall, but that land really isn't all that usable anyway."

The easements are limited to a band of land that's about 100 feet wide adjacent to the river or its major tributaries. The program began in 2005.

"A hundred feet on both sides of the river along a half-mile stretch is maybe 12 acres," Strom said. "Out of a quarter-section, 160 acres, that's 12 to 15 acres that can have a big impact on water quality."

Reach Thom Gabrukiewicz at 331-2320.

WHAT IT IS

An easement is used by landowners to preserve natural and open space values on their land. It is a voluntary legal agreement between a landowner and an organization that spells out what land-use practices are consistent with the landowners' wishes. To get favorable tax treatment, the easements are usually granted in perpetuity.

Online: Find out more about the program **@ARGUSLEADER.COM**

thePublicOpinion.com Watertown, SD
The best part of your day!

Easement deal reached

Posted: Tuesday, April 20, 2010 12:45 pm

LAKE POINSETT - The Big Sioux Watershed Implementation Project closed on a conservation easement April 15 for its largest track of land thus far in its Conservation Easement Program.

The easement, over 100 acres and located near the outlet for Lake Poinsett and the Big Sioux River, pushes the project to over 500 acres, according to Roger Strom of the East Dakota Water Development District. Before the last easement the project was up to 22 miles of protected shoreline, according to Strom.

Appendix 6

Central Big Sioux Implementation Grant Final Report

Grant Number 2006-CSW-022

The project was designed to assist the Central Big Sioux Implementation 319 Grant sponsored by East Dakota water Development District (EDWDD). The project area included the Central and Upper Big Sioux River and its tributaries. The Conservation Districts in the project area served as a local contact for landowners interested in the approved Best Management Practices (BMPs) to address water quality concerns.

District personnel attended four producer informational meetings to explain project goals and promote the BMPs to landowners and producers. News articles were published to increase public awareness of the project. Ranking meetings were held to prioritize projects.

A tour was held in July of 2007 with the assistance of the Moody County Extension Service, Moody County Weed Supervisor, SD Division of Resource Conservation and Forestry, and EDWDD. BMPs that had been implemented were shown with the main focus on riparian area buffers. Benefits of the riparian buffers are bank stabilization to reduce sediment and exclude or reduce livestock access to lower fecal coliform bacteria in the stream. Programs through the USDA Conservation Reserve Program (CRP), Central Big Sioux Project's Riparian Area Management (RAM) practice and easements through Northern Prairies Land Trust were explained to accomplish these benefits. The Moody County Weed Supervisor discussed weed control on grazing land and CRP land. The weeds that need most emphasis are Canada thistle, musk thistle, and leafy spurge.

A Riparian Area Management practice was developed to work with areas that did not qualify for the Conservation Reserve Program (CRP). Some CRP practices limit the amount of tree canopy along the river or streams. RAM would pick up these areas at the same rental rate. If landowner was not going to participant because CRP would not include the whole area, RAM would pay a comparable rate on the balance of the pasture but without the CRP incentives. A 15-year contract is offered with annual payments to the landowner. A conservation plan is developed to manage the RAM area.

The 8 RAM contracts signed cover 102.15 acres. To accomplish this practice participation the Districts made 64 landowner contacts and on site evaluations. Moody County Conservation District sent mailings to all the landowners who have land adjacent to the Big Sioux River in Moody County. Although the grant has expired District staff continues to work with landowners requesting assistance with applications for this practice.

The RAM contracts were in addition to 205.4 acres of the USDA Conservation Reserve Program CP30 Marginal Pastureland – Wetland Buffer practice. 22.4 acres also enhance a CP23 Wetland Restoration project.

Serving as a local contact for landowners, five Conservation Easements were signed with Northern Prairies Land Trusts to exclude livestock and stabilize stream banks along the Big Sioux River. 123.9 acres are included in these easements. Two easements are for 30 years and three are perpetual. The easements are located in Brookings, Hamlin, and Codington counties.

Four Alternative Water Sources were installed to provide livestock water source for animals excluded from riparian areas. Rural water hookups, nose pumps, and above ground pipeline were utilized to establish these systems.

Project failed to establish any grassed waterways, critical area shaping or seeding. This is may be due to current land, cash rent and crop price increases.

The district followed total cost estimates established by EDWDD 319 grant. These estimates exceeded actual needs of the project.

Project goal was to improve water quality by lowering fecal coliform bacteria and sediment in the Big Sioux River. The establishment of riparian buffers and rock crossings should prove to aid in this goal.

Central Big Sioux Grant
Grant # 2006-CSW-022

	RC&F			EPA 319			EDWDD			Local Match			USFWS			Totals		
	Budget	Expenses	Balance	Budget	Expenses	Balance	Budget	Expenses	Balance	Budget	Expenses	Balance	Budget	Expenses	Balance	Budget	Expenses	Balance
Salary and benefits	3400.00	1700.32	1699.68	#######	5101.04	51258.96	0.00	0.00	0.00		0.00	0.00				$59,760.00	$6,801.36	$52,958.64
Alternative Watering Sources	20000.00	4947.96	15052.04	0.00	0.00	0.00	10000.00	3203.34	6796.66	10000.00	7867.59	2132.41		641.21	-641.21	$40,000.00	$8,151.30	$31,848.70
Rock Crossings	11000.00	744.00	10256.00	0.00	0.00	0.00	9500.00	0.00	9500.00	9500.00	3728.00	5772.00				$30,000.00	$744.00	$29,256.00
Fencing												0.00	10000.00	0.00	10000.00	$10,000.00	$0.00	$10,000.00
Grass Waterways	2400.00	0.00	2400.00				1200.00	0.00	1200.00	1200.00	0.00	1200.00				$4,800.00	$0.00	$4,800.00
Critical Area Shaping	2400.00	0.00	2400.00				1200.00	0.00	1200.00	1200.00	0.00	1200.00				$4,800.00	$0.00	$4,800.00
Seeding	160.00	0.00	160.00				120.00	0.00	120.00	120.00	0.00	120.00				$400.00	$0.00	$400.00
Totals	39360.00	7392.28	31967.72	#######	5101.04	51258.96	22020.00	3203.34	18816.66	22020.00	11595.59	10424.41	10000.00	641.21	9358.79	$149,760.00	$15,696.66	$134,063.34

56360.

Conservation Management Plan

[redacted]

Minnehaha and Moody County, South Dakota

This Conservation Management Plan is hereby attached to and made part of the Deed of Conservation Easement granted by [redacted] (Grantor) to Northern Prairies Land Trust (Grantee) pursuant to Big Sioux River Conservation Easement Program. The primary purposes of the Conservation Management Plan are to preserve and enhance water quality in the Big Sioux River and major tributaries and to provide wildlife and plant habitat.

The Conservation Management Plan includes the following terms:

1. Grazing livestock in the Easement Area is not permitted.
2. Tilling or breaking up the soil or grass cover in the Easement Area is not permitted, including digging associated with potential placement of structures, drainways, or drainage pipes. Grantors and Grantee acknowledge there is an existing drainage pipe in Section 36, Moody County. This pipe is allowable, but no expansion of the existing pipe and no additional pipes are allowed.
3. Dumping of manure, human waste, or any other substance defined, listed, or otherwise classified pursuant to any federal, state or local law, regulation, or requirement as hazardous, toxic, polluting, or otherwise contaminating to the air, water, or soil, or in any way harmful or threatening to human health or the environment is prohibited.
4. The boundaries between the Easement Area and the remainder of the Property shall be marked as follows:
    i. Where the Property adjacent to the Easement Area will be used for grazing livestock, there must be a well-maintained fence consisting of either four strands of barbed wire or three strands of electrically charged high tensile electric fencing.
    ii. Where the Property adjacent to the Easement Area will be utilized for any use other than grazing livestock, boundary may be marked by steel fence posts with a fluorescent orange marking or another suitable marker. Property owners agree that if any portion of the adjacent Property is converted to livestock grazing in the future, Property owners will: first, provide a minimum of 30 days notice to Northern Prairies Land Trust of this change in use, as outlined in the Conservation Easement and; erect a fence of either four strands of barbed wire or three strands of electrically charged high tensile electric fencing prior to allowing cattle to graze on that portion of the Property. Property owners understand that this required fencing will be at their own cost and responsibility.
    iii. Property owners remain responsible for maintaining an accurate Easement Area boundary. If the land next to the Easement Area is tilled or grazed, and there are infringements into the Easement Area, Grantee Northern Prairies may, solely in its own discretion, may require a fence as outlined above. Under these circumstances, Property owners are required to erect a fence at their own cost.

5. Long-term storage of any machinery or tanks which have the potential to leak petroleum products, or other hazardous, toxic, polluting, or potential contaminating substances, is not allowed in the Easement Area.
6. The Property owners agree to maintain grass cover in the Easement Area and, if reseeding is necessary, the Easement Area will be seeded with native grass seed, or other plant seeds as agreed to by Northern Prairies Land Trust.
7. Maintenance of a grass cover is vital to preserving and enhancing the water quality of the Big Sioux River. Consequently, cutting of hay or other grasses, burning, or grazing in the Easement Area will not be allowed, except by written permission from Northern Prairies Land Trust. It is recognized that it may be necessary to revitalize the grass cover at some point. Cutting hay or grasses may be allowed by written permission of Northern Prairies, but only after July 15 of any year. Likewise, burning will only be allowed by written permission of Northern Prairies after a request by the property owner. Property owner bears all responsibility and potential liability for any burns conducted on the property. It is not anticipated that cutting of hay or grasses, or burning will be done on a yearly basis. Also, intensive grazing in early spring-time may be appropriate to control certain cool weather grasses. Grazing may be allowed only with prior approval by Northern Prairies and adequate fencing to keep livestock out of the Big Sioux River.
8. If the Easement Area or Big Sioux River is altered by forces of nature, including beaver dams, Property owners retain the right to take appropriate, lawful action to address the alterations. However, any action taken by Property owners is subject to the terms of the Deed of Conservation Easement.
9. Property owners are responsible for weed control. Property owners may utilize agri-chemicals to control weeds provided that such chemicals are safe for use around water, such as Milestone or 2,4,D Aquatic.
10. Property owners will continue to control access to the Property and Easement Area, subject to the provisions of the Deed of Conservation Easement. Property owners retain all other rights and uses of the Property which are consistent with the terms of the Deed of Conservation Easement and this Conservation Management Plan.
11. The Grantor and Grantee further recognize that this Conservation Easement is a restriction on the exercise of the mineral rights. If the Grantor seeks to exercise his mineral rights at some point in the future, Grantor agrees to exercise his mineral rights only in a manner which will not negatively impact the easement area or the Big Sioux River. Also, Grantor agrees, to the best of his ability, to require any other holder of mineral rights to exercise those rights only in a manner which will not negatively impact of the Easement Area or the Big Sioux River.

Print Form

Grant #

Department of Agriculture

Division of Resource Conservation & Forestry

Grant Application Form

APPLICANT INFORMATION:

Organization	Moody County Conservation District	Mailing Address	202 E. 3rd Ave.
Telephone	(605) 997-2949 ext.#3	City, State, Zip	Flandreau, SD 57028
Tax Status	Government Agency	Tax ID or SSN:	46 6000127

A copy of the State-required W-9 form must be attached

Project Contact:

Project Officer	John Hay	Telephone	(605) 997-2949 ext.#3
FAX	(605) 997-5132	E-mail:	john.hay@sd.nacdnet.net

PROJECT INFORMATION:

Project Name: Central Big Sioux River Implementation

Start Date: 7/01/06 End Date: 6/31/08

Legal Description: County: Moody

Township: Range: Section: Quarter: Quarter:

TYPE OF GRANT:

- (●) Conservation Grant
- ( ) Urban & Community Foresty
- ( ) Forest Land Enhancement (FLEP)
- ( ) Invasive Species
- ( ) Forest Stewardship (FSP)
- ( ) Other Specify
- ( ) Living Snow Fence
- ( ) Insect/Disease
- ( ) CTEP

FINANCIAL INFORMATION:

Grant Funds Requested: 54,800.00 Partner Contributions (total): 110,400.00 Total Project Cost: 165,200.00

Please give a brief, descriptive summary of the project. (Use section "D" to provide project detail)

This grant request is to supplement the current sec 319 funds that have been authorized for the North Central and Central Big Sioux River Watershed Project- Segment 1/Part1. Portions of six conservation districts (Codington, Hamlin, Deuel, Brookings, Lake, Minnehaha), and all of Moody County Conservation District are included in the project area. These supplemental funds will be used to provide technical assistance and cost share dollars to establish alternate water sources and rock crossings in the riparian areas within the project area.
See Attatchment

I hereby certify that to the best of my knowledge and belief, this application is true and correct. I further agree to comply with the provisions of the Civil Rights Act of 1964 and regulations issued there under relating to nondiscrimination in federally assisted programs.

APPLICANT SIGNATURE: ______________________ ______________________ __________

Authorized Signature Title Date

For Division Use Only:

Reviewed by: ______________________ ______________________ __________

Signature Title Date

Approved by: ______________________ ______________________ __________

Signature Title Date

77

BUDGET SHEET

The total for each of these three sections should equal the "Total Project Costs" on page 1

A. OPERATING BUDGET

1. Salary/Benefits	75,200.00
2. Travel	
3. Contractual Services	90,000.00
4. Supplies	
5. Equipment (list major equipment)	
6. Consultant Services	
Total Project Costs	**165,200.00**

This total must equal 165,200.00

B. ACTIVITY BUDGET

Activity	Grant Funds	Local Funds	Local In-Kind	Other Funds	Total
1. Salary	18,800.00			56,400.00	75,200.00
2. Alternative Water Sources	20,000.00	20,000.00			40,000.00
3. Rock Crossings	16,000.00	24,000.00			40,000.00
4. Fencing				10,000.00	10,000.00
5.					0.00
6.					0.00
7.					0.00
8.					0.00
9.					0.00
TOTALS	54,800.00	44,000.00	0.00	66,400.00	165,200.00

165,200.00 This total must equal

C. PROJECT PARTNERS: Please list the names of all project partner organizations, the value of their contribution, and indicate whether the contribution is cash or in-kind.

Partners	Amount Cash	Amount In-Kind	Total Cost
1. RC&F	54,800.00		54,800.00
2. EPA 319	56,400.00		56,400.00
3. EDWDD	18,000.00		18,000.00
4. Local Landowner	26,000.00		26,000.00
5. USFWS	10,000.00		10,000.00
6.			0.00
7.			0.00
TOTALS	165,200.00	0.00	165,200.00

165,200.00 This total must equal

SUBMISSION:

Please mail one complete application, including any attachments, to:

SD Department of Agriculture
Resource Conservation & Forestry
523 E. Capitol Avenue
Pierre, SD 57501-3182

SECTION D -- Additional Information Required

PROJECT NARRATIVE INSTRUCTIONS: (Total narrative should not exceed three pages of single-spaced text. Please attach any maps, figures and or photographs you feel are valuable in explaining the project.)

INSTRUCTIONS

Complete the following section for Coordinated Soil & Water Conservation Grants

NOTE: Any practice funded by the Coordinated Soil & Water Conservation grant funds must meet one or more goals of the Coordinated Soil & Water Conservation Plan.

D. Project Description and Need

- Explain who will be the primary beneficiaries of this project (who will receive the benefits when this project is complete)
- Define who will be responsible for the implementation, maintenance and follow-up stages of the project
- Indicate where this project will be located (district, watershed, community, etc. Attach map(s) as relevant).
- Describe the specific environmental, natural resource, ecological, educational and/or socio-economic need(s) the projects will address
- Briefly describe the specific on-the-ground restoration activities to be undertaken on-site to achieve the project objectives, and why it is needed
- Explain if this project is part of a larger regional and/or local watershed effort
- Describe provisions to ensure long-term management and protection of the project (e.g., conservation easements on private land, long-term monitoring program)
- Please indicate if any federal, state or local permits are required to complete the project and the status of efforts to secure necessary authorization

E. Final Products

- Describe the anticipated benefits of the project from an ecological, educational, and/or socio-economic perspective (e.g., number of acres of wetlands or stream miles restored, target audience and how they will benefit)

F. Partner Justification

- Describe the strengths, qualifications and nature of the contribution of your organization and other collaborating organizations

G. Identify how you will measure the success of the project.

Complete the following section for Urban & Community Forestry Grants

Project Description and Need

- The Tree City USA program is very valuable to South Dakota and will be taken into consideration when awarding grants. Communities that are already a Tree City USA or working on becoming a Tree City USA will be given a higher priority using a ranking system developed by the Urban community Forestry Advisory Council. For more information, contact the Division of Resource Conservation and Forestry.
- To be eligible for a grant, you <u>must seek professional advice</u> from the Division of Resource Conservation & Forestry or a qualified consultant. This is to help ensure the soil and tree species selected for planting are compatible. ****Please include this information in the proposal.*****
- Define who will be responsible for the implementation, maintenance and follow-up stages of the project. Participation from clubs, groups and other volunteers is MANDATORY. List possible volunteers and who will be supervisiing the project.
- Tree species selected must be 1 1/4 inch cliper minimum. Include list of tree species along with cost estimates. **Ash trees are only allowed with permission from the Division of Resource Conservation & Forestry.
- Explain who will be the primary beneficiaries (who will receive the benefits when this project is complete).
- Indicate where this project will be located (community, area, district, etc. Attach maps as relevant).
- Briefly describe the specific activities to be undertaken to achieve the project objectives. Why is it needed?
- Describe provisions to ensure long-term management and protection of the project.
- All projects require a 50/50 match which can be in the form of in-kind labor and materials, or a combination of in-kind and hard cash match. This must be shown in above application.
- Grants are provided for purchasing trees and mulch. All labor and supplies to plant trees may be used as match.
- Projects must be on public lands.

The following are Requirements for the Forest Land Enhancement Program (FLEP)

- The undersigned owner of non-industrial private forestlands hereby requests cost-share assistnace from the Forest Land Enhancement Program administered by the South Dakota State forester, to complete the practices described above, and acknowledges that completing this application will not obligate the State of South Dakota or State Forester to provide assistance.
- Owner promises to complete all practices according to the specifications in the practice plan for the practice area as approved by the State Forester.
- Owner promises to maintain these practices for a minimum of 10 years from the date of completion.
- Upon completion of this practice owner agrees to provide the State proof of expenses by submitting a copy of a receipt, invoice or other written document itemizing costs incurred.
- Owner agrees there will be no payment to the owner until such proof, along with a signed "Certification of Practice completion" has been received by the State, and the practice has been certified complete by the State Forester.
- Owner hereby authorized representatives of the State to enter, after reasonable notice, at reasonable times, and in a reasonable manner, the practice area throughout the lifespan of the practice.
- Owner certifies that no work has started on the practice and will not begin before receiving written approval from the State Forester.
- Owner's representations herein shall be binding on all of owner's heirs, successors and assigns.

- **Non-Compliance Recapture Provisions:** When landowners receive payment, they agree to refund all or part of the cost-share assistance paid to them if, before the expiration of the maintenance period, they:
  A. Destroy the approved practice, or
  B. Voluntarily relinquish control or title to the land on which the approed practice has been established and the new owner/operator of the land does not agree in writing to properly maintain the practice for the remainder of the lifetime.

  ** **Exception:** The involuntary loss of control or ability to maintain a practice due to easements, condemnations or local ordinances enacted after the practice was established. Such exceptions must be approved by the State Forester.

The following are requirements for the Living Snow Fence Grant Program (LSF)

- The living snow fence program is very valuable to South Dakota, for the purpose of reducing highway maintenance costs, providing greater service to the traveling public and promoting conservation.
- To be eligible for a grant, you must have a state Department of Transportation Engineer or County Highway Superintendent declare the area as a snow problem area, and seek professional advice from the Division of Resource Conservation and Forestry, or qualified consultant.
- All grants will need a written Forest Management Plan dealing with site description, resource values, recommended management practices, and projected costs. A Division of Resource Conservation and Forestry service forester will review all Forest Management Plans written by consultants.
- Indicate whether LSF is along a federal aid highway or county/township highway.
- Briefly describe needed site preparation, cost, and who is responsible.
- Briefly describe if fencing is needed, cost, and who is responsible.
- Attach tree planting design and species selection.

- Briefly describe how long maintenance is needed, type of maintenance, and who will perform maintenance.

- The living snow fence program is very valuable to South Dakota, for the purpose of reducing highway maintenance costs, providing greater service to the traveling public and promoting conservation.

Summary of project continued:
The projected Coordinated Soil and Water Conservation Grant funds needed for the two year project are as follows:

	CSWC	LANDOWNER	EDWDD	319	USFWS
Alternate Water Sources (10ea)	$20,000.00	$10,000.00	$10,000.00		
Rock Crossings (8ea)	$16,000.00	$16,000.00	$8,000.00		
Technical assistance	$18,800.00			$56,400.00	
Fencing					$10,000.00
	$54,800.00	$26,000.00	$18,000.00	$56,400.00	$10,000.00

We are requesting $27,400 from the Coordinated Soil and Water Conservation Grants program for the first year's anticipated costs to accomplish these practices.

D. Project Description and Need

The Central Big Sioux River is a 10-year TMDL implementation strategy that will be completed in multiple segments. The project will restore and/or maintain the water quality of the Big Sioux River and it's tributaries to meet the designated beneficial uses. The project assessment identified various segments of the Big Sioux River and certain tributaries as failing to meet designated uses due to impairments from total suspended solids and/or fecal coliform bacteria.

Conservation Districts (CD) in the project area (east central South Dakota along the Minnesota/South Dakota border) will be responsible for the promotion and technical assistance to implementation of Best Management Practices (BMPs) funded by this grant. Moody County Conservation District will be responsible for the administration of the grant. These CDs will also assist East Dakota Water Development District with the EPA 319 Central Big Sioux Implementation Grant.

E. Final Products

The implementation of BMPs in the project area will reduce fecal coliform bacteria and sediment loadings the Big Sioux River and its tributaries.

F. Partner Justification

The seven conservation districts will work in partnership with East Dakota Water Development District (EDWDD), US Fish and Wildlife Service (USFWS) and SD Department of Environment and Natural Resources (SD DENR). EDWDD will administer the EPA 319 Grant from the SD Department on Environment and Natural Resources. US Fish and Wildlife Service has committed financial support for fencing of riparian areas.

G. Project Success

EDWDD will conduct water quality monitoring to assess project impacts on impaired water bodies.

Appendix 7

Watershed Physical Processes Research Unit
National Sedimentation Laboratory
Oxford, Mississippi

ANALYSIS OF BANK STABILITY AND POTENTIAL LOAD REDUCTION ALONG REACHES OF THE BIG SIOUX RIVER, SOUTH DAKOTA

By Natasha Bankhead and Andrew Simon

National Sedimentation Laboratory Report Number 64

January 2009

ANALYSIS OF BANK STABILITY AND POTENTIAL LOAD REDUCTION ALONG REACHES OF THE BIG SIOUX RIVER, SOUTH DAKOTA

Prepared by

U.S. Department of Agriculture – Agricultural Research Service

National Sedimentation Laboratory

Watershed Physical Processes Research Unit

For

East Dakota Water Development District

January 2009

ANALYSIS OF BANK STABILITY AND POTENTIAL LOAD REDUCTION ALONG REACHES OF THE BIG SIOUX RIVER, SOUTH DAKOTA

ARS Designated Representative and Project Manager:

Andrew Simon

Technical Direction, Data Analysis:

Andrew Simon and Natasha Bankhead

Report Preparation:

Natasha Bankhead and Andrew Simon

Mapping and GIS
Danny Klimetz

Field Data Collection and Data Processing:

Danny Klimetz, Brian Bell, Lauren Klimetz, Ibrahim Tabanca and Lee Patterson

EXECUTIVE SUMMARY

Excessive erosion, transport, and deposition of sediment in surface waters are major water quality problems in the United States. The 1996 National Water Quality Inventory (Section 305(b) Report to Congress) indicates that sediments are ranked as a leading cause of water-quality impairment of assessed rivers and lakes. The study reach, and several of its tributaries, has a history of exceedance of the Total Suspended Solids water quality standard. Observations along the study reach of the Big Sioux River investigated in this report (extending from 131.36 km upstream of the mouth of the Big Sioux River, to approximately 431 km upstream of the mouth) have indicated that the river's streambanks could be a significant source of the suspended sediment that is an issue along certain reaches of this river. Indeed, significant portions of the study reach were estimated to have greater than 50 % of their banks failing in analysis carried out as part of this report. The main objective of this study, therefore, was to determine rates and loadings of sediment from streambank erosion along main stem reaches of the Big Sioux River, SD.

Bank stability and toe erosion analysis was carried out using the model BSTEM, at five study sites along the study reach, for a range of percentile flow years (90^{th}, 75^{th}, 50^{th}, 25^{th} and 10^{th}). These model results showed that predicted eroded volumes of sediment emanating from streambanks decreased non-linearly from the 90^{th} percentile flow year to the 10^{th} percentile flow year. Predicted volumes of sediment eroded from the streambanks at each site ranged from 169 to 1359 m^3 of sediment per 100 m reach during the 90^{th} percentile year, under existing conditions where the banks have a cover of native grasses. These volumes of eroded sediment were predicted to fall to 0 to 21 m^3 per 100-m reach during the modeled 10^{th} percentile flow year, again, assuming a cover of native grasses.

Bank failures were generally only predicted to occur during the 90^{th} percentile flow year modeled at each site, indicating that during lower percentile flow years, hydraulic scour at the bank toe was the predominant erosion process, rather than mass wasting of the banks by geotechnical failure. It therefore followed, that the addition of toe protection (up to 1m) to banks with existing native grass cover greatly reduced the volume of bank material predicted to erode at each site during an average annual flow year (calculated by appropriately weighting the loadings from each percentile flow year), by protecting the base of the banks from hydraulic scour and thus over-steepening. Further to this, model runs indicated that even when the contribution to total erosion from toe scour was not that great (for example, only 16 to 50 % of total erosion came from toe scour during years where bank failures did occur), if the toe scour was prevented, the overall volume of eroded bank material was reduced by 87 – 100 %.

Contributions of sediment from streambank erosion along the study reach of the Big Sioux River were found to be in the range of 10 – 25% of the total suspended-sediment load. Average, annual contributions of sediment from streambank erosion for the entire study reach (6,340 T) were shown to be about 15%. During a particularly wet, high-flow year as occurred in 1994, streambank contributions were consequently greater (27,000 T), comprising 25% of the total suspended-sediment load over the 300 km study reach. The data further indicated that streambank contributions were generally greater in the lower half of reach than average, annual bank contributions upstream of Brookings and at the 90th percentile flow were about 16% and 10%, respectively.

The relative contribution of streambank loadings to total suspended-sediment transport rates along the Big Sioux River was found to be significantly lower than reported for incised streams in some other parts of the United States where streambank contributions can be in the range of 60-80% (Simon and Rinaldi, 2006). The results reported in this study of the Big Sioux River are, however, supported by a number of observations and findings. First, the iterative simulations conducted in this study showed only a single episode of failure in any given flow year modeled, even under the non-vegetated condition. Second, the relative contribution of streambank loadings is in general agreement with those estimated for the South Branch of the Buffalo River nearby in southwestern Minnesota (Lauer *et al*., 2006). Finally, the average, annual suspended-sediment yields derived for the Brookings and Dell Rapids gages are 2.8 and 3.7 T/y/km^2 respectively, and are within the range of moderately unstable streams in the region (Klimetz *et al*., 2009) where the inter-quartile range is 0.8 to 7.9 T/y/km^2.

The final part of this report investigated the effect of extrapolating the iterative modeling results over the 300 km length of the study reach, for the mitigation strategies tested. As expected, the bare-bank simulations displayed greater average, annual loadings along the entire study reach, with total loadings of 503,000 m^3 (8,810 T). The effect of top-bank grasses (or an assemblage of grasses and young cottonwood trees) was a reduction in average, annual streambank loadings of 28% (to 362,000 m^3 or 6,340 T); 20% for the 90th percentile flow. The addition of bank-toe protection to the grassed bank resulted in a huge total reduction in average, annual loadings (from the bare-bank case) of 97% (to 15,200 m^3 or 267 T). The important role of toe protection was further apparent by comparing the difference in streambank loadings between the bare-bank case and the mitigation strategy that incorporated toe protection alone. Here, average, annual streambank loadings were reduced 51% from 503,000 m^3 (8,810 T) to 243,000 m^3 (4,250 T); 84% for the 90th percentile flow. Without question, however, this strategy represents the most expensive option simulated as toe protection using rock or large wood would have to be obtained and placed along most of the outside bends.

TABLE of CONTENTS

LIST of FIGURES

LIST of TABLES

1. INTRODUCTION, PROBLEM STATEMENT and PROJECT OBJECTIVES

Excessive erosion, transport, and deposition of sediment in surface waters are major water quality problems in the United States. The 1996 National Water Quality Inventory (Section 305(b) Report to Congress) indicates that sediments are ranked as a leading cause of water-quality impairment of assessed rivers and lakes. Impairment by sediment can be separated into problems resulting from chemical constituents adsorbed onto the surface of fine-grained sediments (sediment quality), problems resulting from sediment quantities (clean sediment) irrespective of adsorbed constituents, and alteration of substrate (bed material) by erosion or deposition. The maximum allowable loadings to, or in a stream or waterbody that does not impair designated uses has been termed the "TMDL" (total maximum daily load). The study reach has a history of exceedance of the Total Suspended Solids water quality standard. The 2008 Integrated Report listed the Big Sioux tributaries, Beaver and Stray Horse Creek, as impaired due to TSS. The 2006 Integrated Report listed another Big Sioux tributary, Split Rock Creek as being impaired by TSS. The main stem of the Big Sioux River itself has also been listed as impaired in past reports; the 2004 Integrated Report indicated that the reach on the Big Sioux from Volga to Dell Rapids was impaired for TSS, and the 2002 report listed the reach from Volga to Baltic as impaired also. The 2002 and 2004 listings used data from the period of high flows in the Big Sioux Basin during the late 1990's, while the 2004, 2006 and 2008 listings used data from the low flow period in the early 2000's. Observations along the study reach of the Big Sioux River investigated in this report (extending from 131.36 km upstream of the mouth of the Big Sioux River, to approximately 431 km upstream of the mouth) indicated that the river's streambanks were a potential source of a significant proportion of the sediment causing this suspended sediment issue.

1.1 Overall Objective of this Study:

To determine rates and loadings of sediment from streambank erosion along main stem reaches of the Big Sioux River, SD.

1.1.1 Specific Project Objectives:

1. Model the major controlling processes responsible for bank erosion along the Big Sioux River, SD, using the Bank-Stability and Toe-Erosion Model (BSTEM) developed by the USDA-ARS, National Sedimentation Laboratory. Geotechnical tests of five representative banks will be conducted to determine appropriate input parameters for the modeling effort.

2. Simulate the magnitude of potential load reductions that can be obtained using various mitigation measures in this large agricultural watershed.

3. Extrapolate results for existing and mitigated conditions at five representative reaches to the remainder of the main stem channel using field and aerial reconnaissance of the

extent of streambank failures, to obtain suspended sediment loadings emanating from the banks of the channel.

1.2 Location of the Big Sioux Watershed

The Big Sioux River has its source in Grant county, north of Watertown, S.D., U.S. It flows south and southeast past Sioux Falls, and enters the Missouri River near Sioux City, Iowa, after a course of 420 miles (676 km) (Figure 1), passing through an agricultural region that produces corn, oats, hogs, and beef cattle .

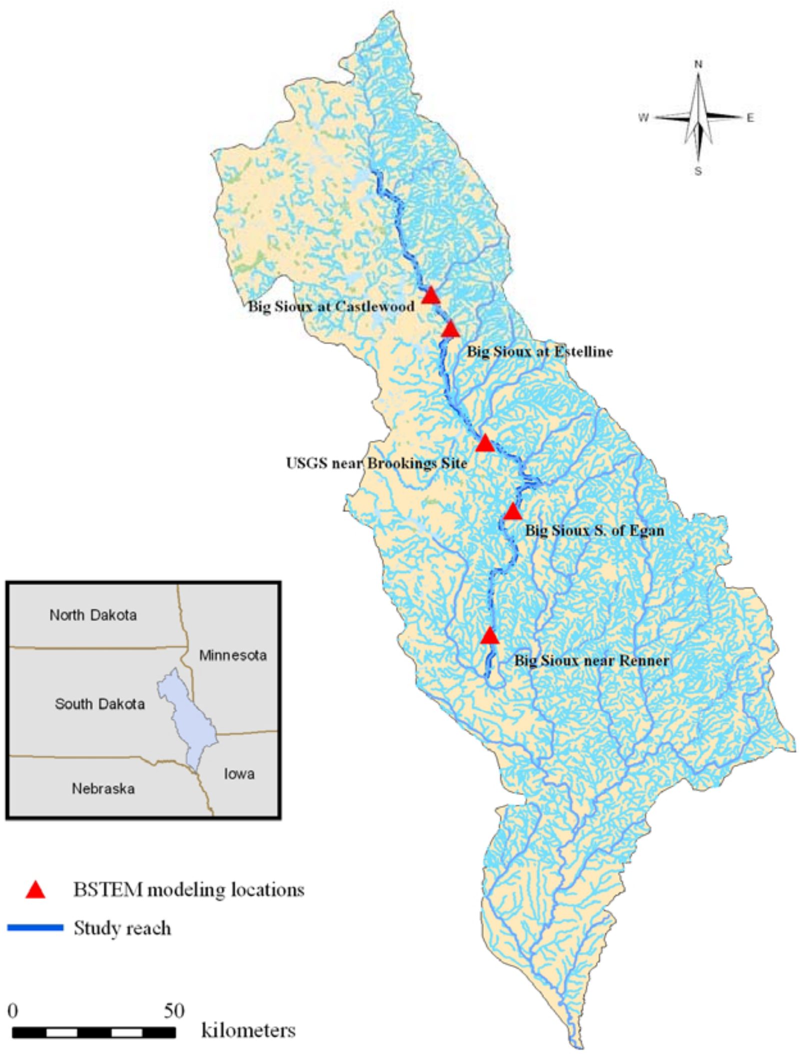


Figure 1. Drainage basin map showing hydrography, the extent of the study reach, and location of the sites studies intensively in this report.

2. FUNDAMENTALS of BANK STABILITY

Conceptual models of bank retreat and the delivery of bank sediments to the flow emphasize the importance of interactions between hydraulic forces acting at the bed and bank toe, and gravitational forces acting on *in situ* bank materials (Carson and Kirkby, 1972; Thorne, 1982; Simon *et al*., 1991). Failure occurs when erosion of the bank toe and possibly the channel bed adjacent to the bank increase the height and angle of the bank to the point that gravitational forces exceed the shear strength of the bank material. After failure, failed bank materials may be delivered directly to the flow and deposited as bed material, dispersed as wash load, or deposited along the toe of the bank as intact blocks, or as smaller, dispersed aggregates (Simon *et al*., 1991).

Bank materials do not maintain constant shear strength (resistance to failure) throughout the year. Strength varies with the moisture content of the bank and the elevation of the saturated zone in the bank mass. The wetter the bank and the higher the water table, the weaker the bank mass becomes and the more prone it is to failure. Bank failures, however, do not occur frequently during high flows because the water in the channel is providing a buttressing, or confining force to the bank mass. This is true even though it is during high-flow events that the bank may be undercut by hydraulic forces. It is upon recession of the flow when the bank loses the confining force but still maintains a high degree of saturation when it is most likely to fail. This is why changes in flow regime can be very important in determining trends of bank stability over time.

Analyzing streambank stability is a matter of characterizing the gravitational forces acting on the bank and the geotechnical strength of the *in situ* bank material. Field data are required to quantify those parameters controlling this balance between force and resistance. If we initially envision a channel deepened by bed degradation in which the streambanks have not yet begun to fail, the gravitational force acting on the bank cannot overcome the resistance (shear strength) of the *in situ* bank material. Shear strength is a combination of frictional forces represented by the angle of internal friction (ϕ'), and effective cohesion (c'). Pore-water pressures in the bank serve to reduce the frictional component of shear strength. A factor of safety (F_s) is expressed then as the ratio between the resisting and driving forces. A value of unity (or the critical case) indicates the driving forces are equal to the resisting forces and that failure is imminent.

The forces resisting failure on the saturated part of the failure surface are defined by the Mohr-Coulomb equation:

$$S_r = c' + (\sigma - \mu) \tan \phi' \quad (1)$$

where μ is the pore pressure and ϕ' is the angle of internal friction.

The geotechnical driving force is given by the term:

$$F = W \sin\beta \quad (2)$$

where, F = driving force acting on bank material (N), W = weight of failure block (N), and β = angle of the failure plane (degrees).

In the part of the streambank above the "normal" level of the groundwater table, bank materials are unsaturated, pores are filled with water and with air, and pore-water pressure is negative. The difference ($\mu_a - \mu_w$) between the air pressure (μ_a) and the water pressure in the pores (μ_w) represents matric-suction (ψ). This force acts to increase the shear strength of the material and with effective cohesion produces apparent cohesion (c_a). The increase in shear strength due to an increase in matric suction is described by the angle ϕ^b. This effect has been incorporated into the standard Mohr-Coulomb equation normally used for saturated soils by Fredlund *et al*. (1978), with a maximum value of ϕ' under saturated conditions (Fredlund and Rahardjo, 1993). The effect of matric suction on shear strength is reflected in the apparent or total cohesion (c_a) term:

$$c_a = c' + (\mu_a - \mu_w) \tan \phi^b = c' + \psi \tan \phi^b \qquad (3)$$

As can be seen from equation 1, negative pore-water pressures (positive matric suction; ψ) in the unsaturated zone provide for cohesion greater than the effective cohesion, and thus, greater shearing resistance. This is often manifest in steeper bank slopes than would be indicated by ϕ'.

Thus, for the unsaturated part of the failure surface the resisting forces as modified by Fredlund *et al.* (1978) are used:

$$S_r = c' + (\sigma - \mu_a) \tan \phi' + (\mu_a - \mu_w) \tan \phi^b \qquad (4)$$

where S_r is shear strength (kPa), c' is effective cohesion (kPa), σ is normal stress (kPa), μ_a is pore air pressure (kPa), μ_w is pore-water pressure (kPa), (μ_a-μ_w) is matric suction, or negative pore-water pressure (kPa), and $\tan \phi^b$ is the rate of increase in shear strength with increasing matric suction.

2.1 Quantifying streambank stability: The Bank Stability and Toe Erosion Model (BSTEM)

The original BSTEM model (Simon *et al*. 1999) allowed for 5 unique layers, accounted for pore-water pressures on both the saturated and unsaturated parts of the failure plane, and the confining pressure from streamflow. The version of BSTEM used in this project (Version 4.1.1) includes a sub-model to predict bank-toe erosion and undercutting by hydraulic shear. This is based on an excess shear-stress approach that is linked to the geotechnical algorithms. Complex geometries resulting from simulated bank-toe are used as the new input geometry for the geotechnical part of the bank-stability model. If a failure is simulated, that new bank geometry can be exported back into either sub-model to simulate conditions over time by running the sub-models iteratively with different flow and water-table conditions. In addition, the enhanced bank-stability sub-model allows the user to select between cantilever and planar-failure modes and allows for inclusion of the mechanical, reinforcing effects of riparian vegetation (Simon and Collison, 2002; Micheli and Kirchner, 2002; Pollen and Simon 2005).

2.1.1 Bank-Toe Erosion Sub-Model

The Bank-Toe Erosion sub-model can be used to estimate erosion of bank and bank-toe materials by hydraulic shear stresses. The effects of toe protection can also be incorporated. The model calculates an average boundary shear stress from channel geometry and flow parameters using a rectangular-shaped hydrograph defined by flow depth and flow duration, and considers critical shear stress and erodibility of separate zones with potentially different materials at the bank and bank toe. The bed elevation is fixed because the model does not incorporate, in any way, the simulation of sediment transport.

Toe erosion by hydraulic shear is calculated using an excess shear approach. The average boundary shear stress (τ_o) acting on each node of the bank material is calculated using:

$$\tau_o = \gamma_w R S \qquad (1)$$

where τ_o = average boundary shear stress (Pa), γ_w = unit weight of water (9.81 kN/m^3), R = local hydraulic radius (m) and S = channel slope (m/m).

The average boundary shear stress exerted by the flow on each node is determined by dividing the flow area at a cross-section into segments that are affected only by the roughness of the bank or bed and then further subdividing to determine the flow area affected by the roughness of each node. The line dividing the bed- and bank- affected segments is assumed to bisect the average bank angle and the average bank toe angle (Figure 13). The hydraulic radius of the flow on each segment is the area of the segment (A) divided by the wetted perimeter of the segment (P_n). Fluid shear stresses along the dividing lines are neglected when determining the wetted perimeter.

An average erosion rate (in m/s) is computed for each node by utilizing an excess-shear stress approach (Partheniades, 1965). This rate is then integrated with respect to time to yield an average erosion distance (in cm; Figure 1). This method is similar to that employed in the CONCEPTS model (Langendoen, 2000) except that erosion is assumed to occur normal to the local bank angle, not horizontally:

$$E = k \Delta t (\tau_0 - \tau_c) \qquad (2)$$

where E = erosion distance (cm), k = erodibility coefficient (cm^3/N-s), Δt = time step (s), τ_0 = average boundary shear stress (Pa), and τ_c = critical shear stress (Pa).

Resistance of bank-toe and bank-surface materials to erosion by hydraulic shear is handled differently for cohesive and non-cohesive materials. For cohesive materials the relation developed by Hanson and Simon (2001) using a submerged jet-test device (Hanson, 1990) is used:

$$k = 0.2\ \tau_c^{-0.5} \qquad (3)$$

The Shields (1936) criteria is used for resistance of non-cohesive materials as a function of roughness and particle size (weight), and is expressed in terms of a dimensionless critical shear stress:

$$\tau^* = \tau_o / (\rho_s - \rho_w)\ g\ D \qquad (4)$$

where τ^* = critical dimensionless shear stress; ρ_s = sediment density (kg/m^3); ρ_w = water density (kg/m^3); g = gravitational acceleration (m/s^2); and D = characteristic particle diameter (m).

2.1.2 Bank Stability Sub-Model

The bank stability sub-model combines three limit equilibrium-methods to calculate a Factor of Safety (F_s) for multi-layered streambanks. The methods simulated are horizontal layers (Simon and Curini, 1998; Simon *et al.*, 2000), vertical slices for failures with a tension crack (Morgenstern and Price, 1965) and cantilever failures (Thorne and Tovey, 1981).

For planar failures the Factor of Safety (F_s) is given by:

$$F_s = \frac{\sum_{i=1}^{I}\left(c_i' L_i + S_i \tan\phi_i^b + \left[W_i \cos\beta - U_i + P_i \cos(\alpha-\beta)\right]\tan\phi_i'\right)}{\sum_{i=1}^{I}\left(W_i \sin\beta - P_i \sin[\alpha-\beta]\right)} \qquad (5)$$

where c_i' = effective cohesion of ith layer (kPa), L_i = length of the failure plane incorporated within the ith layer (m), S_i = force produced by matric suction on the unsaturated part of the failure surface (kN/m), W_i = weight of the ith layer (kN), U_i = the hydrostatic-uplift force on the saturated portion of the failure surface (kN/m), P_i = the hydrostatic-confining force due to external water level (kN/m), β = failure-plane angle (degrees from horizontal), α = bank angle (degrees from horizontal), and I = the number of layers.

For planar failures with a tension crack F_s is determined by the balance of forces in horizontal and vertical directions for each slice and in the horizontal direction for the entire failure block. F_s is given by:

$$F_s = \frac{\cos\beta \sum_{j=1}^{J} \left(c'_j L_j + S_j \tan\phi_j^b + \left[N_j - U_j \right] \tan\phi'_j \right)}{\sin\beta \sum_{j=1}^{J} \left(N_j \right) - P_j} \qquad (6)$$

The cantilever shear failure algorithm is a further development of the method employed in the CONCEPTS model (Langendoen, 2000). The F_s is given by:

$$F_s = \frac{\sum_{i=1}^{I} \left(c'_i L_i + S_i \tan\phi_i^b - U_i \tan\phi'_i \right)}{\sum_{i=1}^{I} \left(W_i - P_i \right)} \qquad (7)$$

The model is easily adapted to incorporate the effects of geotextiles or other bank stabilization measures that affect soil strength. This version of the model assumes hydrostatic conditions below the water table, and a linear interpolation of matric suction above the water table.

2.2 Measuring and Modeling Root-Reinforcement

Estimates of root-reinforcement of soils have commonly been attained using simple perpendicular root models such as those of Waldron (1977) and Wu *et al.* (1979), which calculate root-reinforcement as a single add-on factor to soil strength. The root reinforcement model of Waldron (1977) is based on the Coulomb equation in which soil shearing resistance is calculated from cohesive and frictional forces:

$$S = c + \sigma_N \tan\phi \qquad (8)$$

where S is soil shearing resistance (kPa), σ_N is the normal stress on the shear plane (Pa), ϕ is soil friction angle (degrees), and c is the cohesion (kPa).

Waldron (1977) extended Equation 1 for root-permeated soils, by assuming that all roots extended vertically across a horizontal shearing zone, and that the roots act like laterally loaded piles, so tension is transferred to them as the soil is sheared. The modified Coulomb equation becomes:

$$S = c + \Delta S + \sigma_N \tan\phi \qquad (9)$$

where ΔS is increased shear strength due to roots (kPa).

In the Waldron (1977) model, the tension developed in the root as the soil is sheared is resolved with a tangential component resisting shear and a normal component increasing the confining pressure on the shear plane. ΔS can be represented by:

$$\Delta S = T_r (\sin\theta + \cos\theta \tan\phi)(A_R/A) \qquad (10)$$

where T_r is average tensile strength of roots per unit area of soil (kPa), A_R/A is the root area ratio (no units), and θ is the angle of shear distortion in the shear zone.

Gray (1974) reported the angle of internal friction of the soil appeared to be affected little by the presence of roots. Sensitivity analyses carried out by Wu *et al.* (1979) showed that the value of the first angle term in Equation 3 is fairly insensitive to normal variations in θ and ϕ (40-90°, and 25-40°, respectively) with values ranging from 1.0 to 1.3. A value of 1.2 was therefore selected by Wu *et al.* (1979) to replace the angle term and the simplified equation becomes:

$$\Delta S = 1.2\, T_r (A_R/A) \qquad (11)$$

2.2.1 The RipRoot Model

According to the simple perpendicular root model of Wu *et al.* (1979), the magnitude of reinforcement simply depends on the amount and strength of roots present in the soil. However, Pollen *et al.* (2004) and Pollen and Simon (2005), found that these perpendicular root models tend to overestimate root-reinforcement due to the inherent assumption that the full tensile strength of each root is mobilized during soil shearing, and that the roots all break simultaneously. This overestimation was largely corrected by Pollen and Simon (2005) by constructing a fiber-bundle model (RipRoot) to account for progressive breaking during mass failure. Validation of RipRoot versus the perpendicular model of Wu *et al*. (1979) was carried out by comparing results of root-permeated and non-root-permeated direct-shear tests. The direct-shear tests revealed that accuracy was improved by an order of magnitude by using RipRoot estimates, but some error still existed (Pollen and Simon, 2005).

One explanation for the remaining error in root-reinforcement estimates lies in the fact that observations of incised streambanks suggest that when a root-reinforced soil shears, two mechanisms of root failure occur: root breaking and root pullout. The anchorage of individual leek roots was studied by Ennos (1990), who developed a function for pullout forces based on the strength of the bonds between the roots and soil:

$$F_P = 2\pi r\, S\, L \qquad (12)$$

where F_P is the pullout force for an individual root (N), S is soil shear strength (kPa), r is the radius of the root (m) and L is the length of the root (m). L can be estimated in the absence of field data using (Waldron and Dakessian, 1981):

$$L = R\ r^g \qquad (13)$$

where the constants g and R have ranges: $0.5 < g < 1.0$; $200 < R < 1000$.

Root tensile strength may be considered independent of soil moisture, but root pullout forces are a function of soil shear strength, which is determined by c, ϕ, and soil matric suction. Thus, the forces required for root-pullout vary spatially with material type, and temporally with variations in soil moisture. The original version of RipRoot (Pollen and Simon, 2005) did not account for root pullout forces, and as such could not account for the effect of differing soil types and moistures on estimates of root-reinforcement. This was considered to be a deficiency of the model and the perpendicular root models that preceded it. A paper by Pollen (2007) investigated the forces required to pull out roots in a field study, with the results being tested against Equation 13. Root pullout forces were then compared to root breaking forces obtained from tensile strength testing, and the RipRoot model was modified to account for both root-failure mechanisms. Temporal variability regarding changes in soil moisture could therefore be taken into account, as could spatial variability in root-reinforcement with changes in soil texture.

3. METHODOLOGY

3.1 Testing of Bank Materials

As bank stability is a function of the strength of the bank material to resist collapse under gravity, measurements of the components of shearing resistance (or shear strength) were required. In addition, tests of the resistance of the bank-toe materials to erosion by flowing water were carried out using a CSM device (Tolhurst *et al.*, 1999; Watts *et al.*, 2003). *In situ* tests of the shear strength of bank materials at five unstable sites were conducted using a borehole shear-test device (BST; Lohnes and Handy, 1968). Site selection was based on information obtained during the reconnaissance phase and from the project South Dakota DNER. Data obtained in the field were used as inputs to the Bank-Stability and Toe Erosion Model (BSTEM; Simon et al., 1999) to determine critical conditions for bank stability.

3.1.1 Geotechnical Data Collection: Borehole Shear Tests

To model bank stability at selected reaches of the Big Sioux River using BSTEM, the banks within each reach were characterized. Representative sites were chosen along the study reach. Bank surveys at each site were also conducted. To gather data on the internal shear strength properties of the banks, *in-situ* Borehole Shear Test (BSTs) devices were used.

To properly determine the resistance of cohesive materials to erosion by mass movement, data must be acquired on those characteristics that control shear strength; that is cohesion, angle of internal friction, pore-water pressure, and bulk unit weight. Cohesion and friction angle data can be obtained from standard laboratory testing (triaxial shear or unconfined compression tests), or by *in-situ* testing with a borehole shear-test (BST) device (Lohnes and Handy 1968; Thorne *et al.* 1981; Little *et al*. 1982; Lutenegger and Hallberg 1981). The BST provides direct, drained shear-strength tests on the walls of a borehole (Figure 6). Advantages of the instrument include:

1. The test is performed *in situ* and testing is, therefore, performed on undisturbed material.
2. Cohesion and friction angle are evaluated separately with the cohesion value representing apparent cohesion (c_a). Effective cohesion (c') is then obtained by adjusting c_a according to measured pore-water pressure and ϕ^b.
3. A number of separate trials are run at the same sample depth to produce single values of cohesion and friction angle based on a standard Mohr-Coulomb failure envelope.
4. Data and results obtained from the instrument are plotted and calculated on site, allowing for repetition if results are unreasonable; and

5. Tests can be carried out at various depths in the bank to locate weak strata (Thorne *et al*. 1981).

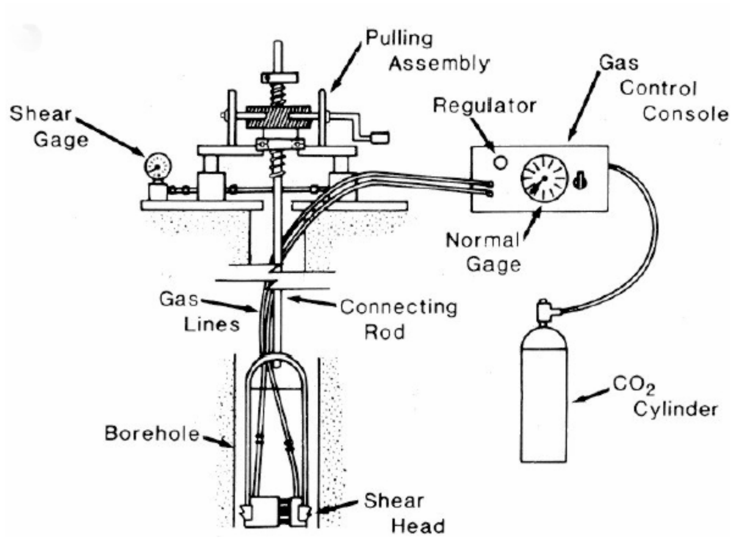


Figure 2. Schematic representation of borehole shear tester (BST) used to determine cohesive and frictional strengths of in situ streambank materials. Modified from Thorne et al., 1981.

At each testing depth, a small core of known volume was removed and sealed to be returned to the laboratory. The samples were weighed, dried and weighed again to obtain values of moisture content and bulk unit weight, both required for analysis of streambank stability.

3.1.2 Geotechnical Data Collection: tests with a Cohesive Strength Meter (CSM)

A submerged jet-test device is often used to estimate the resistance of materials to hydraulic forces in fine-grained materials *in situ* (Hanson 1990; 1991; Hanson and Simon, 2001). The device shoots a jet of water at a known head onto the streambed causing it to erode at a given rate. As the bed erodes, the distance between the jet and the bed increases (and is measured using a point gage), resulting in a decrease in applied shear stress. Theoretically, the rate of erosion beneath the jet decreases asymptotically with time to zero. Average boundary shear stress, representing the stress applied by flowing water along the edge of the bank is calculated from channel geometry and stage data collected at the sites, using Eq.1. A critical shear stress for the material can then be calculated from the field data as that shear stress where there is no erosion. The rate of scour ε (ms^{-1}) is assumed to be proportional to the shear stress in excess of a critical shear stress as is expressed in Eq. 2.The measure of material resistance to hydraulic stresses is a function of both τ_c and k. Based on observations from across the United States, k can be estimated as a function of τ_c (Hanson and Simon, 2001) (Eq. 3). Critical shear stress of non-cohesive materials can then be calculated using conventional (Shields-type) techniques as a function of particle size and weight.

As an alternative to the submerged jet-test device a Cohesive Strength Meter (CSM: Tolhurst *et al.*, 1999; Watts *et al.*, 2003) was used to establish toe material resistance at each of the five geotechnical sites along the study reach of the Big Sioux River, SD. The CSM is different to the submerged jet test device in that it does not include a point gage to measure scour depth over time. Instead, there in an optical sensor in the sample head which measures light transmission through the water column as the test progresses. The shear stress corresponding to a reduction in light transmission to 90 % (starting near 100 %) is considered to indicate incipient motion of particles and thus represents the critical shear stress (τ_c) of the material being tested. As the eroded depth over time is not obtained with tests using the CSM, k cannot be calculated directly from the test results and must instead be calculated using the relation of Hanson and Simon (2001) between τ_c and k (Eq.3)

3.2 Air Reconnaissance Survey and Estimating Percent of Reach Failing using a modified RGA

The length of the study reach was videoed and photographed from a low-flying helicopter using a high-speed video camera. From the air it was possible to characterize active geomorphic processes and relative stability along different sections of the study reach, for example, by observing bank failures, and areas of significant aggradation. Locations were identified from mile markers posted along the river. Rapid geomorphic assessments (RGAs) were conducted approximately every 2 river kilometers. A modified version of the Rapid Geomorphic Assessment tool (Simon, 1995; Simon and Klimetz, 2008) was used to assess channel stability throughout the study reach. This approach was used as the method allows for a very rapid analysis of many sites, and highlights the important processes occurring at each site, enabling assignment of stages of channel evolution. RGAs utilize diagnostic criteria of channel form to infer dominant channel processes and the magnitude of channel instabilities through a series of nine questions. Granted, evaluations of this sort do not include an evaluation of watershed or upland conditions; however, stream channels act as conduits for energy, flow and materials as they move through the watershed and will reflect a balance or imbalance in the delivery of sediment. RGAs provide an efficient method of assessing in-stream geomorphic conditions, enabling the rapid characterization and stability of any given channel.

Generally, the RGA procedure consists of five steps to be completed on site:

1. Determine the ‘reach’. The ‘reach’ is described as the length of channel covering 6-20 channel widths, thus is scale dependent and covers at least two pool-riffle sequences.
2. Take photographs looking upstream, downstream and across the reach; for quality assurance and quality control purposes. Photographs are used with RGA forms to review the field evaluation
3. Make observations of channel conditions and diagnostic criteria listed on the channel-stability ranking scheme.
4. Sample bed material.
5. Perform a survey of thalweg, or water surface if the water is too deep to wade. Bed or water surface slope is then calculated over at least two pool-riffle sequences.

In this case, however, the RGA methodology was used simply to establish the longitudinal extent of recent streambank failures in each 2 mile reach. This was quantified as the percent of the reach failing as estimated from the video taken during the air reconnaissance flight. These percentages are broken into classes (0-10, 11-25, 25-50, 51-75 and 76-100) and used as a measure of the severity of bank instability and when mapped, the extent of that instability. Bed sampling and stages of channel evolution were not evaluated for this particular study reach.

3.3 Modeling the frequency and volumes of bank erosion along the Big Sioux River using BSTEM:

Five study sites were selected from the 300 km study reach, to act as representative conditions for the entire reach. The locations of these five sites are shown in Figure 3, along with the USGS gages located on this river. The Bank-Stability and Toe-Erosion Model (BSTEM) developed by the USDA-ARS National Sedimentation Laboratory was used to model current bank-stability conditions and to determine stable-bank configurations (Simon *et al.*, 2000). Data collected at field sites, in addition to flow data from USGS gages were used to model a range of typical flow conditions ranging from low summer flows (<100 m^3/s), to large springtime events (up to 6000 m^3/s).

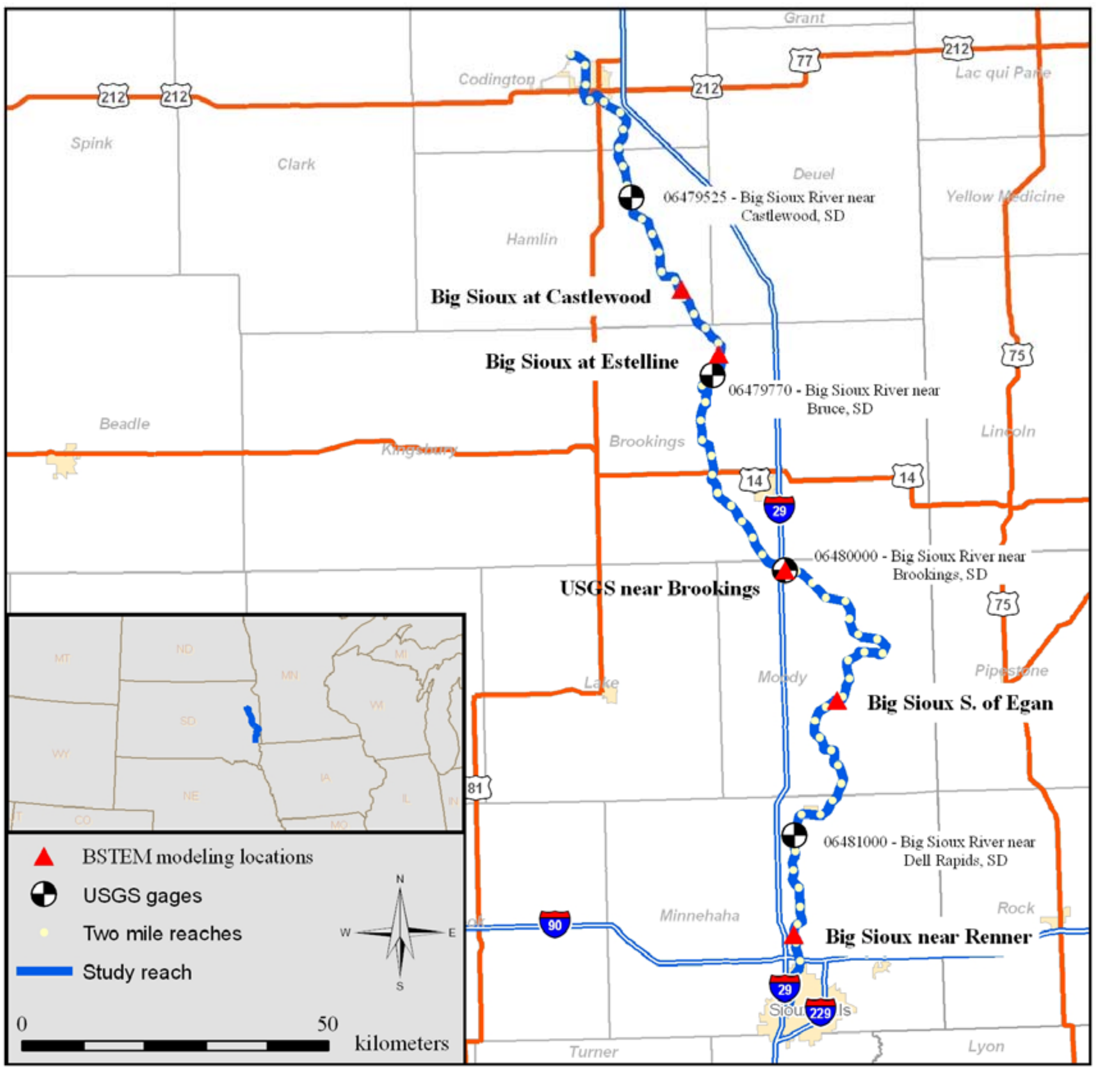


Figure 3. Map showing the five locations for geotechnical analysis and bank stability modeling along the Big Sioux River, RGA sites every 2 river Km, and USGS gage locations.

Bank instabilities typically occur during wet periods where shear strength of the banks is reduced by the loss of matric suction and the generation of positive pore-water pressures. Thus years of high precipitation and associated flow rates generally exhibit the greatest amount of streambank erosion via toe erosion and mass failures and represent an appropriate period to simulate critical conditions and rates of bank instability. However, iterative modeling results of a typical high-flow year would only provide estimates of loadings during that type of flow year. To evaluate average, annual streambank loadings rates, a range of typical flow years was required. To accomplish this flow years representing the range of the flow frequencies was selected (Figure 4). Bank stability model runs were, therefore, carried out for the five selected sites to examine rates of bank retreat and eroded volumes of sediment during flow years representing different percentiles for annual discharge (90%, 75%, 50%, 25% and 10%) (Table 1). Mean-daily flow records for the gage closest to each site (Table 2) were plotted for the entire available data record.

Table 1. Years selected to represent 10th, 25th, 50th, 75th and 90th percentiles for annual discharge, along with the number of storms modeled iteratively with BSTEM, for each gage, at each percentile.

PERCENTILE	YEAR	USGS GAGE NUMBER		
		0648 0000	0647 9525	0648 1000
90	1994	7	8	7
75	1999	6	5	6
50	2002	2	2	2
25	1988	3	1	1
10	2003	1	1	1

Table 2. Gages selected for use at each site, along with drainage areas, and available periods of record for mean daily data. Curly brackets on left designate which gage data was used for each site.

USGS GAGE OR SITE	Period of Record Available	Drainage Area (km^2)
USGS 06479525 Big Sioux R Near Castlewood, SD	1977 – 2008	1399
Castlewood		1445
Estelline		3190
USGS 06479770 Big Sioux River Near Bruce, SD	2001 - 2008	3359
Brookings		5472
USGS 06480000 Big Sioux River Near Brookings, SD	1954 - 2008	5472
Egan		6451
USGS 06481000 Big Sioux R Near Dell Rapids, SD	1949 - 2008	6983
Renner		7073

In the case of the Estelline site, data from USGS gage 06479770 was used. However, mean daily data for this gage was only available for the years 2001-2008. Some of the years selected to represent the 10^{th} through 90^{th} percentile flow years at the other gages where data records dated back at least 30 years, were outside the record of this gage. To solve this problem, a relationship was developed between discharge at gage 06479770 and the closest gage downstream of it, 06480000, using mean daily data from 2001-2007. Once this relation had been developed, data from gage 06480000 was used to predict the discharges for gage 06479770 for years predating its period of record.

The annual hydrographs selected (Figure 4) were first discretized into a series of steady-state rectangular-shaped discharge events (Figures 5 and 6). Discharge values for each flow event were then converted to a series of flow depths, based on stage-discharge relations developed for each USGS gage used (Figure 7), along with corresponding water table heights. As water table height information was unavailable for the study reach, for bank stability modeling purposes it was assumed that water table height equaled flow height at the peak of each hydrograph.

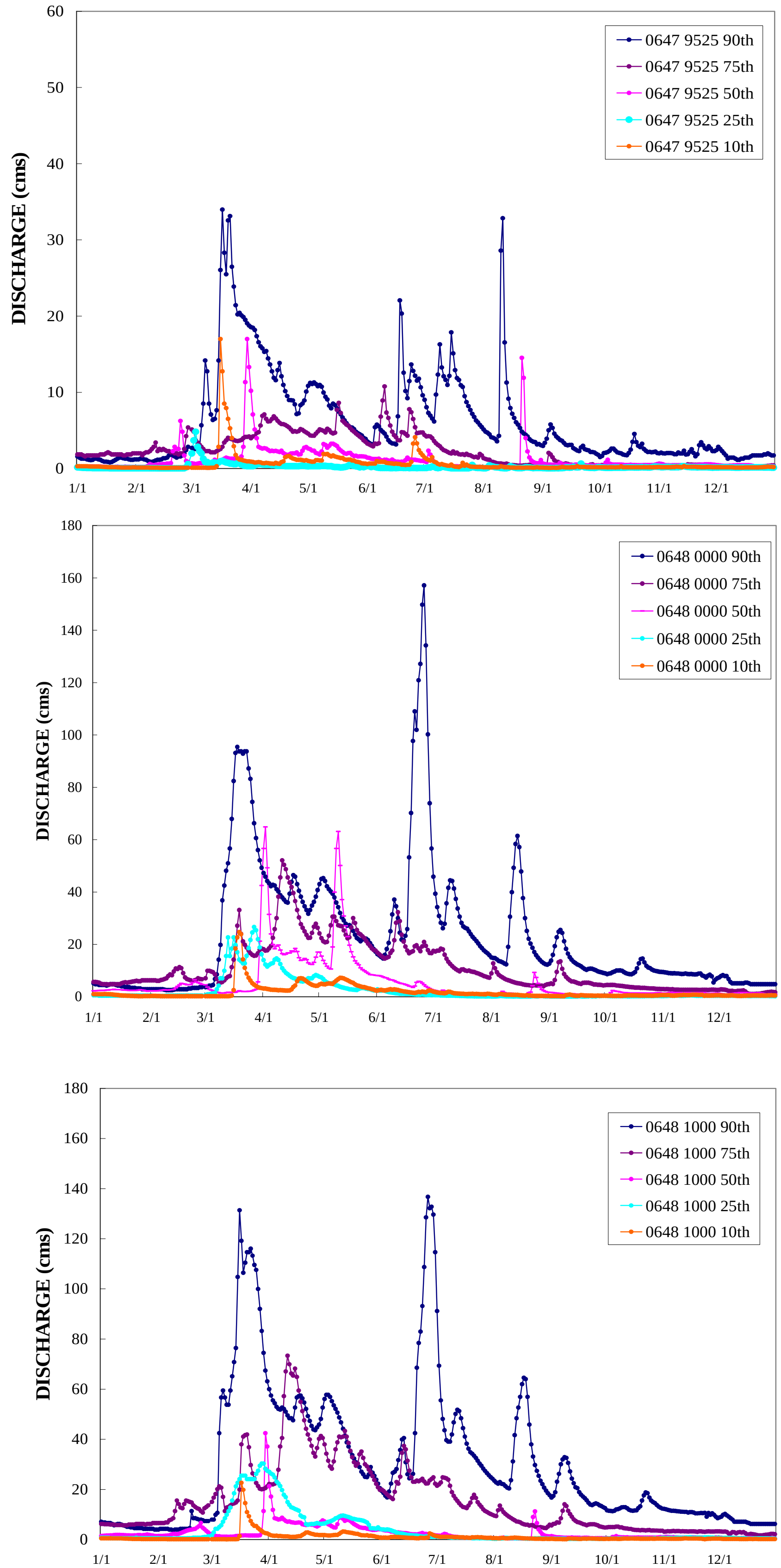


Figure 4. Hydrographs selected to represent the 90th, 75th, 50th, 25th and 10th percentile flow years at gages 06479525, 06480000 and 06481000.

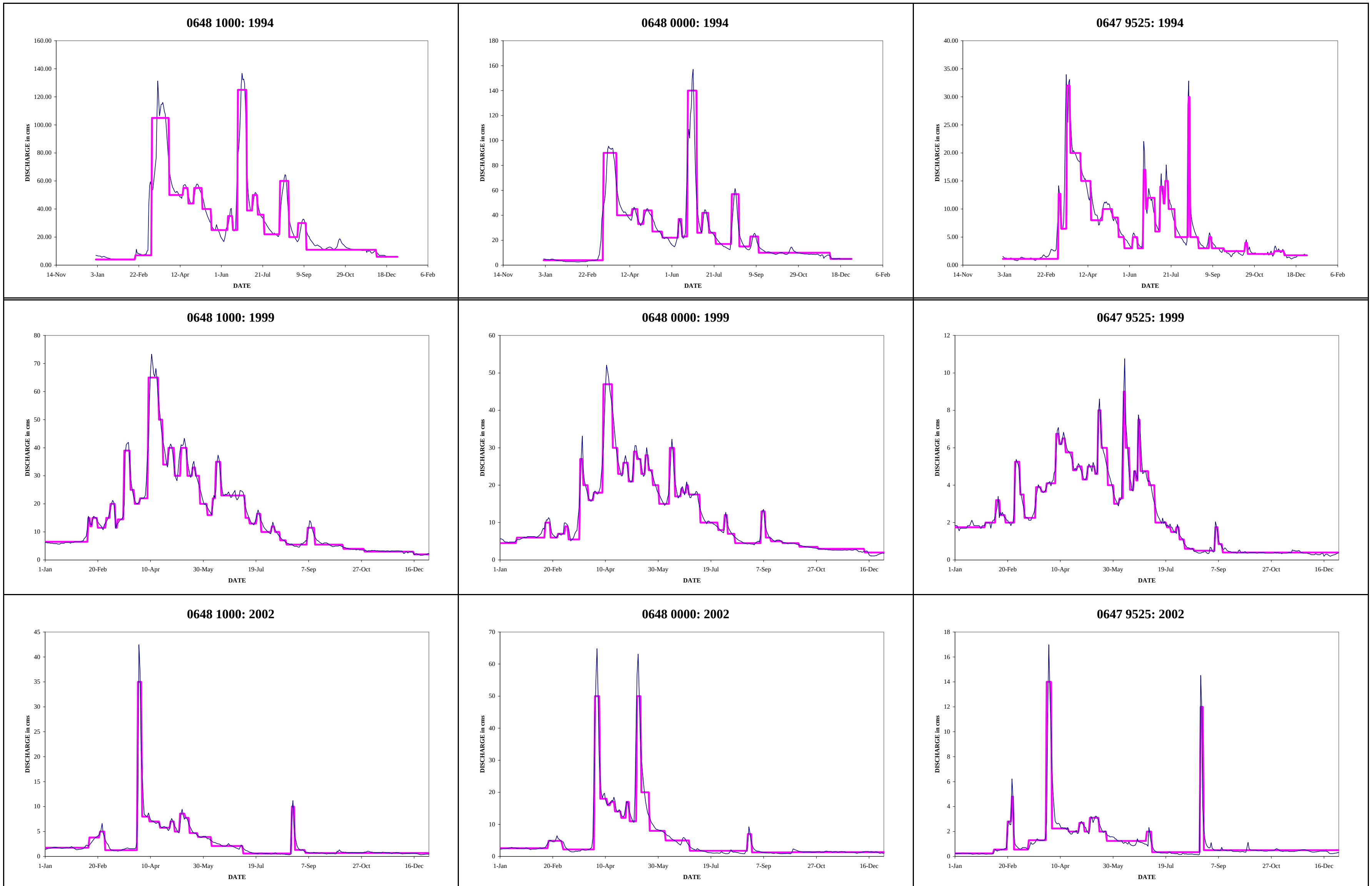


Figure 5. Discretized hydrographs for 90th (top), 75th (middle) and 50th (bottom) percentile flow years at each gage.

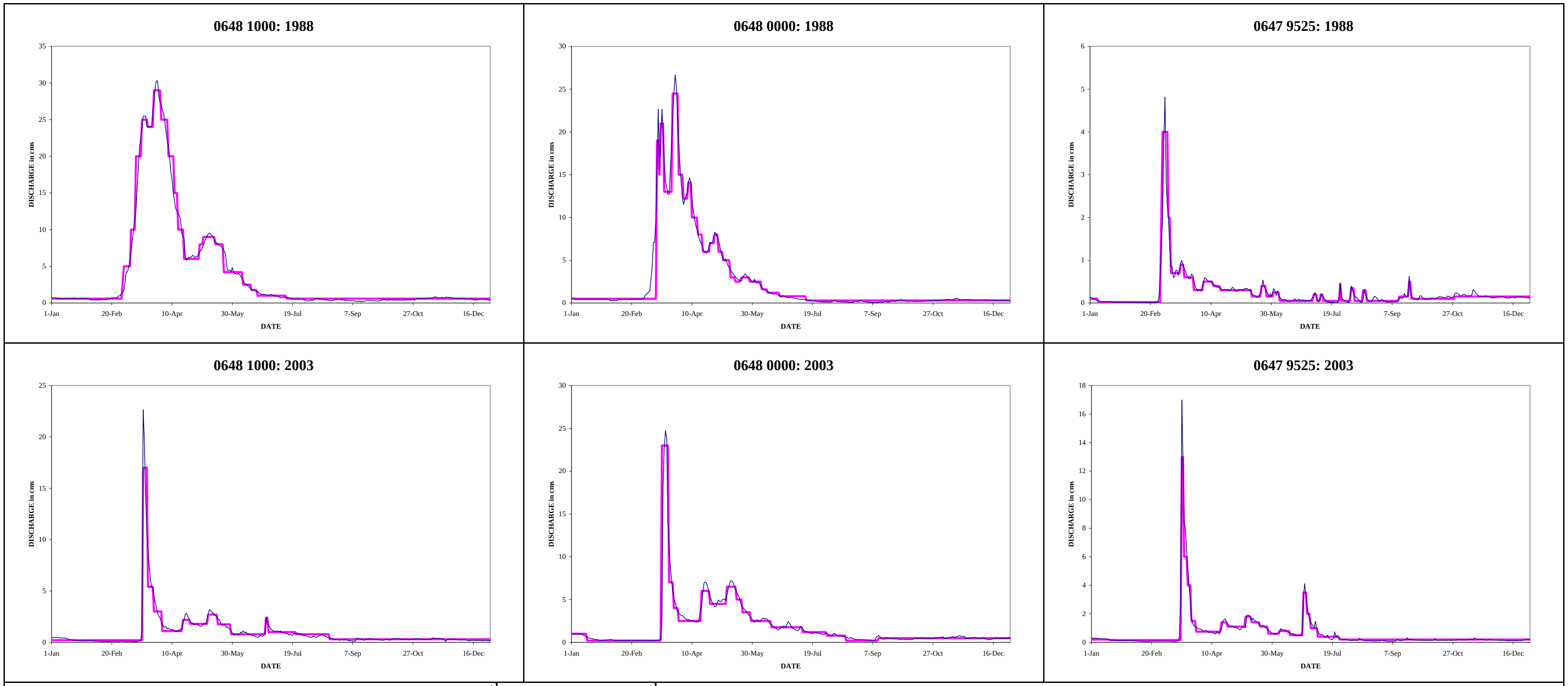


Figure 6. Discretized hydrographs for 25th (top) and 10th (bottom) percentile flow years at each gage.

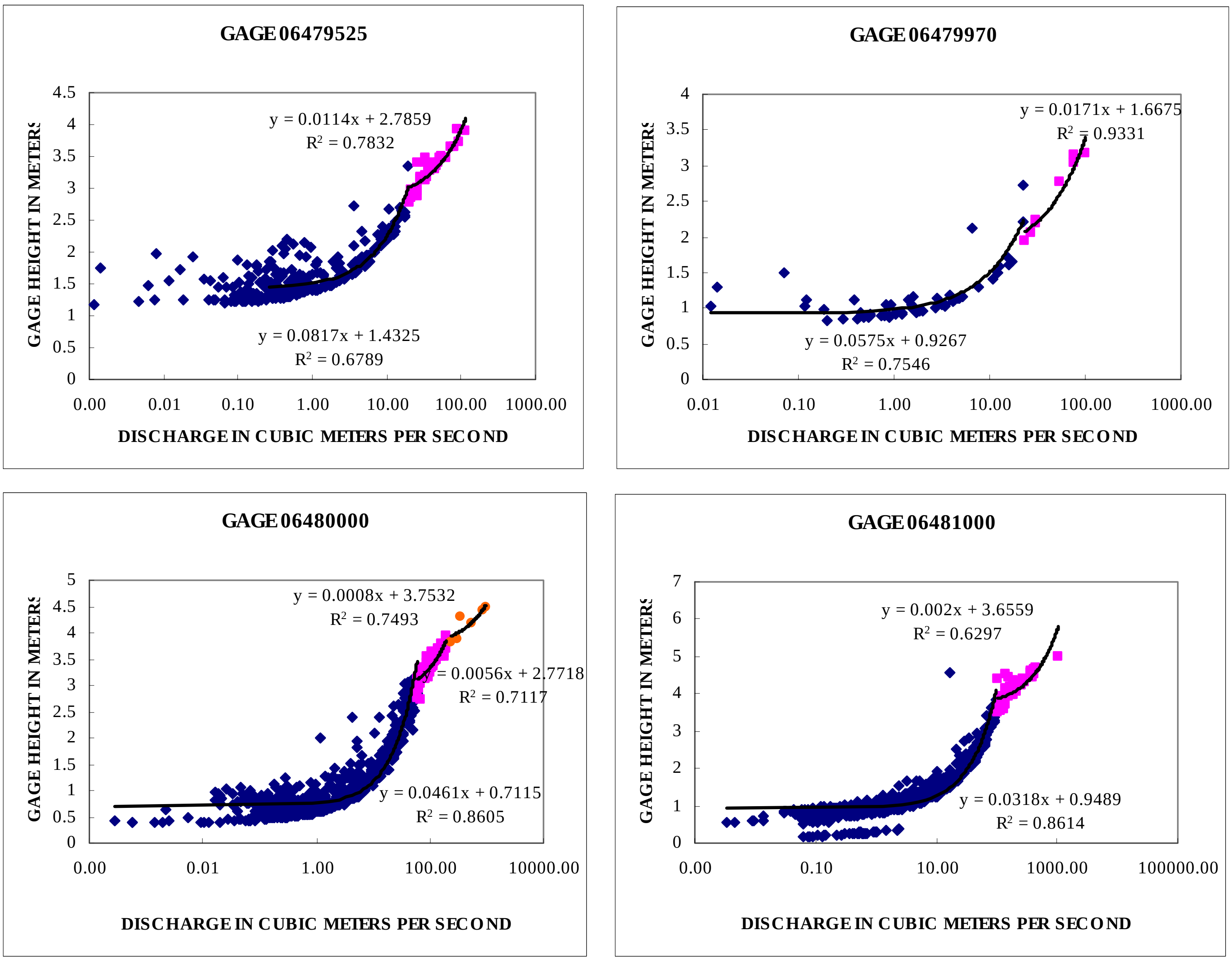


Figure 7. Stage-discharge relations for each of the gages used along the study reach of the Big Sioux River, SD.

3.3.1. Iterative Procedure for modeling discretized flow hydrographs. Once the flow events from each year had been discretized into rectangular shaped hydrographs, the storm events from a given year were iterated through using the following approach to run the toe erosion and bank stability algorithms in BSTEM:

1. The effects of the first flow event was simulated using the toe-erosion sub model to determine the amount (if any) of hydraulic erosion and the change in geometry in the bank-toe-region (Figure 8).

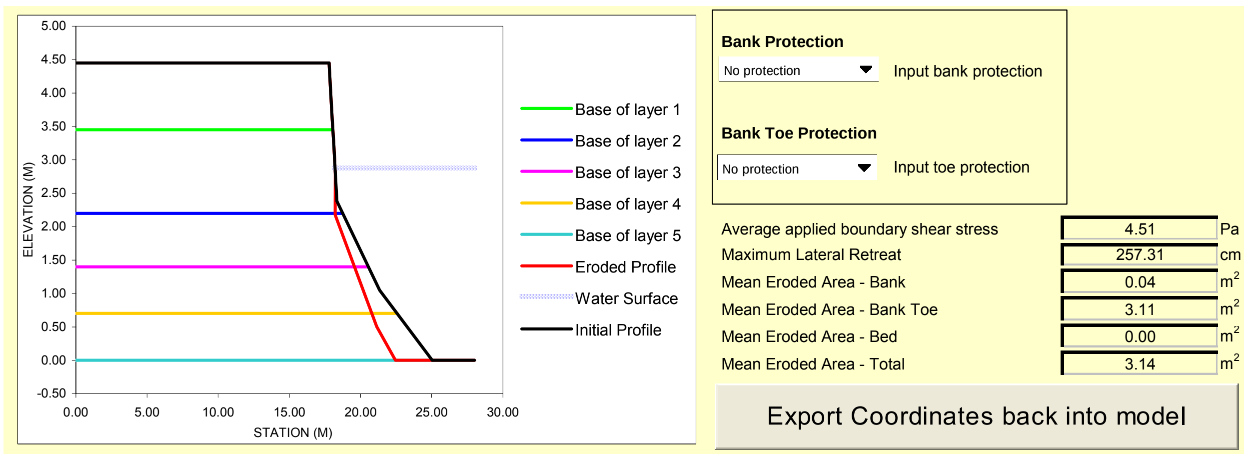


Figure 8. Example results from toe-erosion sub-model of first flow event and resulting hydraulic erosion.

2. The new geometry was exported into the bank-stability sub-model to test for the relative stability of the bank.
    a. If the factor of safety (F_s) was greater than 1.0, geometry was not updated and the next flow event was simulated (Figure 9).

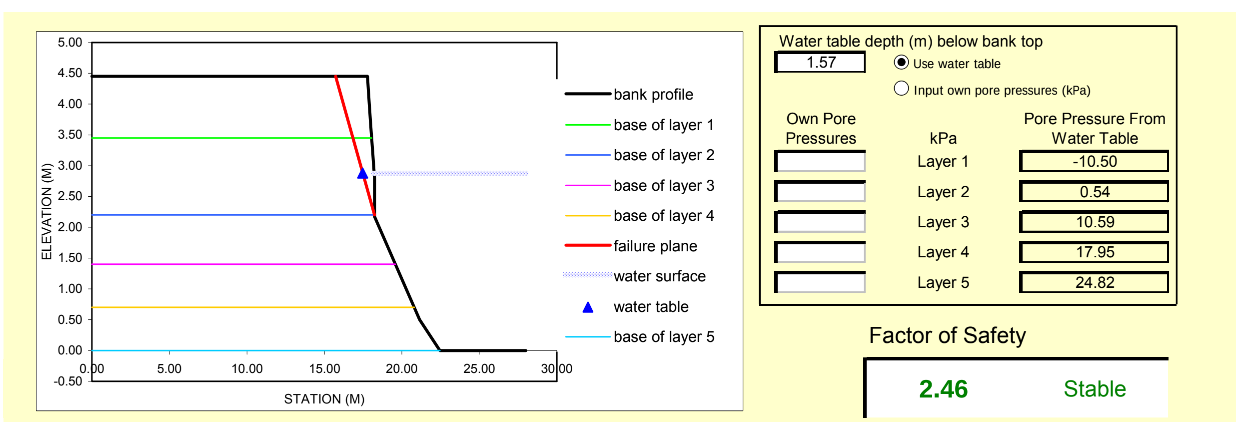


Figure 9. Example results from the bank-stability sub-model following the first flow event. This simulation shows a stable bank.

b. If F_s was less than 1.0, failure was simulated and the resulting failure plane became the geometry of the bank for simulation of toe erosion for the next flow event in the series.

c. If the next flow event had an elevation lower than the previous one, the bank-stability sub-model was run again using the new flow elevation to test for stability under drawdown conditions. If F_s was less than 1.0, failure was simulated and the new bank geometry was exported into the toe-erosion sub-model for the next flow event (Figure 10).

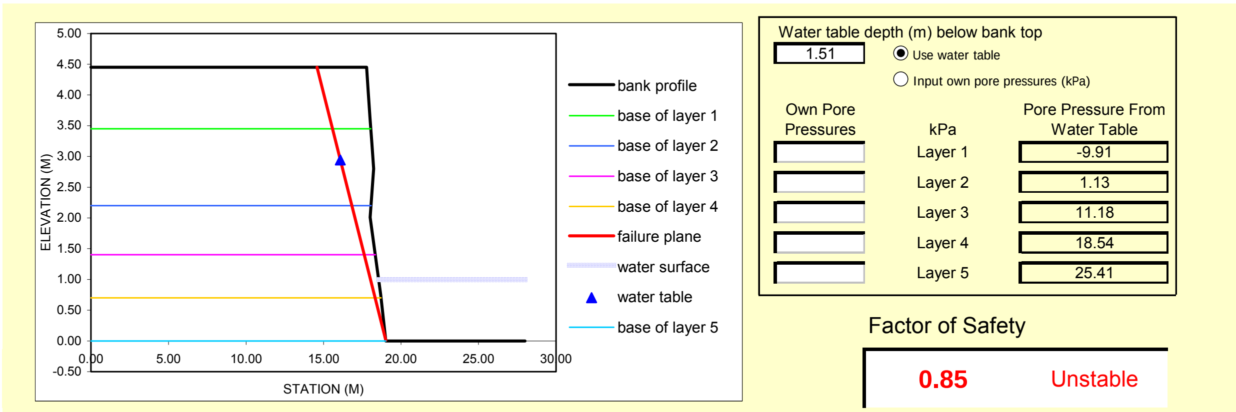


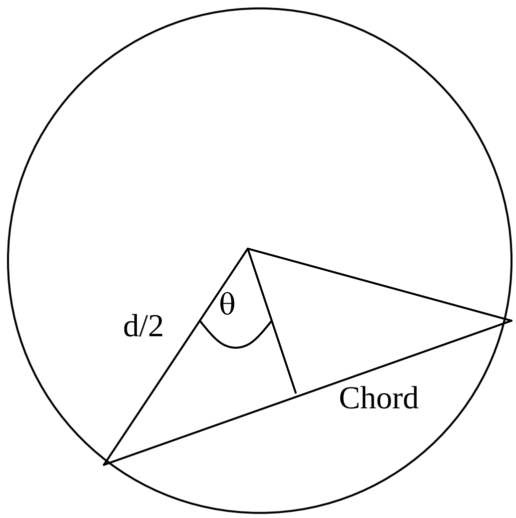
Figure 10. Example results from the bank-stability sub-model showing an unstable bank under drawdown conditions. In this case, the bank geometry exported to simulate the next flow event is represented by the failure plane (in red) and the original bank toe.

3. The next flow event in the series was simulated.

3.4 Estimating Reinforcement due to Roots

To determine reinforcement due to roots at each site, two 2.5 x 6.0 inch cores were taken from the top of each bank at each of the five sites. The dominant vegetation at all five sites were native grasses. Cores were analyzed in the laboratory to separate roots from soil, through and combination of wet sieving and dry sieving depending on the texture of the soil sampled. Once the roots had been separated from the soil they were air-dried and weighed to obtain estimates of biomass. Special care was taken to ensure that roots were removed intact from the soil so that they could be weighed, then counted, and their diameters measured. Once an estimate of the number of roots contained in each sample had been attained, it was necessary to convert this number to an approximate number of roots crossing a one meter square shear plane passing through the streambank.

We wanted to know the mean chord length for each 2.5 x 6.0 inch core.



The length of the chord is $2(d/2)\sin\theta$

The average of any quantity can be calculated by taking the integral and dividing by the range over which the area is calculated, so in this case (with θ in radians). Note that we only calculate the area over ½ the circle (θ radians/ 180 degrees) because in the other half, the area is negative and an area of zero would be calculated:

$$\bar{c} = \left[\frac{1}{\pi}\int_0^{\pi} d\sin\theta\right] \qquad (14)$$

$$\bar{c} = \frac{-d}{\pi}\cos\theta\Big|_0^{\pi} = \frac{-d}{\pi}(-1-1) = \frac{2d}{\pi} \qquad (15)$$

The values in Table 3 show how many roots in each root diameter size class were present in each sample. Using Equations 14 and 15, these numbers were converted to the number of roots crossing a shear plane with an area of one meter squared, and an average value for each site was calculated.

The next step was to account for the fact that the samples were taken from the top six inches of the streambank. As rooting densities decline exponentially with increasing depth in a soil profile, root-reinforcement applied to each streambank modeled should reflect these changes with depth. Jackson et al. (1996) found that the vertical distribution of roots was best described by the following asymptotic function, taken from Gale and Grigal (1987):

$$Y = 1 - \beta^{d} \tag{16}$$

where Y is the cumulative root fraction (a proportion between 0 and 1) from the soil surface to depth d in cm, and β is the fitted coefficient. High β values correspond to a greater proportion of roots at depth in the soil and low β values imply a higher proportion of roots near the soil surface.

The values for β given in Table 5 (Taken from Pollen-Bankhead and Simon, 2008), show how β tends to vary for different plant types and biomes. In the absence of field data pertaining to changing rooting densities with depth at the field sites studied on the Big Sioux River, an average value for β (0.956) was calculated from similar native grasses highlighted in the table. Values for root reinforcement from the native grasses at the five sites ranged from 5.1 to 10.9 kPa (Table 4), averaged over the top meter of the soil profile. At each site the approximate rooting depth of the grass was estimated from the bank face, with root-reinforcement being restricted to the depths observed in the field during the modeling of each bank in BSTEM.

Table 3. Number of roots present in soil-root cores taken at each of the BSTEM geotechnical modeling sites

SITE	SAMPLE	Number of roots in sample <1 mm	1-2 mm	2-3 mm	Total number of roots in sample
CASTLEWOOD	1	38	8	1	47
	2	47	13	5	65
ESTELLINE	1	49	11	5	65
	2	57	15	2	74
EGAN	1	29	1	1	31
	2	31	5	3	39
BROOKINGS	1	53	16	6	75
	2	46	6	2	54
RENNER	1	49	12	4	65
	2	48	8	5	61

Table 4. Number of roots estimated to cross each meter square of shear surface within each bank, resulting cohesion due to roots in each sample, and average cohesion over the top meter of the bank.

SITE	SAMPLE	MAXIMUM ROOTING DEPTH (cm)	Number of roots per m^2 of shear surface				AVERAGE NUMBER OF ROOTS FOR EACH SITE	COHESION DUE TO ROOTS(kPa)	AVERAGE SURFACE COHESION DUE TO ROOTS (kPa)	AVERAGE COHESION OVER 1m DEPTH (kPa) $B = 0.956$	VEGETATION AND CONDITION
			<1mm	1-2mm	2-3mm	roots per m^2					
CASTLEWOOD	1	50.8	3183	670	84	3937	4691	24.5	29.2	8.8	**CRP good condition**
	2	50.8	3937	1089	419	5444		33.8			
ESTELLINE	1	60.96	4104	921	419	5444	5821	32.2	36.2	10.9	**heavy grazing**
	2	60.96	4774	1256	168	6198		40.1			
EGAN	1	91.44	2429	84	84	2597	2932	15.6	16.9	5.1	**CRP good condition**
	2	91.44	2597	419	251	3267		18.2			
BROOKINGS	1	86.36	4439	1340	503	6282	5402	36.7	31.2	9.4	**heavy grazing**
	2	86.36	3853	503	168	4523		25.6			
RENNER	1	152.4	4104	1005	335	5444	5277	33.5	31.0	9.3	**native grasses**
	2	152.4	4020	670	419	5109		28.5			

Table 5. Taken from Pollen-Bankhead and Simon (2008). β values for each species and for biomes (Jackson et al. 1996), with corresponding average age for specimens, and the percentage of root biomass in the top 0.3 m of soil. Two native grass species, Rye grass and Reed Canary grass are highlighted in the table. In the absence of field data pertaining to changing rooting densities with soil depth, the average between these two values (β = 0.956) was selected to be used as the value for β for the native grasses in this study.

SPECIES*/ BIOME**	β	Average age (years)	% root biomass in upper 30 cm	
Tamarisk	0.996	10	11	
Russian olive	0.988		30	
Lemmon's willow	0.985	10	36	
Sandbar willow	0.982	4	43	roots more
Temperate coniferous forest	0.976		52	evenly
Desert	0.975		53	distributed
Oregon ash	0.973	30	56	
Tropical grassland savanna	0.972		57	
Cottonwood	0.972	4	57	
Temperate deciduous forest	0.966		65	
Sclerophllous shrubs	0.964		67	
Mature Lodgepole pine	0.963	45	68	
Tropical evergreen forest	0.962		69	
Crops	0.961		70	
Tropical deciduous forest	0.961		70	
Black willow	0.961	5	70	
Reed canary grass	0.959	5	72	
Rye grass	0.953	5	76	
Eastern sycamore	0.952	8	77	
River birch	0.951	7	78	
Longleaf pine	0.950	8	79	
Boreal forest	0.943		83	
Temperate grassland	0.943		83	roots
Young Lodgepole pine	0.939	6	85	concentrated
Sweetgum	0.936	5	86	near surface
Tundra	0.914		93	
Alder	0.902	20	95	

* Values from riparian species investigations
** Values from Jackson et al. (1996)

One of the mitigation strategies investigated in this report was the potential benefit of the presence of riparian buffers along the streambanks of the Big Sioux River. Riparian tree and shrub species commonly found in the study area are green ash (Fraxinus pennsylvanica), boxelder (Acer negundo), peachleaf and sandbar willow (Salix amygdaloides and S. exigua), and american elm (Ulmus americana) (Dieter, 1987). Species found occasionally throughout the area are hawthorn (Crataegus mollis), hackberry (Celtis occidentalis), Tartarian honeysuckle (Lonicera tatarica),American plum (Prunus americana), and cottonwood (Populus deltoides) (Dieter, 1987). In the absence of having tree root density and strength data pertaining to this particular region or river, cottonwood data collected from other sites in the USA (Pollen-Bankhead and Simon, 2008) were used.

To determine what age of cottonwood trees would be added to the mitigated bank stability scenarios involving trees, a series of bank stability runs were carried out for a critical condition at the Egan site, using cohesion due to roots for 2 to 25-year-old cottonwood trees. Root-reinforcement estimates were calculated using the root-reinforcement model, RipRoot, and root tensile strength and distribution data taken from Pollen-Bankhead and Simon (2008). The critical condition selected for bank stability, occurred where the bank water table height was high and flow was low (a condition often seen during the receding limb of a hydrograph), and F_s was just less than 1 with no cohesion due to roots. Table 6 shows the F_s values obtained during these model runs. A F_s value of less than one indicates an unstable bank, and it is generally considered that values for F_s between 1.0 and 1.3 indicate conditional stability, with values greater than 1.3 representing stable banks. The age of cottonwood trees corresponding to a F_s greater than 1.3 (9 years) was thus selected to add to the streambanks in the mitigated scenarios involving riparian trees, as it was estimated that it would take 9-years of growth of newly planted cottonwood saplings to have a significant effect on bank stability at the sites studied.

Table 6. Changes in streambank F_s at the Egan site with cottonwood trees of different ages, for a critical condition with a high groundwater table and low flow.

TREE AGE (years)	F_S WITH COHESION DUE TO COTTONWOOD TREE ROOTS (no units)
0	0.99
2	1.01
5	1.08
6	1.12
8	1.24
9	1.31
10	1.39
12	1.53
15	1.72
20	1.93
25	2.12

The next task was to determine values of root-cohesion for not just the cottonwood trees alone, but to simulate root reinforcement for an assemblage of native grasses and cottonwood trees. This was important because any cottonwood saplings planted at a site would grow alongside the native grasses already present. Over time it was assumed that the relative percent contributions to the assemblage from the native grasses and the cottonwood trees would change, as the trees matured. Figure 11 shows an example of the root cohesion provided by such a species assemblage at the Egan site. Figure 12 shows the total assemblage cohesion at each site for comparison (Figure 12, Table 7).

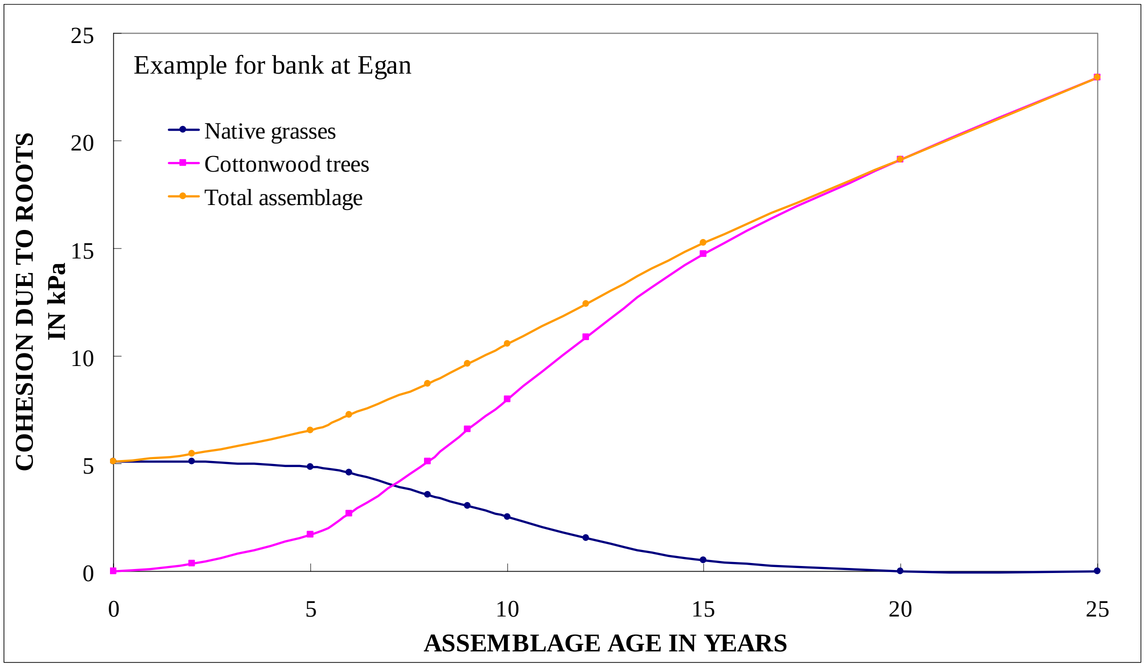


Figure 11. Contributions from native grasses and cottonwood trees to total cohesion estimated at the Egan site.

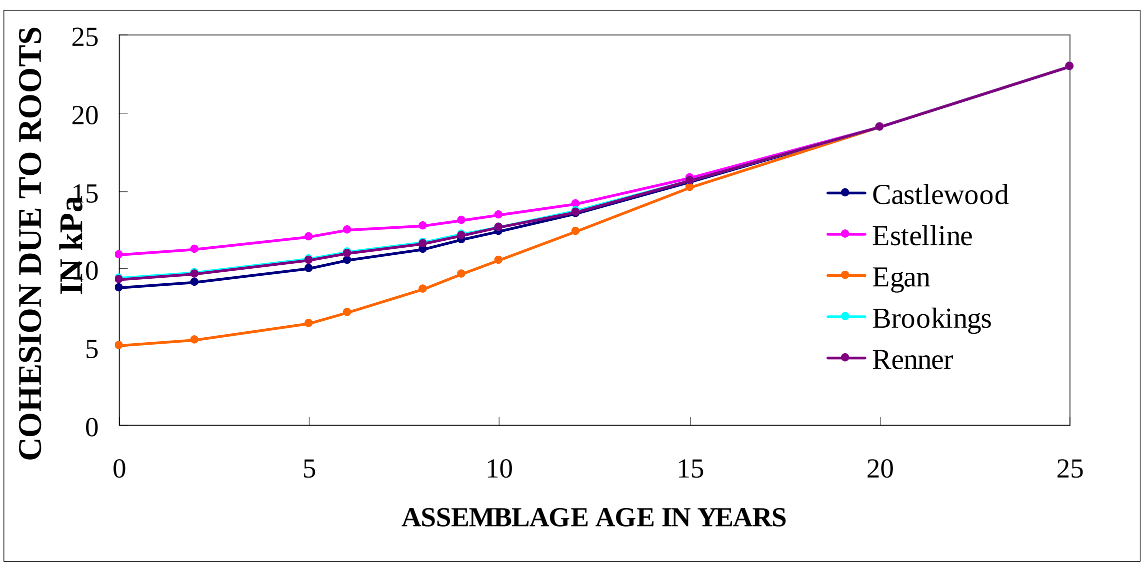


Figure 12. Total root cohesion provided by native grasses and cottonwood trees estimated at each site.

Table 7. Cohesion due to roots of native grass and cottonwood tree assemblage, at each site.

ASSEMBLAGE AGE (years)	COHESION DUE TO ROOTS (kPa)				
	CASTLEWOOD	ESTELLINE	BROOKINGS	EGAN	RENNER
0	8.8	10.9	9.4	5.1	9.3
2	9.2	11.3	9.8	5.5	9.7
5	10.1	12.1	10.6	6.5	10.5
6	10.6	12.5	11.1	7.3	11.0
8	11.3	12.8	11.7	8.7	11.6
9	11.9	13.1	12.2	9.7	12.2
10	12.4	13.5	12.7	10.6	12.7
12	13.5	14.2	13.7	12.4	13.7
15	15.6	15.8	15.7	15.3	15.7
20	19.1	19.1	19.1	19.1	19.1
25	22.9	22.9	22.9	22.9	22.9

The values for root reinforcement provided by the grasses were taken from the soil cores taken at each site, shown in yellow in Table 4. Each of these values for grass was assumed to be the starting value for root-reinforcement at zero years, when only native grasses were present in the assemblage. Up until five years of growth the cottonwood trees were assumed to have no effect on the biomass of the native grass roots (Igurdsson *et al*., 1988), with grass root biomass declining to less than 50% of its initial value by approximately 12 years of over storey growth (Sharma *et al*., 1999), and to 0% after 20 years of over storey growth. The values highlighted in yellow were the root-reinforcement values selected for use in the mitigation strategies involving both grasses and trees as, as has previously been explained, 9-years of growth was selected as the critical amount of time for the cottonwood trees to provide significant strength to the streambanks along the study reach.

3.5 Simulations of Alternative Mitigation Strategies

Model runs were first conducted to determine volumes of sediment eroded at each site, using the bank profiles surveyed at each site, with native grasses growing on the bank tops, as is the present condition on the majority of the banks along the study reach. In addition to this first set of model runs, additional runs were conducted with no riparian vegetation, to simulate for example, those sites where cropland extends all the way to the bank edge. Finally, the potential benefits of four different mitigation strategies on bank retreat rates and sediment volumes were investigated. In all cases the "existing" bank profiles surveyed at each site in 2007 were used as the starting bank geometry. To evaluate the effects of individual bank treatments, the following model simulations were conducted:

1) Native grasses present at each site;
2) No top-bank vegetation (e.g. where cropland extends to bank edge);
3) Young cottonwood trees with the existing bank-top grasses;
4) Riprap placed at the bank toe to a height of 1m with no riparian vegetation;
5) Riprap placed at the bank toe to a height of 1m with existing bank-top native grasses; and
6) Riprap placed at the bank toe to a height of 1m with existing bank top grasses and young cottonwood trees.

Volumes of sediment erosion by hydraulic and geotechnical processes, and the number of mass failures were noted for each flow event and bank-stability simulation. As the bank-stability sub-model provides calculations of the amount of failed material in two dimensions (m^2), a reach length of 100 m was assumed for all simulations to provide eroded volumes in m^3.Values were summed for all events to obtain the amount of erosion under the prevailing conditions. This process was then repeated to simulate the effects of bank-toe protection and vegetation as stabilizing factors.

4. RESULTS

4.1 Results of *in situ* Geotechnical Tests

Results of the CSM tests carried out at the five selected sites along the Big Sioux River showed considerable variation in τ_c and k values both between tests conducted at each site, and between the mean values calculated for each site (Table 8). Values of τ_c and k, were fairly consistent within the sets of tests at Castlewood, Brookings and Egan, but varied more at Estelline and Renner (see standard deviations in Table 8). The mean values of τ_c and k, calculated for each site showed that k varied only a small amount between sites (0.08 to 0.12 cm^3/N-s), but the mean τ_c was more variable, ranging from 0.76 Pa at Castlewood to 1.46 Pa at Renner. The mean τ_c and k value for each site was used in BSTEM to represent the erodibility of the toe material. The BST data collected at each site also showed considerable variability between sites. The data in Table 9 indicate the measured apparent cohesion in each bank layer tested, along with the calculated effective cohesion for each layer. Effective cohesion values ranged from 0.0 kPa in the top layer at Estelline (predominantly sand), to 19.85 kPa for the high, steep bank geometry at Renner (high clay content). Similar to the CSM data, the values for c', ϕ' and γ_{sat} given in Table 9 were applied to the appropriate bank layers for each site in BSTEM.

Table 8. Summary of CSM data collected at sites along the Big Sioux River.

Site	τ_c Pa	k cm^3/N-s	Mean τ_c	Mean k^1	Stdev. τ_c	Stdev. k^1
Castlewood	0.88	0.107	**0.76**	**0.12**	0.088	0.007
	0.74	0.116				
	0.67	0.123				
	0.82	0.111				
	0.70	0.119				
Esteline	0.80	0.112	**1.01**	**0.11**	0.568	0.023
	1.85	0.073				
	0.60	0.129				
	0.80	0.112				
Brookings	1.42	0.084	**1.43**	**0.08**	0.012	0.0004
	1.44	0.083				
Egan	1.19	0.092	**1.02**	**0.10**	0.153	0.007
	0.89	0.106				
	0.98	0.101				
Renner	1.02	0.099	**1.46**	**0.10**	0.853	0.042
	0.77	0.114				
	0.33	0.175				
	2.34	0.065				
	2.10	0.069				
	2.18	0.068				

***k^1* : Calculated from Hanson and Simon (2001)**

Table 9. Summary of BST data collected at sites along the Big Sioux River.

Site Name	Layer #	Right or Left Bank	BST Depth	Depth of Layer (From top to bottom (m))	Material	c_a (kPa)	c' (kPa)	ϕ' (degrees)	Pore Pressure (kPa)	γ_{sat}
Castlewood	1	L	1.3	0-1.7	ML-CL	8.245	1.57	13.5	37.9	16.7
	2	L	1.9	1.7-WT	CL-SP	11.8	11.76	33.7	0.2	18.1
Estelline	1	R	0.86	0-1.39	CL-ML	3.63	0.00	34.2	21.8	17.6
	2	R	1.65	1.39-WT	ML-SP	3.03	0.25	31.4	15.8	18.5
Brookings	1	R	0.79	0-1.3	SP-ML	16.0	6.13	16.7	56	18.4
	2	R	1.85	1.3-2.10	ML-SP	12.93	10.52	24.2	13.7	17.3
	3	R	-	2.10-WT	SP	-	-	-	-	-
Egan	1	L	0.91	0-1.00	ML-CL	27	16.7	31.0	58.4	17.0
	2	L	1.27	1.01-2.25	ML-CL	15.6	7.79	19.8	44.3	16.5
	3	L	2.36	2.26-WT	ML-SP	5.3	3.38	30.5	10.9	19.5
Renner	1	R	1.18	0-3.65	ML-SP	10.175	1.67	18.6	75.6	16.6
	2	R	4.63	3.65-WT	ML-CL	29.15	19.85	18.1	82.3	17.8

Table 10. Iterative modeling results for the Big Sioux River at Egan for existing conditions with grasses. F_s is factor of safety; SW=GW is ground-water level set to surface-water level.

Existing Conditions with Grasses (assuming 100 m reach): 90th Percentile Flow Year													
Event #	**Toe erosion**	**Shear stress**	**Amount**	**F_s SW=GW**	**Failure**	**Amount**	**F_s Drawdown**	**Failure**	**Amount**	**Shear emergence**	**Failure Angle**	**Total Erosion**	**Total fines**
		Pa	**m^3**			**m^3**			**m^3**	**m**	**degrees**	**m^3**	**m^3**
1a	**yes**	4.51	314	2.18	no	0	2.03	no	0	2.2	42	314	77.872
1b	**yes**	5.95	43	2.23	no	0	-	-	0	2.2	42	43	10.664
2a	**yes**	4.88	35	2.18	no	0	2.16	no	0	2.2	42	35	8.68
2b	**yes**	9.99	2	2.16	no	0	-	-	0	2.2	42	2	0.496
3a	**yes**	4.56	49	2.1	no	0	1.78	-	0	0.01	30	49	12.152
3b	**yes**	24.89	0.1	2.16	no	0	2.08	no	0	0.01	30	0.1	0.0248
3c	**yes**	18.25	0.001	2.19	no	0	-	-	0	0.01	30	0.001	0.000248
4a	**yes**	42.16	0.885	2.11	no	0	1.87	**no**	0	0.01	30	0.885	0.21948
4b	**no**	20.36	0	2.18	no	0	-	**-**	0	0.01	30	0	0
5a	**yes**	5.94	127.3	1.8	no	0	1.07	no	0	0.01	35	127.3	31.5704
5b	**yes**	2.73	8.3	1.71	no	0	-	-	0	0.01	35	8.3	2.0584
6a	**yes**	3.86	31.5	1.56	no	0	1.34	no	0	0.01	35	31.5	7.812
6b	**yes**	2.83	6.4	1.55	no	0	1.47	no	0	0.01	35	6.4	1.5872
6c	**yes**	1.67	5.7	1.55	no	0	-	-	0	0.01	35	5.7	1.4136
7a	**yes**	4.73	60.2	1.28	no	0	0.76	yes	654	0.01	45	714.2	177.1216
7b	**yes**	2.16	6.7	2.41	no	0	-	-	0	0.01	35	6.7	1.6616
8a	**yes**	2.86	12.6	2.1	no	0	1.91	no	0	0.01	35	12.6	3.1248
8b	**yes**	1.13	2.1	2.03	no	0	-	-	0	0.01	35	2.1	0.5208
TOTALS			**705**		**0**	**0**		**1**	**654**			**1359**	**337**

4.2 Estimates of Eroded Sediment Volumes, and Relative Contributions from Hydraulic Scour versus Mass Failure.

Results of the BSTEM analysis for a range of percentile flow years (90th, 75th, 50th, 25th and 10th) showed that predicted eroded volumes of sediment emanating from streambanks decreased non-linearly from the 90th percentile flow year to the 10th percentile flow year, in all cases except for results from the Castlewood site, which will be explained in more detail later in this section. An example of the results table obtained from each set of iterative runs for a given flow year is shown in Table 10, indicating factor of safety at each stage of the modeling process, and the amounts of erosion occurring during each storm event.

4.2.1 BSTEM runs for existing bank conditions with native grass cover. Predicted volumes of sediment eroded from the streambanks at each site ranged from 169 to 1359 m^3 of sediment per 100 m reach during the 90th percentile year, under existing conditions whereby the banks have a cover of native grasses (Table 14). These volumes of eroded sediment were predicted to fall to 0 to 21 m^3 per 100-m reach during the modeled 10th percentile flow year, again, assuming existing bank top vegetation. Overall, the sites investigated at Brookings and Egan showed the highest volumes of sediment predicted to erode in all percentile flow years, with the site at Estelline showing generally the lowest sediment volumes.

Bank failures were generally only predicted to occur during the 90th percentile flow year modeled at each site. The exception to this finding was the site at Castlewood, where one bank failure also occurred during the 50th and 10th percentile flow years, as a result of rapid drawdown occurring after one storm in each of those flow years. This drawdown condition destabilized the upper part of this bank, leading to a bank failure in each case. At all the other sites bank failures only occurred during BSTEM runs for the 90th percentile flow year, and in each case only one failure was observed throughout the entire year modeled. Additionally, it should be noted that the site at Renner was not predicted to have any bank failures occurring, under any of the hydrologic conditions modeled, largely due to the fact that water table height was assumed to equal flow depth at the peak of each hydrograph. As such, the pore-water pressures in the upper part of the 17-m high embankment modeled at Renner never became sufficient enough to induce a bank failure. Inclusion of infiltrating rainfall to the upper part of the bank may have modified this outcome.

4.2.2 BSTEM runs with the addition of toe protection to existing banks. The addition of toe protection (up to 1m) to banks with existing native grass cover greatly reduced the volume of bank material predicted to erode at each site by 87-100 % (Table 11) by protecting the base of the banks from hydraulic scour and thus over-steepening. In all cases the addition of toe protection to the existing bank condition (with grasses) thereby prevented bank failures from occurring. In the case of Castlewood, Egan and Renner, the volume of eroded sediment was reduced to 0 m^3 for all percentile flow years. model results showed that when bank failures are taking place the contribution to total erosion from toe scour may not be that high (16 to 50% of total erosion came from toe scour during 90th percentile year model runs where bank failures occurred, under existing conditions with grasses; Tables 14-16; Figures 13-15). However, if this toe scour can be prevented, the overall volume of eroded bank material can be reduced by 87 – 100 %. This is a similar result to that found by Simon et al. (2008) on a study of the contributions to sediment loadings from banks of the Upper Truckee River, in California.

Table 11. Percent change from existing bank with grass and no toe protection, to existing bank with toe protection

SITE	PERCENTILE FLOW YEAR				
	90	75	50	25	10
CASTLEWOOD	-100.0	-100.0	-100.0	-100.0	-100.0
ESTELLINE	-87.0	-87.8	-90.0	-94.1	-100.0
BROOKINGS	-97.3	-96.0	-91.2	-100.0	-100.0
EGAN	-100.0	-100.0	-100.0	-100.0	-100.0
RENNER	-100.0	-100.0	-100.0	-100.0	-

NB. Positive numbers indicate more bank and toe erosion and negative numbers indicate reduced bank and toe erosion.

4.2.3 BSTEM runs with no riparian vegetation. The stability of the banks at each site without any vegetative cover was investigated in one set of BSTEM runs. This set of runs indicated the stability of the banks in cases where vegetation is absent, for example, in cases where agricultural production has been extended to the edge of the streambanks, as is the case at certain locations along the study reach of the Big Sioux. These runs showed that during the 90th percentile flow year, the predicted volume of eroded sediment was higher for banks with no riparian vegetation at the Castlewood, Estelline and Brookings sites, with increases of 41 to 352 % (Table 12). The reason for this, is that the existing riparian vegetation (native grasses) provided additional cohesion to the upper part of the bank, which acted as an additional resisting force and reduced the predicted volume of eroded sediment when compared to the case without vegetation. At Estelline the model run involving no existing riparian vegetation indicated one bank failure during the 90th percentile flow year, where none were predicted with riparian vegetation present. For the Castlewood and Brookings sites, one bank failure was predicted at each site whether or not riparian vegetation was present, but the magnitude of the bank failure was greater when no vegetation was present. No increase in eroded volume of sediment was predicted at the Egan and Renner sites when vegetation was removed from the model runs. In the case of Egan, the same size bank failure was recorded whether or not the extra resisting force provided by the roots of the native grasses was present. At Renner no bank failures occurred either with or without riparian vegetation. The model runs performed here only accounted for root-reinforcement. In addition, at certain times of the year vegetation will help to reduce streambank pore water pressures, thus further increasing bank stability (Simon and Collison, 2002)

For the remaining percentile flow years, in almost all cases, no difference was seen between the runs with and without existing riparian vegetation, as the presence or absence of riparian vegetation had no effect on erosion of material from the bank toe, and no failures occurred during the lower percentile flow years. As was the case with the BSTEM runs for existing conditions, the exception to this rule was the site at Castlewood. It is interesting to note that the presence of native riparian grasses on the top of the banks modeled, did not reduce the number of failure events at Castlewood and Brookings, but it did reduce the volume of material eroded during each bank failure.

Table 12. Percent change from existing bank with grass and no toe protection, to bare bank

SITE	PERCENTILE FLOW YEAR 90	75	50	25	10
CASTLEWOOD	40.6	0.0	467.9	0.0	1410.0
ESTELLINE	352.1	0.0	0.0	0.0	0.0
BROOKINGS	42.3	0.0	0.0	0.0	0.0
EGAN	0.0	0.0	0.0	0.0	0.0
RENNER	0.0	0.0	0.0	0.0	-

NB. Positive numbers indicate more bank and toe erosion and negative numbers indicate reduced bank and toe erosion.

4.2.4 BSTEM runs for banks with no riparian vegetation, but with the addition of toe protection. This set of model runs investigated the result of adding toe protection to banks where there is currently no riparian buffer. BSTEM runs showed that the addition of toe protection to a height of 1m up the bank, prevented bank failures from occurring at both the Brookings and Egan sites by preventing erosion at the base of the bank by hydraulic scour and thus stopping the bank from over-steepening and becoming unstable. At Castlewood and Estelline one bank failure was still predicted to occur at each site during the 90th percentile flow year, in both cases as a result of destabilization of the upper part of the bank during drawdown conditions after a large flow event. It was noted however, that the volume of material eroded during each mass failure event was smaller when toe protection was present, compared to the same bank with no vegetation or toe protection present as only the upper part of the bank failed, and the toe remained protected. The addition of toe protection to an un-vegetated bank was shown to greatly reduce volumes of sediment emanating from the banks, by 71 % at the Estelline site to 100 % at the Egan and Renner sites. Similar to the case reported in section 4.2.2, although toe erosion only accounted for 12 – 52 % of total erosion when mass failures occurred from banks modeled with no vegetation, by reducing the scour of toe material with the addition of toe protection, thereby preventing over steeping of the banks, overall erosion was reduced by 71-100 % (Table 13; Figures 13 – 15).

Table 13. Percent change bare bank with no vegetation and no toe protection, to bare bank with toe protection

SITE	PERCENTILE FLOW YEAR 90	75	50	25	10
CASTLEWOOD	-79.8	-100.0	6.3	-100.0	-0.7
ESTELLINE	-70.8	-87.8	-90.0	-94.1	-100.0
BROOKINGS	-98.1	-96.0	-91.2	-100.0	-100.0
EGAN	-100.0	-100.0	-100.0	-100.0	-100.0

RENNER	-100.0	-100.0	-100.0	-100.0	-

NB. Positive numbers indicate more bank and toe erosion and negative numbers indicate reduced bank and toe erosion.

4.2.5 BSTEM runs with the addition of 9-year old Cottonwood trees to existing banks and existing banks with toe protection. The addition of 9-year-old cottonwood trees to the riparian buffer assemblage in BSTEM runs did act to increase the factor of safety values at each stage of the iteration through the individual flow events in each year modeled. However, in these scenarios, the increases in bank factor of safety were never large enough to prevent any of the bank failures from occurring that were predicted in the existing condition with just native grasses growing on the top of the banks. As riparian vegetation did not have an effect on the amount of erosion occurring at the bank toe in these model runs, the addition of cottonwood trees of this age to the riparian species assemblage modeled did not make a difference to the overall volumes of sediment eroded in each flow year. It can therefore be concluded that under the conditions modeled, newly planted trees in the riparian buffer zone would take more than nine years to provide any significant impact to overall amounts of sediment delivered to the river from the streambanks.

Table 14. Predicted eroded sediment volumes at each site, for each percentile flow year modeled, and under different bank treatment options. Values are in m^3 per 100-m reach of river and include both toe erosion and mass wasting.

ALL EROSION in m^3 per 100m reach

	NO VEGEGATION, NO TOE PROTECTION				
	90	75	50	25	10
CASTLEWOOD	665	42	159	2	151
ESTELLINE	764	98	40	17	12
BROOKINGS	1383	200	125	13	10
EGAN	1359	218	190	32	21
RENNER	680	78	25	29	0
	TOE PROTECTION				
	90	75	50	25	10
CASTLEWOOD	134	0	169	0	150
ESTELLINE	223	12	4	1	0
BROOKINGS	26	8	11	0	0
EGAN	0	0	0	0	0
RENNER	0	0	0	0	0
	WITH BANK TOP VEGETATION - GRASSES – EXISTING CASE				
	90	75	50	25	10
CASTLEWOOD	473	42	28	2	10
ESTELLINE	169	98	40	17	12
BROOKINGS	972	200	125	13	10
EGAN	1359	218	190	32	21
RENNER	680	78	25	29	0
	WITH BANK TOP VEGETATION –COTTONWOOD TREES + GRASS ES				
	90	75	50	25	10
CASTLEWOOD	473	42	28	2	10
ESTELLINE	169	98	40	17	12
BROOKINGS	972	200	125	13	10
EGAN	1359	218	190	32	21
RENNER	680	78	25	29	0
	WITH TOE PROTECTION + BANK TOP VEG - GRASSES				
	90	75	50	25	10
CASTLEWOOD	0	0	0	0	0
ESTELLINE	22	12	4	1	0
BROOKINGS	26	8	11	0	0
EGAN	0	0	0	0	0
RENNER	0	0	0	0	0
	WITH TOE PROTECTION + BANK TOP VEGETATION -CW TREES + GRASSES				
	90	75	50	25	10
CASTLEWOOD	0	0	0	0	0
ESTELLINE	22	12	4	1	0
BROOKINGS	26	8	11	0	0
EGAN	0	0	0	0	0
RENNER	0	0	0	0	0

Table 15. Predicted eroded sediment volumes at each site, for each percentile flow year modeled, and under different bank treatment options. Values are in m^3 per 100-m reach of river and include just the volumes eroded by hydraulic scour of the bank toe.

TOE EROSION in m^3 per 100m reach

	90	75	50	25	10
	NO VEGETATION, NO TOE PROTECTION				
CASTLEWOOD	79	42	28	2	142
ESTELLINE	198	98	40	17	12
BROOKINGS	464	200	125	13	10
EGAN	704	218	190	32	21
RENNER	680	78	25	29	0
	TOE PROTECTION				
CASTLEWOOD	0	0	0	0	0
ESTELLINE	13	12	4	1	0
BROOKINGS	26	8	11	0	0
EGAN	0	0	0	0	0
RENNER	0	0	0	0	0
	WITH BANK TOP VEG - GRASSES – EXISTING CASE				
CASTLEWOOD	76	42	28	2	10
ESTELLINE	169	98	40	17	12
BROOKINGS	363	200	125	13	10
EGAN	704	218	190	32	21
RENNER	680	78	25	29	0
	WITH BANK TOP VEG -COTTONWOOD TREES + GRASS ES				
CASTLEWOOD	76	42	28	2	10
ESTELLINE	169	98	40	17	12
BROOKINGS	363	200	125	13	10
EGAN	704	218	190	32	21
RENNER	680	78	25	29	0
	WITH TOE PROTECTION + BANK TOP VEG ETATION - GRASSES				
CASTLEWOOD	0	0	0	0	0
ESTELLINE	22	12	4	1	0
BROOKINGS	26	8	11	0	0
EGAN	0	0	0	0	0
RENNER	0	0	0	0	0
	WITH TOE PROTECTION + BANK TOP VEGETATION -CW TREES + GRASSES				
CASTLEWOOD	0	0	0	0	0
ESTELLINE	22	12	4	1	0
BROOKINGS	26	8	11	0	0
EGAN	0	0	0	0	0
RENNER	0	0	0	0	0

Table 16. Predicted eroded sediment volumes at each site, for each percentile flow year modeled, and under different bank treatment options. Values are in m^3 per 100-m reach of river and include just the volumes of sediment eroded by mass wasting of the banks.

MASS WASTING EROSION in m^3 per 100m reach

	NO VEGETATION, NO TOE PROTECTION				
	90	75	50	25	10
CASTLEWOOD	427	0	131	0	9
ESTELLINE	566	0	0	0	0
BROOKINGS	919	0	0	0	0
EGAN	654	0	0	0	0
RENNER	0	0	0	0	0
	TOE PROTECTION				
	90	75	50	25	10
CASTLEWOOD	134	0	169	0	150
ESTELLINE	210	0	0	0	0
BROOKINGS	0	0	0	0	0
EGAN	0	0	0	0	0
RENNER	0	0	0	0	0
	WITH BANK TOP VEG - GRASSES – EXISTING CASE				
	90	75	50	25	10
CASTLEWOOD	397	0	0	0	0
ESTELLINE	0	0	0	0	0
BROOKINGS	609	0	0	0	0
EGAN	654	0	0	0	0
RENNER	0	0	0	0	0
	WITH BANK TOP VEG -COTTONWOOD TREES + GRASS ES				
	90	75	50	25	10
CASTLEWOOD	397	0	0	0	0
ESTELLINE	0	0	0	0	0
BROOKINGS	609	0	0	0	0
EGAN	654	0	0	0	0
RENNER	0	0	0	0	0
	WITH TOE PROTECTION + BANK TOP VEGETATION - GRASSES				
	90	75	50	25	10
CASTLEWOOD	0	0	0	0	0
ESTELLINE	0	0	0	0	0
BROOKINGS	0	0	0	0	0
EGAN	0	0	0	0	0
RENNER	0	0	0	0	0
	WITH TOE PROTECTION + BANK TOP VEGETATION -CW TREES + GRASS ES				
	90	75	50	25	10
CASTLEWOOD	0	0	0	0	0
ESTELLINE	0	0	0	0	0
BROOKINGS	0	0	0	0	0
EGAN	0	0	0	0	0
RENNER	0	0	0	0	0

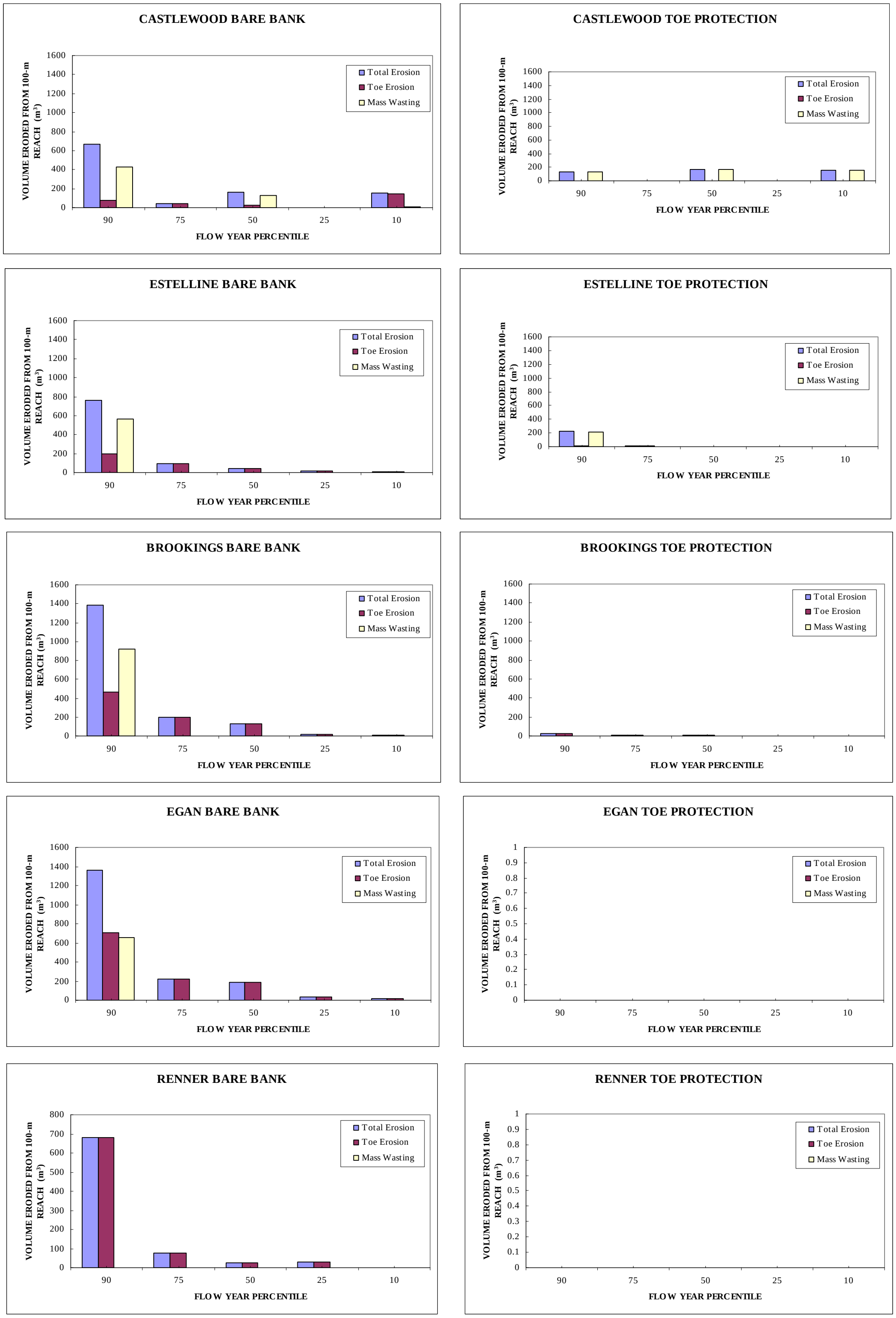


Figure 13. Graphs showing total volumes of sediment eroded at each site, and the volumes separated into toe erosion and mass wasting.

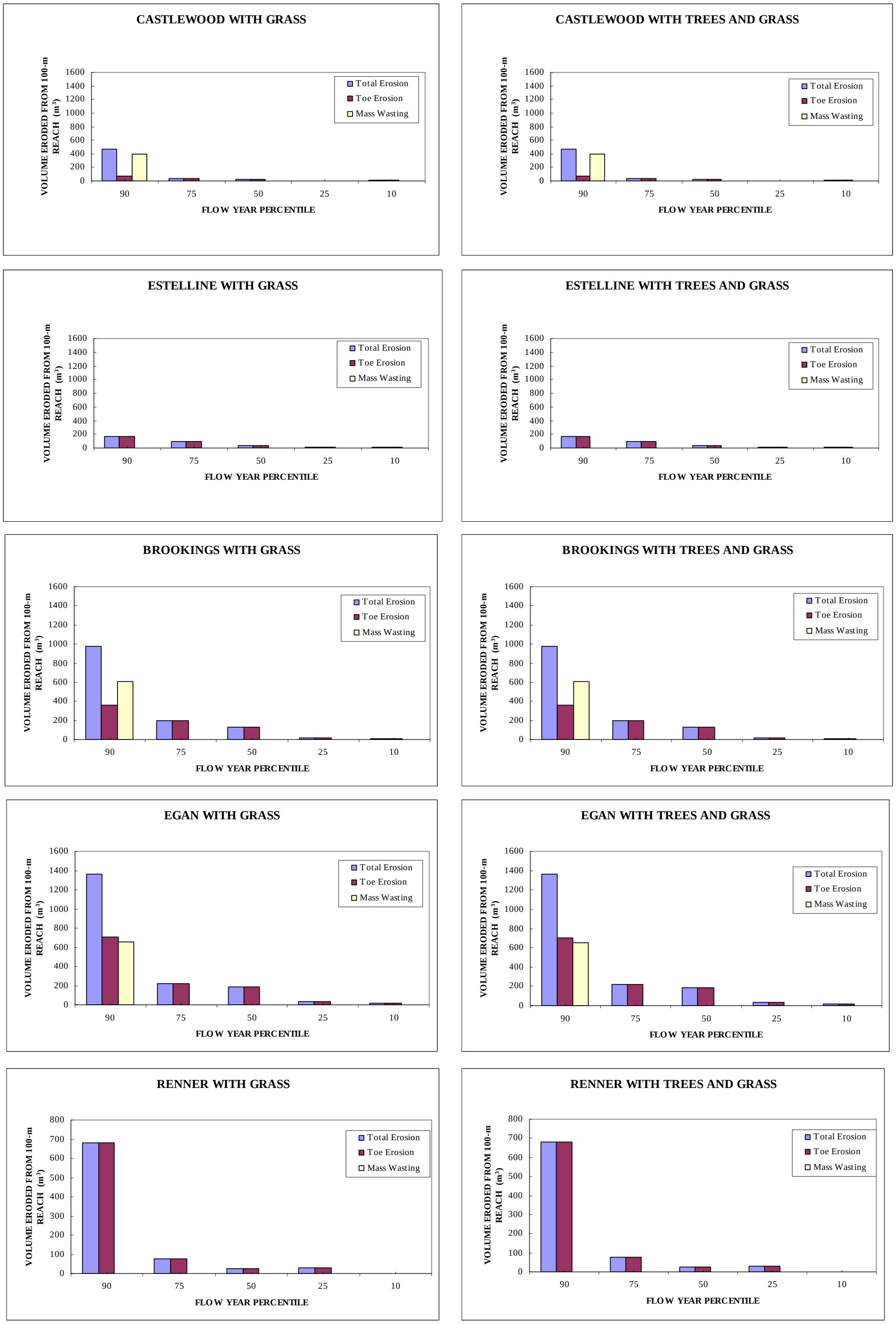


Figure 14. Graphs showing total volumes of sediment eroded at each site, and the volumes separated into toe erosion and mass wasting.

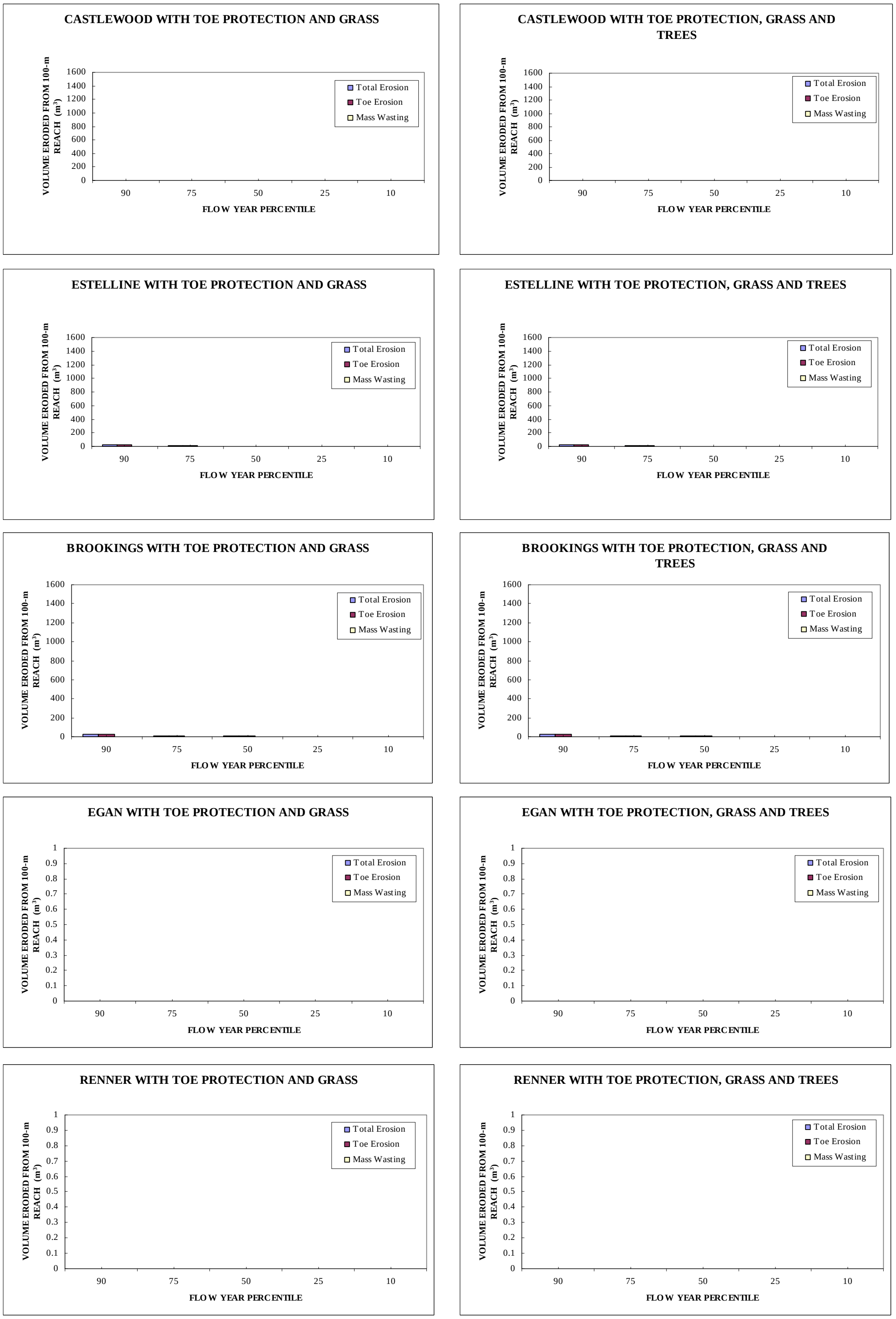


Figure 15. Graphs showing total volumes of sediment eroded at each site, and the volumes separated into toe erosion and mass wasting.

4.3 Predicted Changes in Channel Cross-Section Geometry under different mitigation strategies.

In all cases, the banks modeled with no riparian vegetation and no toe protection showed the most change in their bank profiles, as shown in Figures 16 - 20. As with the volumes of eroded sediment reported in section 4.2, changes to the bank profile were greatest after the 90th percentile flow year runs, with changes to the bank profiles rapidly diminishing for the 75th through 10th percentile flow years.

4.3.1 The effect of riparian vegetation and toe protection on bank profiles. The bank profiles for Estelline provide a useful example of the effects of both vegetation and toe protection on the shape of the bank profile. The shape of the Estelline bank in Figure 17 shows that the addition of toe protection prevented scour at the base of the bank, but with toe protection alone, the upper part of the bank still experienced a bank failure, reducing the angle of the upper bank. In contrast, the profile shown for the bank modeled with just riparian vegetation shows how the vegetation prevented bank failure of the upper part of the bank, and the steeper upper bank profile was therefore maintained. However, in this case it can be seen that the toe of the bank was eroded and steepened by hydraulic scour. The profile showing results with riparian vegetation and toe protection being present in the model runs showed however, both the toe of the bank remaining in place, and also the upper part of the bank.

At the Brookings site, a slightly different scenario was seen. At this site, the addition of toe protection was sufficient to prevent failure of the upper part of the bank by preventing over-steepening of the bank. It is interesting to note from the bank profiles at this site (Figure 18), that the presence of riparian vegetation alone was not sufficient to prevent a failure of the upper bank, because toe erosion over-steepened the bank to a critical point. The differences at just these two sites indicate that the results of different treatment options may vary at each bank location, and that often more than one approach is required to stabilize a bank because of the complex combination of both hydraulic and geotechnical processes occurring.

At Renner, almost no change to the bank profile after the range of flow years modeled, and the high, steep side-slope was not predicted to fail. Some toe erosion was seen in the model runs and over time such erosion may lead to steepening of the bank to a critical configuration.

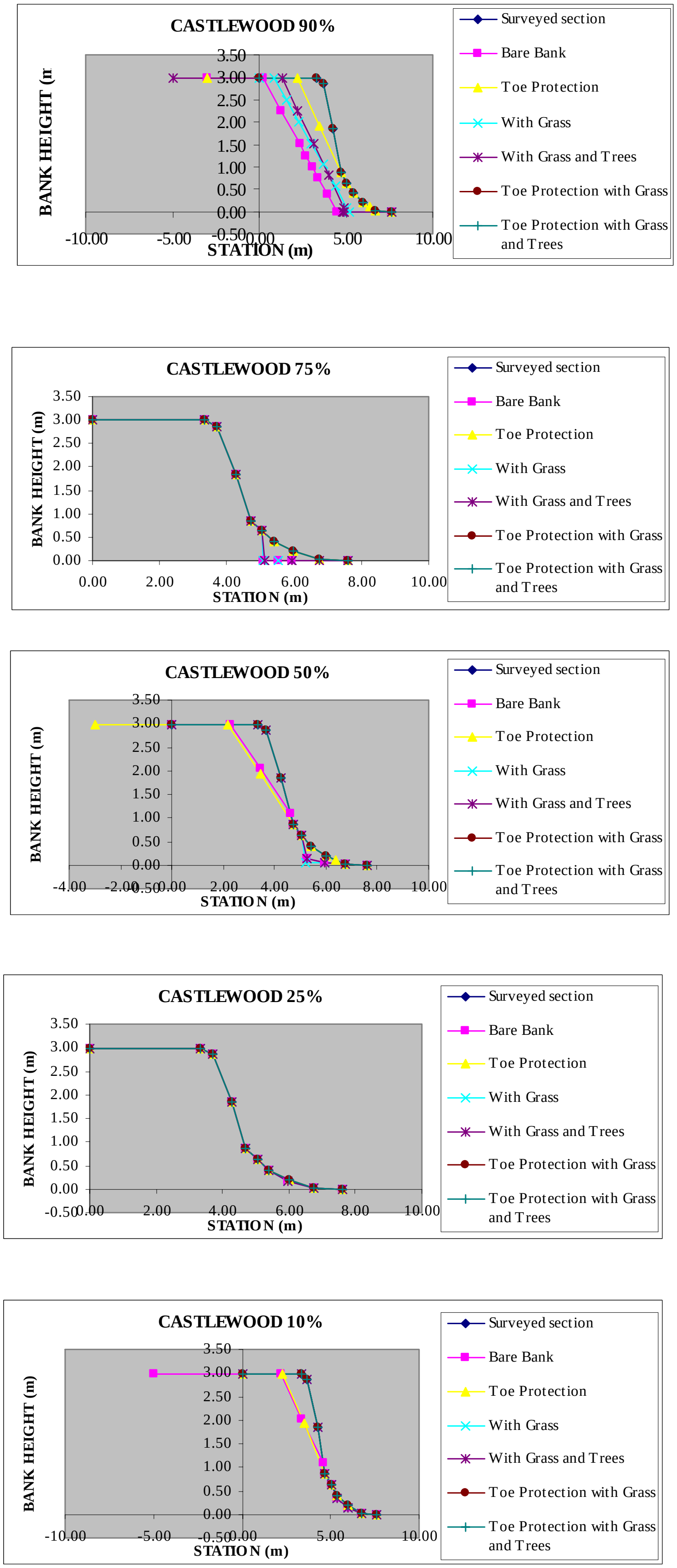
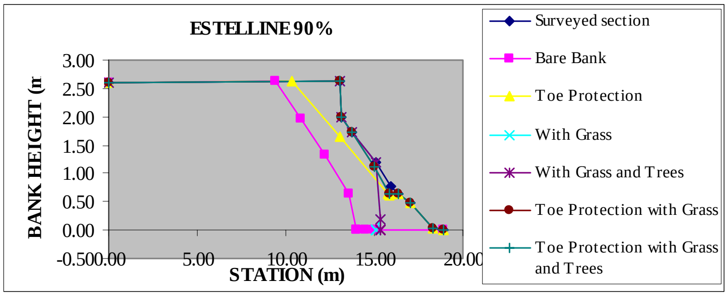
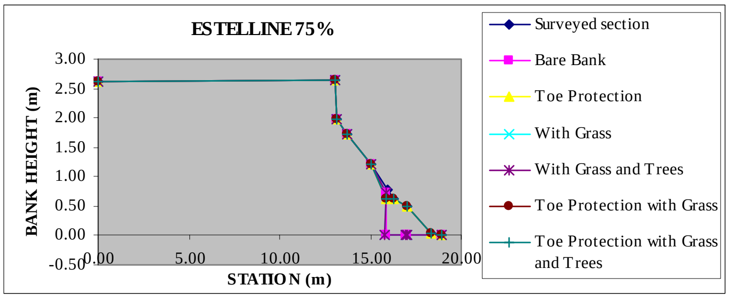
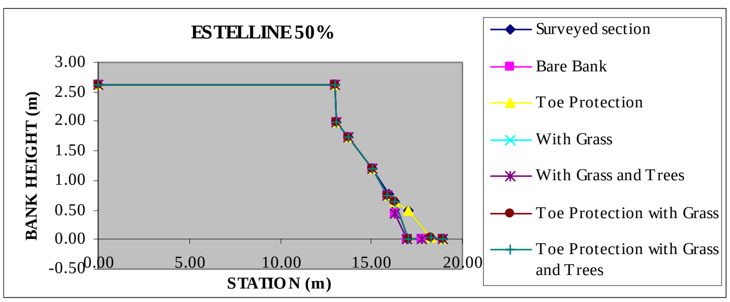
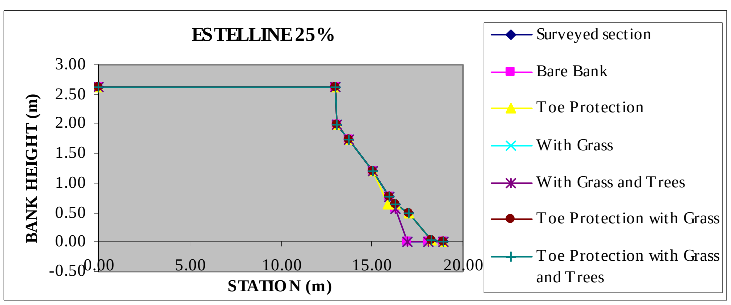


Figure 16. Changes in bank profiles for Castlewood site after different percentile flow years and with different bank treatments.









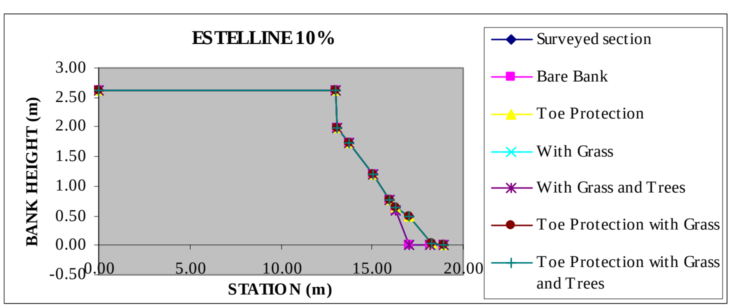


Figure 17. Changes in bank profiles for Estelline site after different percentile flow years and with different bank treatments.

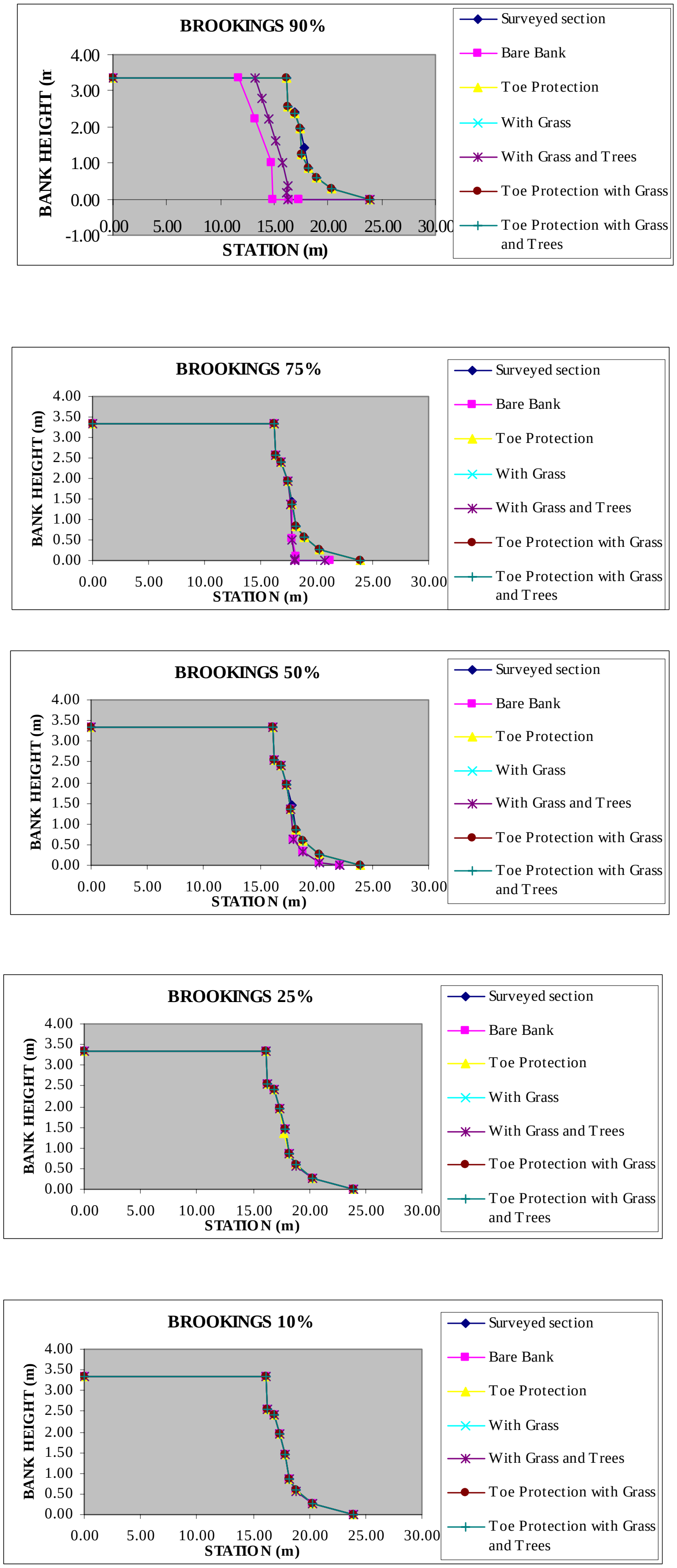


Figure 18. Changes in bank profiles for Brookings site after different percentile flow years and with different bank treatments.

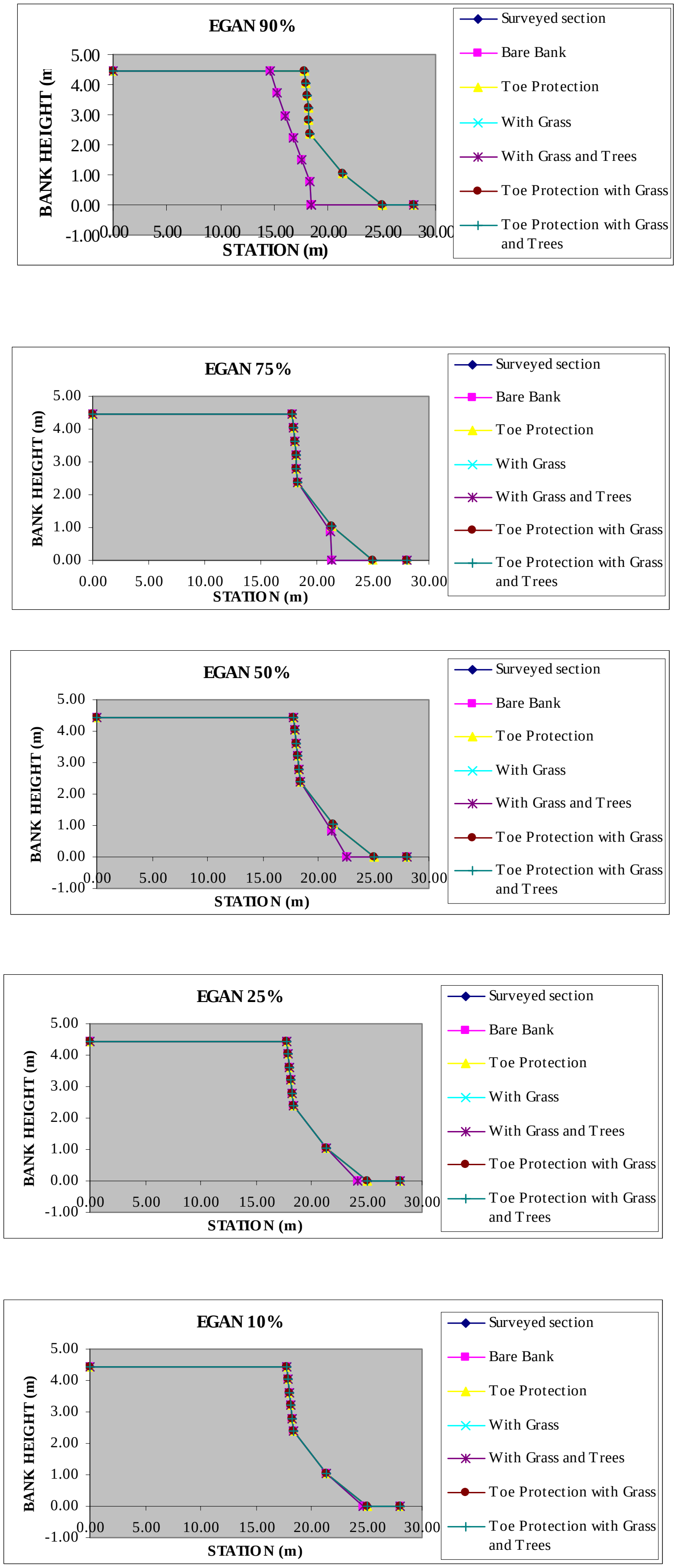


Figure 19. Changes in bank profiles for Egan site after different percentile flow years and with different bank treatments.

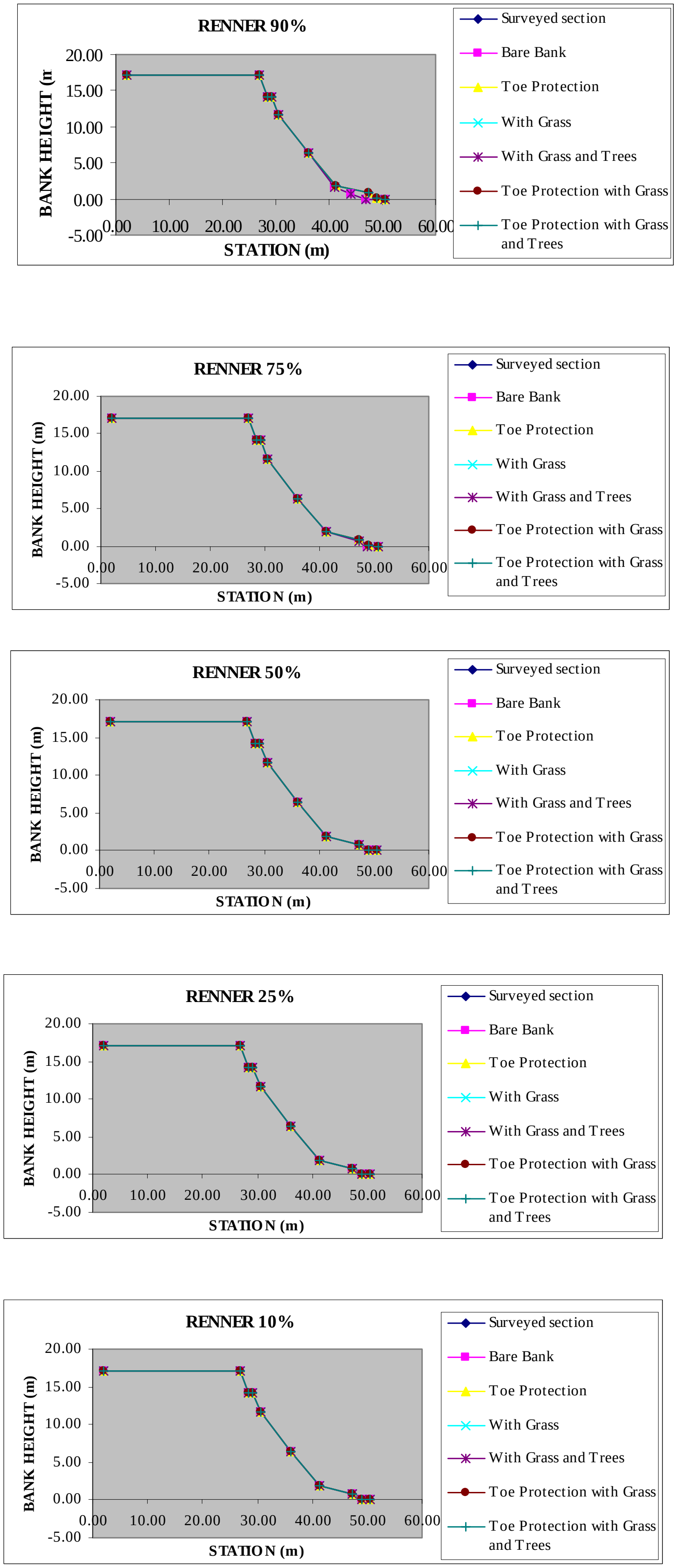


Figure 20. Changes in bank profiles for Renner site after different percentile flow years and with different bank treatments.

5. APPLICATION and EXTRAPOLATION OF RESULTS

The significant reductions in streambank erosion predicted by iterative modeling pertains to conditions at representative sites for the modeled flow years yet have provided a relatively consistent estimate of the reduction in the amount of sediment provided from the study sites. Extrapolation of these findings over time and space was required to obtain:

(1) average, annual streambank loadings,
(2) a means to compare simulated erosion rates with measured data from USGS stream gages, and
(3) an estimate of the total load reduction that could be anticipated for the 300 km study length along the Big Sioux River.

5.1. Temporal Extrapolation: Average, Annual Streambank Loadings at a Site.

Simulations were conducted for the different flow years discussed in the Methods Section representing the 90th, 75th, 50th, 25th, and 10th flow-magnitude years. Simulated loadings for the control case of existing geometry with top-bank grasses are shown as an example in Table 17 and plotted in Figure 21. To obtain estimates of average, annual loadings for each site, simulated volumes for each percentile flow year were multiplied by the appropriate weighting factor to reflect the percent of time that the flow would occur over the long term. Thus, volumes simulated for the 90th percentile year were multiplied by 0.1; by 0.25 for the 75th percentile year and so on. Results for the control condition are shown in Table 18. Average, annual values are then calculated by summing each row. Values are further converted from m^3/100 m to m^3/km. Average, annual loadings values were also converted to tonnes per kilometer (T/km) using the average, bulk unit weight of the bank material obtained from field samples (Table 19). This procedure was conducted for each set of modeling runs representing the different bank conditions and mitigation strategies

Table 17. Unit loading values per 100 m of channel for the control case of existing geometry with top-bank grasses.

Site	Percentile of Flow Magnitude				
	90	75	50	25	10
	Volume eroded in m^3/100 m of channel				
Castlewood	473	42	28	2	10
Estelline	169	98	40	17	12
Brookings	972	200	125	13	10
Egan	1359	218	190	32	21
Renner	680	78	25	29	0

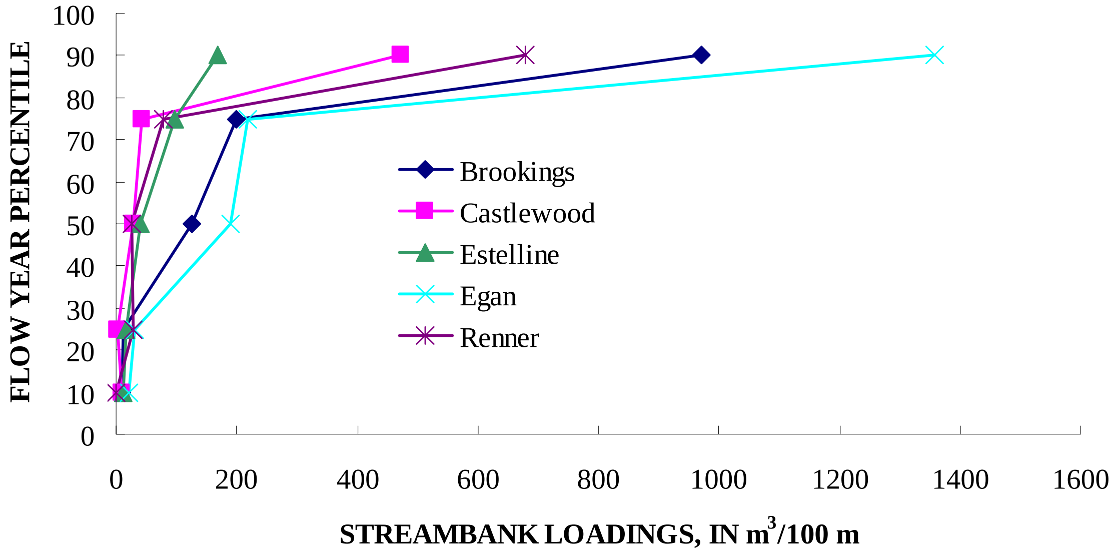


Figure 21. Unit streambank loadings per 100 m of channel for the control case of existing geometry with top-bank grasses.

Table 18. Example results of weighting values from Table 17 to produce average, annual streambank loadings expressed as a volume (m^3/km) and a mass (T/km).

Site	Percentile of Flow Magnitude					Average annual		
	90	75	50	25	10			
	Volume eroded							
	m^3/100 m						m^3/km	T/km
Castlewood	47.3	10.5	14.0	1.5	9.0	82.3	823	14.3
Estelline	16.9	24.5	20.0	12.8	10.8	85.0	850	15.3
Brookings	97.2	50.0	62.5	9.8	9.0	228	2285	40.9
Egan	136	54.4	95.0	24.0	18.9	328	3282	58.1
Renner	68.0	19.5	12.5	21.8	0.0	122	1218	20.6

Table 19. Average bulk unit weight values obtained from field samples used to convert streambank loadings from volume in m^3/km to mass in T/km.

Site	Castlewood	Estelline	Brookings	Egan	Renner
Bulk unit weight, in kN/m^3	17.4	18.0	17.9	17.7	16.9

It is important to keep in mind that the average, annual values displayed in Table 18 represent streambank loadings for only the 1 km reach in the vicinity of each site and not the loadings for the entire study reach. To calculate that, the average, annual data for the study sites must be extrapolated over the length of the channel.

5.2 Spatial Extrapolation: Streambank Loadings for the Entire Study Reach.

Average, annual streambank loadings for the entire study reach were calculated using a procedure that combined the modeled results for the representative sites (expressed as unit loadings per 100 m) with observations of the longitudinal extent of recent bank failures along the length of the main-stem channel. Rapid geomorphic assessments (RGAs) that use diagnostic characteristics of channel form to infer dominant, active processes were used for this purpose. The dominant process and the extent of recent bank failures were noted for each bank in a reach (6-20 channel widths in length) and expressed as one of five percentage ranges (0-10%, 11-25%, 26-50%, 51-75%, 76-100%) representing the length of the reach that had experienced recent bank failures. The midpoint of the range (ie. 18% for the 11-25% class) for each bank (left and right) was used to calculate a local average failure extent. The midpoint of the range was also used to calculate a maximum failure extent for the reach. Both of these indices are shown graphically in Figure 22 and are mapped in Figure 23.

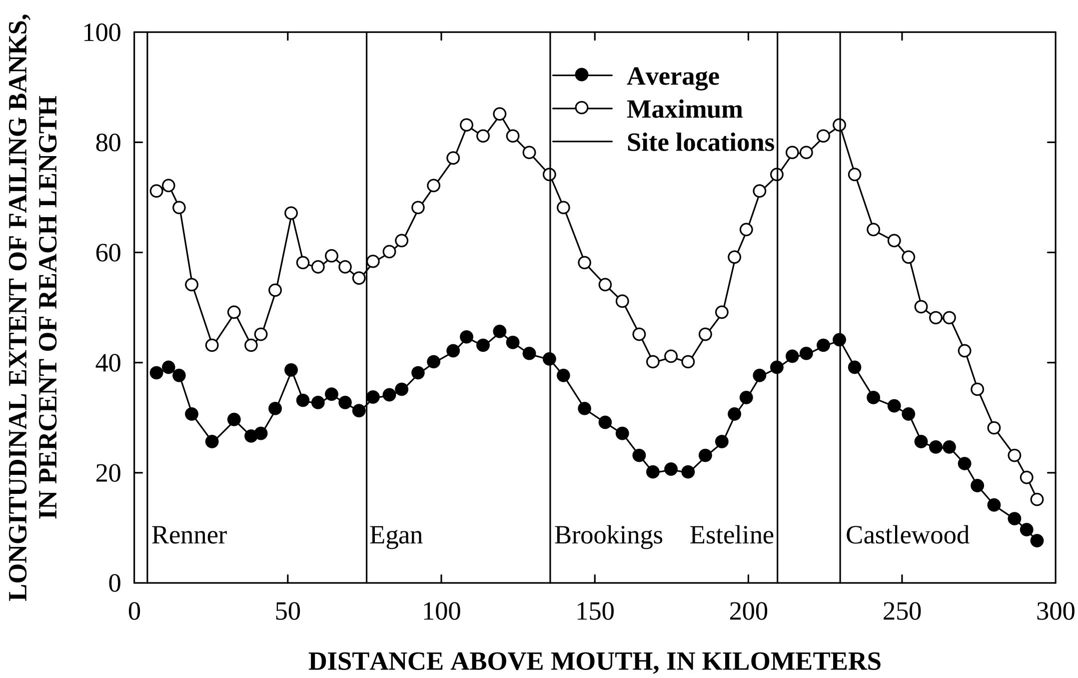


Figure 22. Average and maximum longitudinal extent of recent bank failures expressed as percent of reach length.

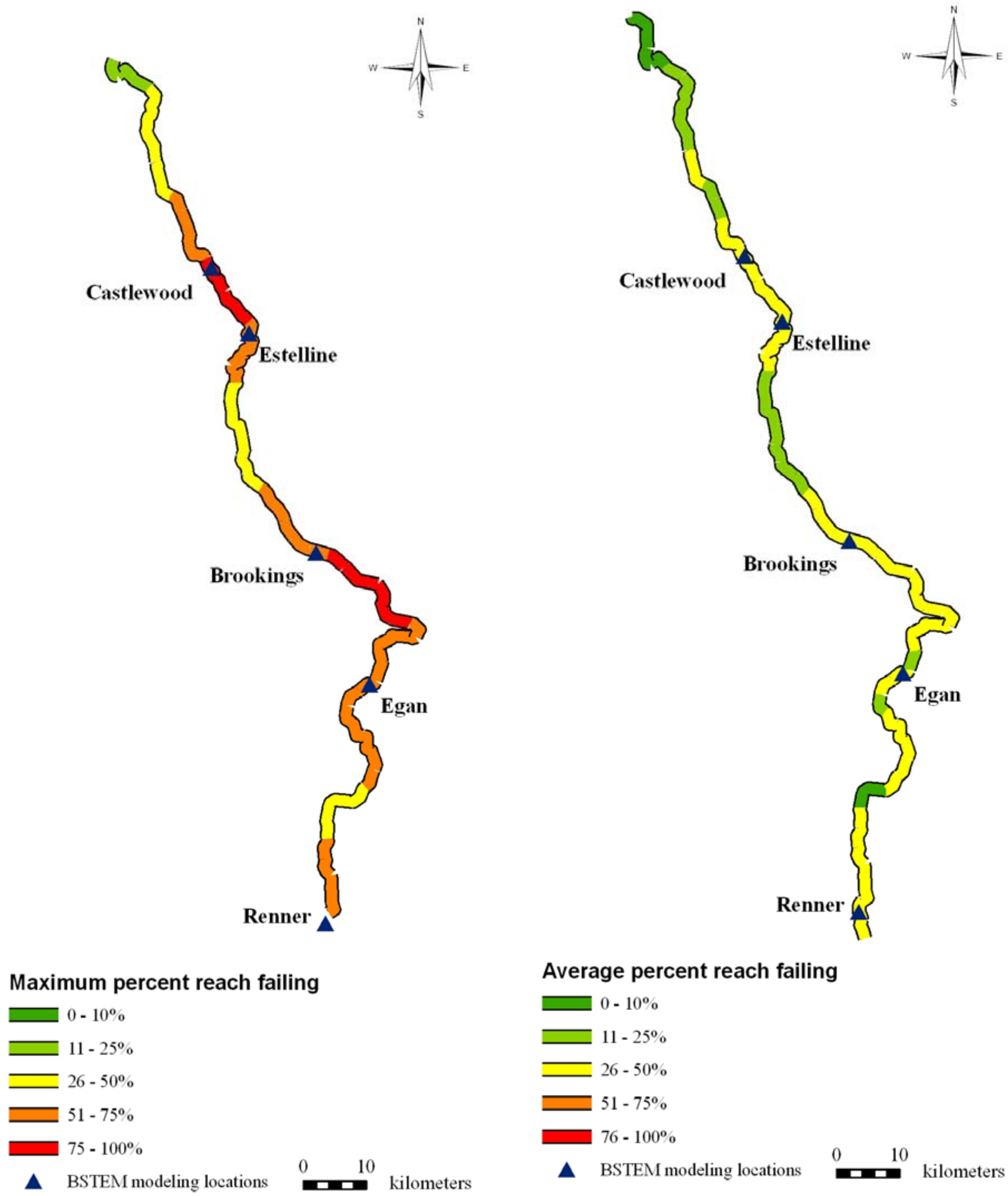


Figure 23. Maps showing the maximum percent reach failing (left) and average percent of banks failing (right) along the study reach of the Big Sioux river, SD.

To obtain a loading value (in m^3) for a given reach, a weighting factor, defined as the product of the reach length (in km) and the percent of reach failing was calculated. This value was then multiplied by 10 times a unit loading value (in m^3/100m) to obtain the volume of material eroded over the length of the reach, and then summed for all reaches to obtain a total value for streambank loadings.

Two general methods of extrapolating unit streambank loadings over the length of the Big Sioux River were tested for reliability and consistency. The first method is similar to the procedure used for the Upper Truckee River, California (Simon *et al*., 2008). Here, the authors classified both the observed percent of reach failing for each reach and the unit loading rates under a given modeling scenario as low, moderate or high. Unit loads associated with the three classes were selected for each modeling scenario by comparing bank-derived sediment volumes estimated from the numerical simulations. The appropriate unit loading rate was then matched to the class of "percent of reach failing" for each reach such that a high "percent reach failing" was multiplied by the high unit loading rate; moderate percent failing with the moderate unit loading rate, and so on. Classes of "percent of reach failing" were arbitrarily assigned. These are shown along with examples of the associated unit loading rates for the control simulations of existing geometry with top-bank grasses for the 90th percentile flow year and for average, annual conditions (Table 20).

Table 20. Values for percent reach failing for all modeling scenarios and example unit streambank loadings for the control simulations of existing geometry with top-bank grasses for the 90th percentile flow year and for average, annual conditions.

Class	Average percent failing	Maximum percent failing	Unit loading rate for 90th percentile flow year (m^3/km)	Unit loading rate for average, annual conditions (m^3/km)
Low	< 20	< 40	1690	836
Moderate	20 - 40	40 - 80	5765	1218
High	>40	> 80	11655	2783

Instead of using classed values of unit loadings and percent reach failing, the second method of extrapolating streambank loadings was to establish a relation between the two variables for the 90th percentile flow year. These flow conditions were used exclusively because it is under these wetter, high-flow conditions that bank instabilities do occur. The resulting relation shown in Figure 24, therefore, provides a continuous distribution of unit stream loading values to be applied for a given value of percent reach failing.

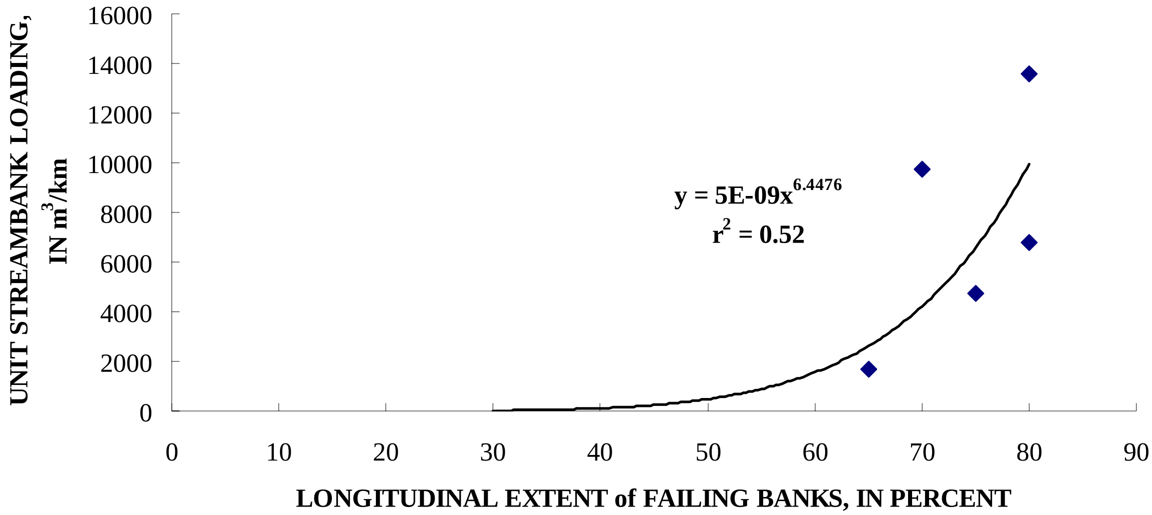


Figure 24. Relation between unit streambank loading and percent reach failing for the control condition of existing geometry and top-bank grasses for the 90th percentile flow year.

The result of applying the unit streambank loadings for the 90th percentile flow year by the two methods produces similar trends of streambank loadings (in m^3) (Figure 25). As one might expect there was a greater range in the results using Method 2 (the regression equation) because of the greater range of applied unit loadings (Figure 24) than for the low/medium/high classed values from Table 20.

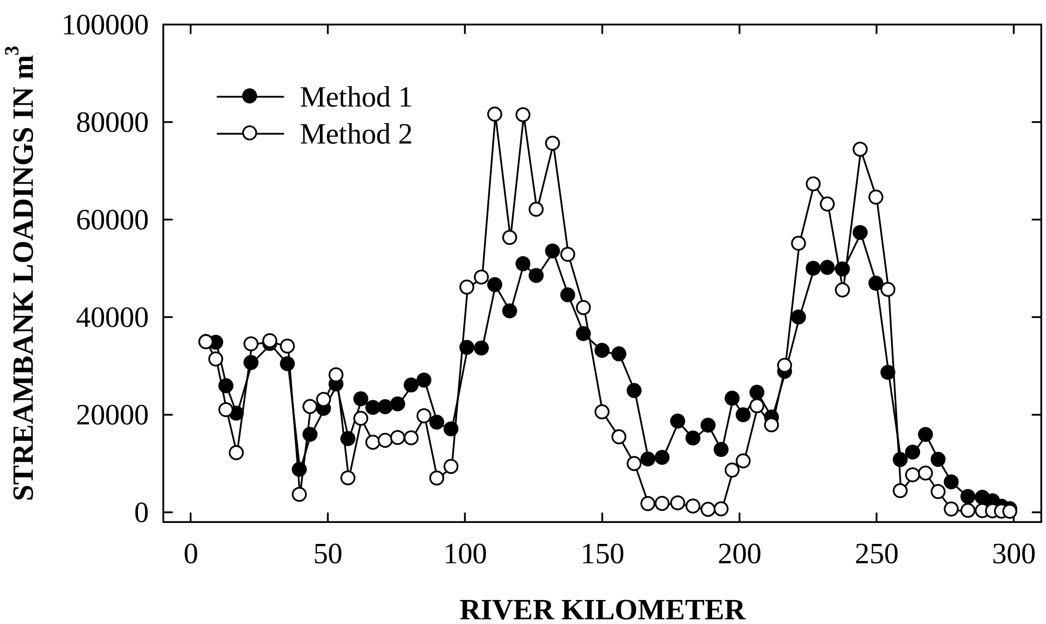


Figure 25. Streambank loadings for the 90th percentile flow year along the Big Sioux River calculated using the two methods described in the text above.

Summing each of the calculated streambank loadings values (shown in Figure 25) provides a total streambank loading for the entire study reach during the 90th percentile flow year of about 1.5 million m^3 or about 27,000 T using both methods. This compares to an average, annual streambank loadings value of about 362,000 m^3 or about 6,340 T/y, derived using the average, annual unit loadings values shown in Table 20 and shown in Figure 26 below.

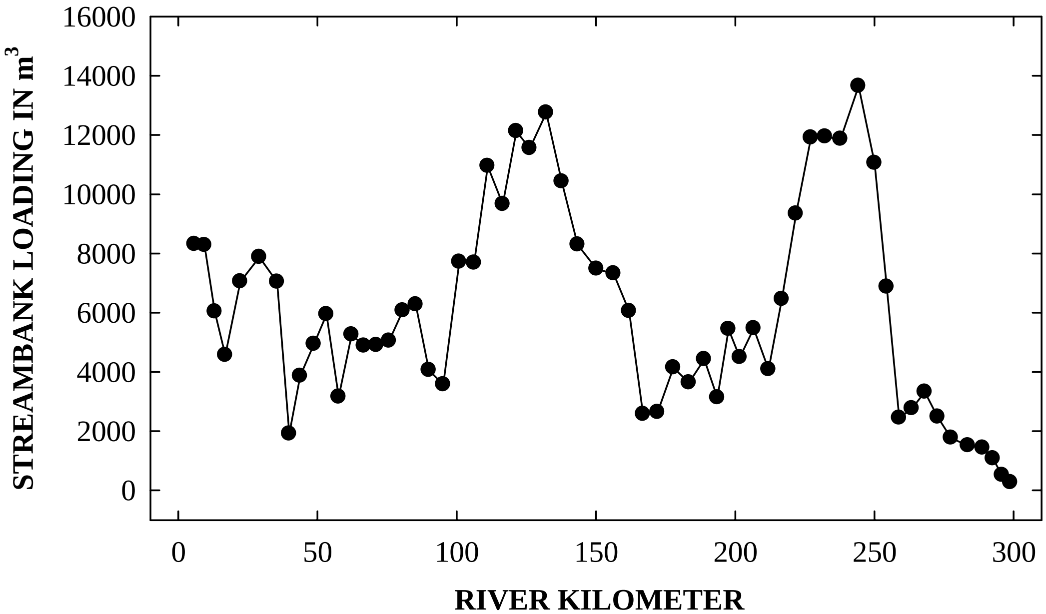


Figure 26. Average, annual streambank loadings along the study reach of the Big Sioux River.

5.3 Comparison of Streambank Loadings to Measured Sediment-Transport Rates

To evaluate the relative contribution of streambank loadings to total, suspended-sediment transport rates, the values derived in this study using the iterative modeling results were compared to data from two U.S. Geological Survey sampling stations in the reach:

(1) Big Sioux River at Brookings, SD: Station 06480000, and
(2) Big Sioux River at Dell Rapids, SD: station 06481000.

Comparisons were conducted for the specific year that was simulated using BSTEM as well for average, annual values. Raw data on instantaneous suspended-sediment concentration and associated water discharge for the two stations were analyzed as part of another study (Klimetz *et al*., 2009) and used to determine daily and annual suspended-sediment transport rates. Daily values were summed for each complete year of flow record to obtain an annual suspended-sediment load. These latter values were then compared to values obtained by the iterative modeling for the specific flow year that was used for the BSTEM simulations. For instance, the streambank loadings derived from reaches upstream of each gage during the 90th percentile flow year (1994) were directly compared to the annual suspended-sediment load for 1994. Data from the Dell Rapids gage (06480000) represent loadings at the downstream end of the study reach. In addition, an average, annual suspended-sediment load was calculated by taking the mean suspended-sediment load for all years of complete record. This value was compared to the average, annual streambank loadings obtained in this study.

Contributions of sediment from streambank erosion are in the range of 10 – 25% of the total suspended-sediment load (Table 21). Average, annual contributions of sediment from streambank erosion for the entire study reach (6,340 T) is about 15%. During a particularly wet, high-flow year as occurred in 1994, streambank contributions are consequently greater (27,000 T), comprising 25% of the total suspended-sediment load over the 300 km study reach. The data further indicate that streambank contributions are generally greater in the lower half of reach as average, annual bank contributions upstream of Brookings and at the 90th percentile flow are about 16% and 10%, respectively.

Table 21. Comparison of simulated streambank loadings data (in tonnes) with measured suspended-sediment transport data from USGS stations. Note: [1] Data from Klimetz *et al*., (2009); Classed high, moderate and low unit-loading rates for 90th percentile flow [2] and for average, annual conditions [3] were used for spatial extrapolation.

Station	90th percentile flow: 1994			Average annual		
	Measured[1]	**Banks[2]**	**% Bank Contribution**	**Measured[1]**	**Banks[3]**	**% Bank contribution**
Brookings	77,500	12,200	**15.8**	28,700	2,910	**10.1**
Dell Rapids	108,000	27,000	**25.0**	42,900	6,340	**14.8**

The relative contribution of streambank loadings to total suspended-sediment transport rates along the Big Sioux River is significantly lower than reported for incised streams in some other parts of the United States where streambank contributions can be in the range of 60-80% (Simon and Rinaldi, 2006). The results reported in this study of the Big Sioux River are, however, supported by a number of observations and findings. First, the iterative simulations conducted in this study showed only a single episode of failure, even under the non-vegetated condition. Second, the relative contribution of streambank loadings is in general agreement with those estimated for the South Branch of the Buffalo River nearby in southwestern Minnesota (Lauer *et al*., 2006). In this study streambank contributions were estimated to be 11%. Finally, the average, annual suspended-sediment yields derived for the Brookings and Dell Rapids gages are 2.8 and 3.7 T/y/km^2 respectively, and are within the range of moderately unstable streams in the region (Klimetz *et al*., 2009) where the inter-quartile range is 0.8 to 7.9 T/y/km^2.

5.4 Total Streambank Loadings Under Alternative Mitigation Strategies and Bank Conditions

Iterative modeling results were extrapolated over the 300 km length of the study reach using the classed high, moderate and low unit loadings (as described above) for the mitigation strategies tested. These include the addition of top-bank vegetation (grasses and an assemblage of grasses and young cottonwood trees) as well as bank-toe protection. Average, annual streambank loadings for the various cases are shown graphically in Figure 27, and are also illustrated spatially in Figure 28. Results for top-bank assemblage of grasses and young cottonwood are not shown because they are very similar to grasses alone. The maps in Figure 28 indicate that it was the reaches in the vicinity of Castlewood, and downstream of Brookings, which had the highest sediment loadings, but with the addition of varying degrees of mitigation, sediment loads decreased along the entire study reach.

As expected, the bare-bank simulations display greater average, annual loadings along the entire study reach, with total loadings of 503,000 m^3 (8,810 T). The effect of top-bank grasses (or an assemblage of grasses and young cottonwood trees) is a reduction in average, annual streambank loadings of 28% (to 362,000 m^3 or 6,340 T); 20% for the 90th percentile flow (Table 22). The reduction is a function of the additional bank strength provided by root reinforcement. The addition of bank-toe protection to the grassed bank results in a huge total reduction in average, annual loadings (from the bare-bank case) of 97% (to 15,200 m^3 or 267 T). This is the consequence of the combined effects of greatly reduced hydraulic erosion along bank toes that prevent bank steepening with the increase strength of the bank mass from root reinforcement. Without question, however, this strategy represents the most expensive option simulated as toe protection using rock or large wood would have to be obtained and placed along most of the outside bends.

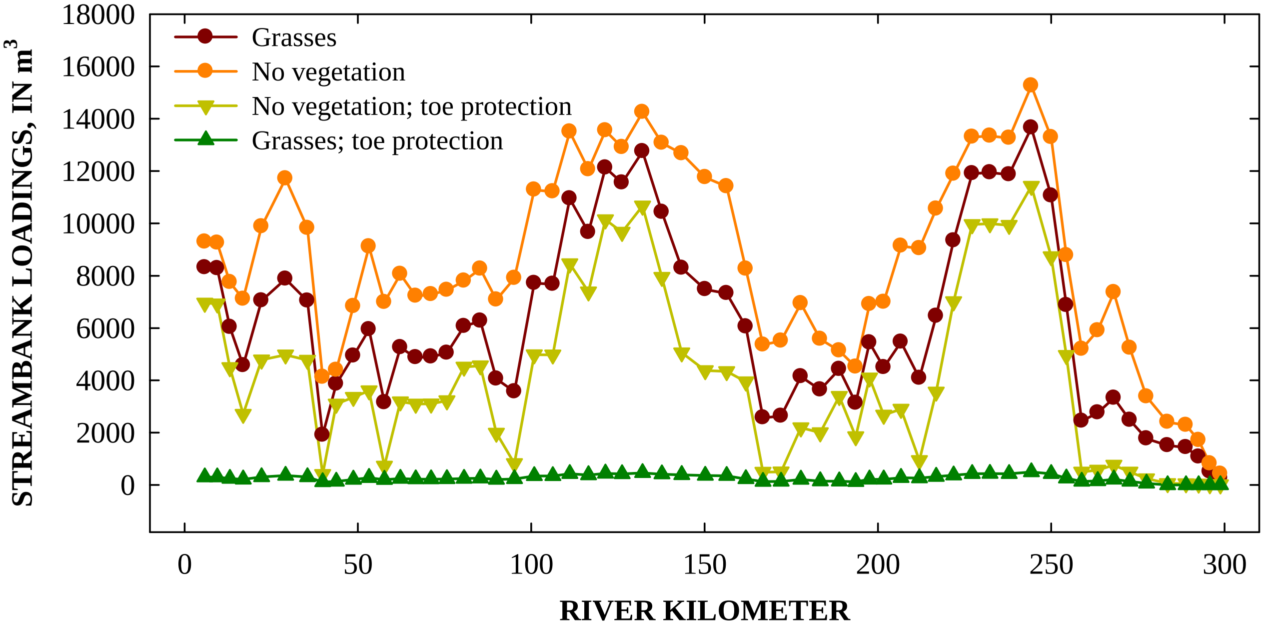


Figure 27. Graph showing average, annual streambank loadings for a range of mitigation strategies and bank conditions. Results for top-bank assemblage of grasses and young cottonwood are not shown because they are very similar to grasses alone.

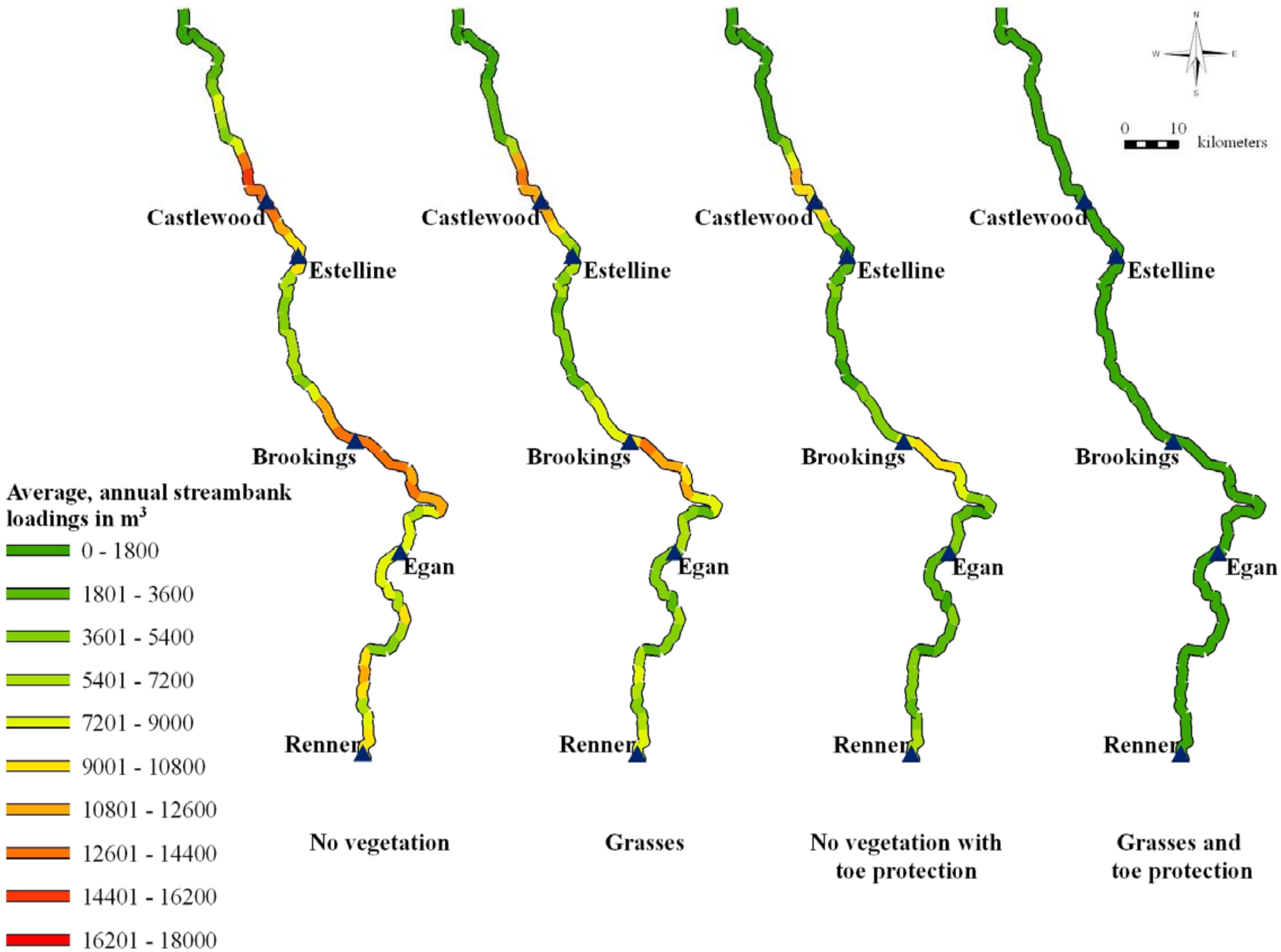


Figure 28. Spatial illustration of average annual streambank loadings in meters cubed, for a range of mitigation strategies and bank conditions.

The important role of toe protection is further apparent by comparing the difference in streambank loadings between the bare-bank case and the mitigation strategy that incorporates toe protection alone. Here, average, annual streambank loadings are reduced 51% from 503,000 m^3 (8,810 T) to 243,000 m^3 (4,250 T); 84% for the 90th percentile flow. The potential effectiveness of toe-protection along the Big Sioux River in mitigating streambank erosion that is dominated by mass failures has been discussed in detail in earlier sections and is in agreement with quantitative results from the Upper Truckee River, California (Simon *et al*., 2008)..

Table 22. Comparison of total streambank loadings for range of mitigation strategies and bank conditions. Numbers in parentheses are loadings in m^3. Negative percentages indicate less erosion; positive numbers indicate more erosion. Results for top-bank assemblage of grasses and young cottonwood are not shown because they are very similar to grasses alone.

Condition	**Streambank Loading (tonnes)**		**% Difference from grassed bank (control)**		**% Difference from bare bank**	
	90th percentile flow	**Average annual**	**90th percentile flow**	**Average annual**	**90th percentile flow**	**Average annual**
No vegetation	33,800 (1,930,000)	8,810 (503,000)	**25.5**	**39.0**	**-**	**-**
Top-bank with grasses	27,000 (1,540,000)	6,340 (362,000)	**-**	**-**	**-20.3**	**-28.0**
No vegetation; toe protection	5,400 (304,000)	4,250 (243,000)	**-80.0**	**-32.9**	**-84.0**	**-51.7**
Top-bank grasses; toe protection	707 (40,400)	267 (15,200)	**-97.4**	**-95.8**	**-97.9**	**-97.0**

6. CONCLUSIONS

Observations along the study reach of the Big Sioux River investigated in this report (extending from 131.36 km upstream of the mouth of the Big Sioux River, to approximately 431 km upstream of the mouth) have indicated that the river's streambanks could be a significant source of the suspended sediment that is causing turbidity to be an issue along certain reaches of this river. Indeed, significant portions of the study reach were estimated to have greater than 50 % of their banks failing in analysis carried out as part of this report. The main objective of this study, therefore, was to determine rates and loadings of sediment from streambank erosion along main stem reaches of the Big Sioux River, SD.

Conceptual models of bank retreat and the delivery of bank sediments to the flow emphasize the importance of interactions between hydraulic forces acting at the bed and bank toe, and gravitational forces acting on *in situ* bank materials. As such, analyzing streambank stability is a matter of characterizing the gravitational forces acting on the bank and the geotechnical strength of the *in situ* bank material. Five study sites were selected from the 300 km study reach, to act as representative conditions for the entire reach. At each site data pertaining to geotechnical strength and hydraulic resistance were measured to use as input data to BSTEM.

Results of the BSTEM analysis for a range of percentile flow years (90^{th}, 75^{th}, 50^{th}, 25^{th} and 10^{th}) showed that predicted eroded volumes of sediment emanating from streambanks decreased non-linearly from the 90^{th} percentile flow year to the 10^{th} percentile flow year, in almost all cases. Predicted volumes of sediment eroded from the streambanks at each site ranged from 169 to 1359 m^3 of sediment per 100 m reach during the 90^{th} percentile year, under existing conditions whereby the banks have a cover of native grasses. These volumes of eroded sediment were predicted to fall to 0 to 21 m^3 per 100-m reach during the modeled 10^{th} percentile flow year, again, assuming existing bank top vegetation. Overall, the sites investigated at Brookings and Egan showed the highest volumes of sediment predicted to erode in all percentile flow years, with the site at Estelline showing generally the lowest sediment volumes.

It is interesting to note that bank failures were generally only predicted to occur during the 90^{th} percentile flow year modeled at each site, suggesting that during lower percentile flow years, hydraulic scour at the bank toe is the predominant erosion process, rather than mass wasting of the banks by geotechnical failure. It therefore followed, that the addition of toe protection (up to 1m) to banks with existing native grass cover greatly reduced the volume of bank material predicted to erode at each site by protecting the base of the banks from hydraulic scour and thus over-steepening. Further to this, model runs indicated that even when the contribution to total erosion from toe scour was not that great (for example, only 16 to 50 % of total erosion came from toe scour during years where bank failures occurred), if the toe scour was prevented, the overall volume of eroded bank material was reduced by 87 – 100 %. This is a similar result to that found by Simon et al. (2008) on a study of the contributions to sediment loadings from banks of the Upper Truckee River, in California.

Contributions of sediment from streambank erosion along the study reach of the Big Sioux River were found to be in the range of 10 – 25% of the total suspended-sediment load. Average, annual contributions of sediment from streambank erosion for the entire study reach (6,340 T) was shown to be about 15%. During a particularly wet, high-flow year as occurred in 1994, streambank contributions were consequently greater (27,000 T), comprising 25% of the total suspended-sediment load over the 300 km study reach. The data further indicated that streambank contributions were generally greater in the lower half of reach as average, annual bank contributions upstream of Brookings and at the 90^{th} percentile flow were about 16% and 10%, respectively.

The relative contribution of streambank loadings to total suspended-sediment transport rates along the Big Sioux River was found to be significantly lower than reported for incised streams in some other parts of the United States where streambank contributions can be in the range of 60-80% (Simon and Rinaldi, 2006). The results reported in this study of the Big Sioux River are, however, supported by a number of observations and findings. First, the iterative simulations conducted in this study showed only a single episode of failure, even under the non-vegetated condition. Second, the relative contribution of streambank loadings is in general agreement with those estimated for the South Branch of the Buffalo River nearby in southwestern Minnesota (Lauer *et al*., 2006). In this study streambank contributions were estimated to be 11%. Finally, the average, annual suspended-sediment yields derived for the Brookings and Dell Rapids gages are 2.8 and 3.7 T/y/km^2 respectively, and are within the range of moderately unstable streams in the region (Klimetz *et al*., 2009) where the inter-quartile range is 0.8 to 7.9 T/y/km^2.

The final part of this report investigated the effect of extrapolating the iterative modeling results over the 300 km length of the study reach, for the mitigation strategies tested. These include the addition of top-bank vegetation (grasses and an assemblage of grasses and young cottonwood trees) as well as bank-toe protection. As expected, the bare-bank simulations displayed greater average, annual loadings along the entire study reach, with total loadings of 503,000 m^3 (8,810 T). The effect of top-bank grasses (or an assemblage of grasses and young cottonwood trees) was a reduction in average, annual streambank loadings of 28% (to 362,000 m^3 or 6,340 T); 20% for the 90^{th} percentile flow. The reduction was a function of the additional bank strength provided by root reinforcement. The addition of bank-toe protection to the grassed bank resulted in a huge total reduction in average, annual loadings (from the bare-bank case) of 97% (to 15,200 m^3 or 267 T). This was the consequence of the combined effects of greatly reduced hydraulic erosion along bank toes that prevented bank steepening with the increased strength of the bank mass from root reinforcement. The important role of toe protection was further apparent by comparing the difference in streambank loadings between the bare-bank case and the mitigation strategy that incorporated toe protection alone. Here, average, annual streambank loadings were reduced 51% from 503,000 m^3 (8,810 T) to 243,000 m^3 (4,250 T); 84% for the 90^{th} percentile flow. Without question, this strategy represents the most expensive option simulated as toe protection using rock or large wood would have to be obtained and placed along most of the outside bends.

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Appendix 8

Final report

Project Title: Better Management Practices to Improve Water Quality in the Central and Upper Big Sioux Watershed.

Project investigators: David E. Clay, C. Gregg Carlson, Kurtis D. Reitsma, and Ronald Stover

Project Initiation December 1, 2008 **Project Completion Date: April 1st, 2010.**

EPA Section 319 Grant Number:

Grant Source: $60,000 from East Dakota Water Development District

Summary

The goals of this project were:

- To develop an assessment method for targeting educational activities in Eastern South Dakota Big Sioux River.
- Develop educational materials for best management practices (BMP) for landowners that are economically and logistically feasible that reduce pollutant loading.
- Conduct a series of interviews to assess the barriers for adoption of BMP's, watershed characterization, and adoption rate of prescribed BMP's.
- Conduct one-on-one discussions with landowners within high risk areas as identified by the river assessment.

The project developed a GIS-based method for identifying high risk areas along the Big Sioux River. A geographic information system based method was developed by integrating the USDA-NRCS Soil Survey Geographic (**SSURGO**) Database, field scale land use, and hydrology data. Three different information gathering techniques were conducted to assess barriers limiting BMP adoption. The first approach was interviews of producers that was conducted by Dr. Ronald Stover, SDSU Rural Sociologist. Interviews showed that most respondents acknowledge some responsibility for water quality problems but are highly critical of activities of other producers. All respondents accepted an obligation to protect water quality for future generations and most agreed that action should be taken with most favoring local control over activities. The second approach was conducted by County Extension Educators during one-on-one interviews with producers in high risk areas. A total of thirty one land-owner/operators were contacted by extension educators in Brookings (16) and Moody (15) County. These land-owners/operators were selected from the priority land parcels identified by the GIS model. In all cases, extension educators contacted land-owners personally and were prepared to recommend at least one BMP prior to the visit. Of the 31 land-owners contacted, 16 implemented at least one of the BMP's prescribed by the Extension educator. In the third approach, a phone survey of 100 producers showed that 53% knew who their extension educator by name. Twenty-four percent said that they had visited their farm, 58% said that they had asked them for advice and 56% said they were satisfied with that advice. When asked if they felt that their extension educator provided a valuable service, 83% indicated that they did.

Educational materials produced

Clay, D.E., K.D. Reitsma, and S.A. Clay (eds). 2009. Best Management Practices for Corn Production in South Dakota. EC 929. South Dakota State University, South Dakota Cooperative Extension Service, Brookings SD.

Reicks, G.W., D.E. Clay, C.G. Carlson, and S.A. Clay. 2008. Better Management Practices for Improved Profit and Water Quality FS 944. South Dakota State University, South Dakota Cooperative Extension Service, Brookings SD.

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Introduction:

The entire Big Sioux River watershed is approximately 6-million acres in size; about 4.23-million acres are in South Dakota. The Big Sioux River has designated beneficial uses of stock watering, immersion recreation, warm-water fishery, and public water supply (ARSD §74:51:03:07). These beneficial uses vary by reach segment of which many segments are impaired due to fecal coli-form bacteria, total suspended solids, and nutrients. It is important to note that the Big Sioux River is a source of drinking water for the city of Sioux Falls, the largest city in South Dakota.

Located on the eastern-edge of South Dakota, land uses within the watershed are largely agricultural including cropland, hayland, range, and pasture. Impairments are thought to be due to runoff from agricultural land with feedlots and adjacent urban areas also contributing significant amounts.

As activities within this project were limited to the Brookings and Moody counties, this report will limit discussions to areas within these counties. The Big Sioux River watershed occupies approximately 691,000 acres within these counties. The majority of this area is cropland used for cereal grain production. The East Dakota Water Development District (EDWDD) defined the area of major contribution to be within 2-miles of the Big Sioux River or a major tributary. This area occupies approximately 335,000 acres consisting of 236,000 and 52,000 acres of cropland and pasture land respectively with the remaining in urban and other uses (See Map, Appendix 1).

With limited resources, available for water quality projects, the ability to target lands that are most likely to contribute to pollutant loading increases the potential of efficacy. The ability to target these lands further reduces the number of land owners to contact and focuses resources where they are needed most. A geographic information system (GIS) was used to select land parcels based on proximately to the Big Sioux River and major tributary and/or soil erosivity. Land parcels were selected using common land unit (CLU) data that included land use by parcel for 2005, two-mile stream buffer supplied by EDWDD and data for Brookings and Moody county from the Soil Geographic (SSURGO) database from the USDA, Natural Resource Conservation Service.

In an effort to improve adoption of BMP's, this project explored the attitudes of landowners in an attempt to understand some of the barriers that exist in BMP adoptions. Personal interviews were conducted in the summer of 2007 and 2008 with twenty-one (21) producer families to investigate the attitudes of the families toward water quality of the Big Sioux River (See Appendix 2). At the time of contact by the extension educator, further interviews were conducted to determine the amount of land each individual owned vs. rented, generalized farming operation and management, and likelihood of BMP adoption. Extension educators repeated this interview one-year later and determined if the land-owner accepted BMP recommendations. A third survey was conducted with fifty (50 - each) individuals from Brookings and Moody county, randomly selected from the South Dakota Private Pesticide Applicator Certification database (https://apps.sd.gov/doa/pat/PAS_Searchlist.asp?cmd=reset). This survey was designed to assess the attitudes toward the Cooperative Extension Service and get a sampling of selected farming practices. Several Extension Circulars (EC) were published and methods for selecting priority crop and pasture land were presented at professional meetings.

Project Goals, Objectives, and Activities:

The goals of this project were to develop a method for identifying land parcels most likely to contribute to pollutant loading, understand the barriers for BMP adoption, and evaluate the effectiveness of personal land-owner/operator contact by agricultural professionals, prescribing specific BMP's. The information that follows discusses the outcomes of these activities.

Objective 1. Develop a GIS based land targeting system.

Task 1. Conceptualize and build a GIS based model for selecting priority crop and pastureland over a large area.

Sediment and nutrients are the primary pollutants impairing the Big Sioux River. Therefore, cropland that was likely to erode by water within the two (2) mile buffer defined by the EDWDD was selected as priority land. Livestock that water from the Big Sioux River or major tributary is thought to contribute to sediment and nutrient loading from livestock treads degrading stream banks and direct manure deposition. Therefore, pasture land was selected based solely on proximity (within 100 ft) to the Big Sioux River or major tributary.

Cropland erosivity was assessed taking a universal soil loss equation approach (USLE). The USDA-NRCS, Soil Survey Geographic (SSURGO) data sets were obtained for Moody and Brookings Counties. The data was aggregated using a novel system developed by the South Dakota Department of Agriculture. Each soil mapping unit was evaluated based using a portion of the universal soil loss equation (USLE);

$$E=R*K*LS$$

where E = Erodibility, R = Rainfall Intensity Factor, K = Erodibility Factor, and LS = Slope/Length – Estimated by soil mapping unit.

The residue cover (C) and contributing practice (P) factors of the USLE were ignored to conservatively assess the likelihood of pollutant contribution of a particular soil mapping unit. Soil mapping unit values for LS were obtained from the USDA-NRCS. If E exceeded 8 tons/acre*year, then a soil mapping unit was assumed to be a potential pollutant contributor.

Soil mapping units selected as potential contributors were extracted from the dataset and clipped to the 2 – mile buffer area. Common land unit (CLU) data obtained from the USDA-NRCS that included land use class from 2005 was used to identify individual parcels of land. Cropland was extracted from the CLU datasets, clipped to the 2 – mile buffer, and intersected with the soils layer that identified soil mapping units as potential contributors. Upon intersection, if an identified soil mapping unit occupied at least 10% of the cropland parcel, it was selected as priority land. Results of this analysis for cropland and pasture land for Brookings and Moody counties are shown in Appendix 1.

Use of this model reduced the amount of crop and pasture land to address appreciably, making it 'manageable' for extension educators to contact land owners. The amount of cropland to address in the 2 – mile buffer was reduced from 107,174 to 6,640 acres in Brookings and 129,176 to 28,775 acres in Moody, overall an 85% reduction between the two counties. Pasture land to address in the 2 – mile buffer was reduced from 21,637 to 9,594 acres in Brookings and 31,071 to 12,552 acres in Moody county, overall and 58% reduction between the two counties.

Task 2. Validate land selection model.

Extension educators were provided with detail maps of the locations of priority crop and pasture lands to conduct a visual assessment of the land selected by the model. Visual road-side inspections were conducted to 1) verify appropriate model selection, and 2) determine if further management was warranted. In total there were 140 visual inspections conducted by SDSU staff and extension educators; 70 in Brookings and 70 in Moody. The model selected land appropriately 68/70 incidents in Brookings and 64/70 incidents in Moody. However, evaluations by extension educators did not find that further management was warranted in these cases. From these evaluations, extension educators selected land owners/operators to call on and developed a list of suggested BMP's that would reduce pollutant loading and improve productivity.

Objective 2. Conduct a series of interviews and surveys to assess the attitudes toward water quality, barriers for adoption of BMP's, general farming practices, and project efficacy.

Task 1. Develop questionnaire, contact and interview respondents, and summarize findings for assessment of attitudes toward water quality.

Dr. Ronald Stover (SDSU Rural Sociologist) conducted interviews with producer families, both retired and active in the Big Sioux River watershed from Watertown to Brandon. In total, twenty-one (21) families were interviewed. More males than females were interviewed as some candidates were single and time constraints prohibited participation of working wives. Males and females were segregated during interviews so as not to influence responses and to evaluate differences in responses between males and females. Results of the interviews are summarized in appendix 3 by Dr. Stover.

Task 2. Develop questionnaire to be used at the time of land owner/operator contact to assess proportion of land ownership/rental, production enterprise, and attitudes toward adoption of BMP's.

At the time of land owner/operator contact, extension educators conducted a short interview. One year later, when extension educators called upon land owners/operators to determine if recommended BMP's were adopted, the same questionnaire was completed to determine if there were any changes. A copy of this interview questionnaire and summarized results are provided in appendix 4.

The results of the questionnaire in appendix 4 reflect average responses from producers who were personally contacted at their farm by Extension educators. The demographics portion of the interview results are provided in Table 1.There was little no change in responses when these same producers were contacted 1-year later. This may be due to the short amount of time between interviews, indicating that change may take place over extended time or not at all.

Table 1. Farm Demographic Summary, Extension Educator Visits			
	Brookings (BG)	Moody (MY)	Region
	Average (Range)		Average
Average Age	53 (34 – 68)	57 (50 – 70)	55
Years in Big Sioux	35 (6 – 68)	31 (10 – 50)	33
Cash Crop (%)	75 (0 – 100)	65 (0 – 100)	70
Feed Crop (%)	25 (0 – 100)	35 (0 – 100)	30
Livestock (%)	40 (0 – 100)	37 (0 – 100)	39
Heir to Continue (% Yes)	38	14	26
Land Holding Summary			
Cropland Owned (Acres)	485 (0 – 800)	358 (80 – 980)	422
Cropland Rented (Acres)	540 (0 – 800)	175 (0 – 480)	358
Owned vs. Rented (%)	47% (0 – 100)	67% (14 – 100)	54%
Pasture Owned (Acres)	353 (0 – 700)	167 (0 – 500)	260
Pasture Rented (Acres)	489 (0 – 880)	84 (0 – 160)	287
Owned vs. Rented (%)	42% (0 – 100)	67% (0 – 100)	55%
CRP (Acres)	50 (0 – 380)	45 (0 – 160)	48
Other Uses (Acres)	17 (0 – 100)	11 (0 – 50)	14
Total Land Holdings (Acres)	1,383 (240 – 2,140)	681 (310 – 1,680)	1032
Total Land Owned (Acres)	838 (240 – 1,330)	525 (80 – 1,380)	682
Total Land Rented (Acres)	655 (0 – 1,120)	259 (0 – 480)	457
Owned vs. Rented (%)	61% (19 – 100)	77% (17 – 100)	69%

The demographics provide an indication of sociological status of those interviewed (Table 1.) Average ages of producers interviewed in Brookings and Moody were similar. The youngest producers were in Brookings county. One hypothesis for future research could be the assessment of willing to test new practices and age. Note that more producers in Brookings (38%) county expect their heir to continue the farming enterprise compared to Moody (14%) county. Producers retiring, not expecting their heir to continue the farming operation is likely to resist investing in or adopting new practices.

Land ownership and proportion of owned vs. leased land differs between Brookings and Moody county, demonstrating another barrier for BMP adoption. Producers are more likely to invent in or implement a BMP on land they own but may be more hesitant on rented land due to the uncertainty of the length of time they will operate the land. Land-lords may be hesitant in investing in structural conservation practices as it will not likely change rental rates and see little benefit in an investment.

The second part of the interview was designed to assess current land management practices and the likelihood that a producer would adopt new management practices that have the potential to improve profit and water quality. Summarized results of the assessment are provided in appendix 4. Producers in both counties indicated that they scout and soil sample between 60 –

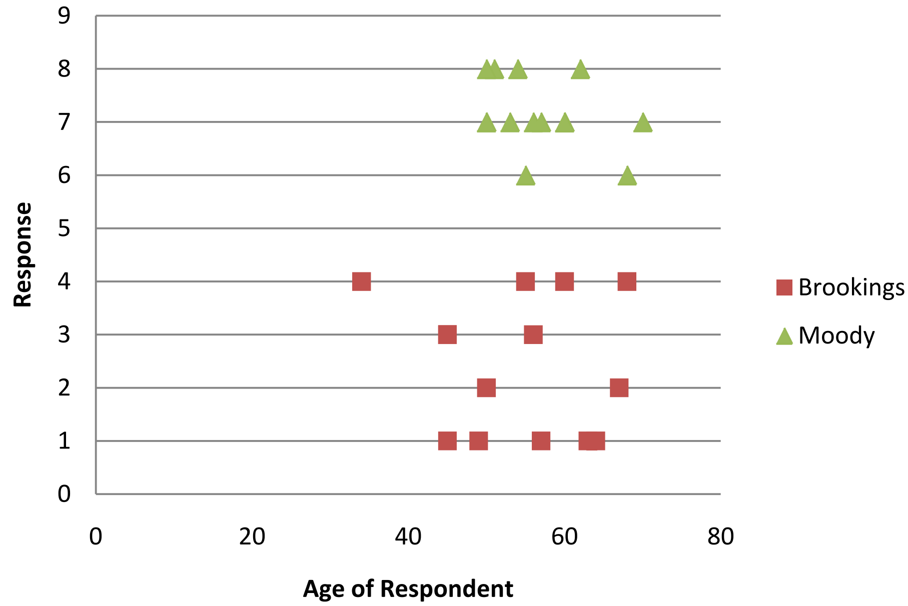


Figure 1. Age of respondent and response to questions 9 and 10 of Extension Educator – Producer questionnaire.

80% of their land holdings. However, producers in Moody County indicated that fertilizer and manure rates are adjusted to results from soil and manure tests "Sometimes" where producers in Brookings indicated that rates are adjusted "Usually". It is not understood as to why producers would invest in soil sampling and scouting time and not use the results to optimize nutrients. Further work may be needed in this area. Producers in Moody county indicated that tillage is "Sometimes" conducted in the spring where producers in Brookings county indicated that they "Usually" conduct spring tillage. The differences may be due to indigenous soil conditions and locally accepted cultural practices developed over long periods of time. Soils in Moody County tend to be heavier with more poorly drained areas. Fall tillage may be more popular in Moody County to reduce residue cover and allow for more soil water evaporation, allowing earlier field entry. Brookings County soils generally tend to be more well drained with less slope, allowing for spring tillage or no-till.

Questions 6 to 8 were designed to assess general pasture management with respect to adjacent or bisecting streams. Producers in Brookings and Moody county indicated that "Sometimes" the stream provides the sole source of water for their livestock. Producers in Moody County indicated that "Sometimes" they provide shade away from the stream where producers in Brookings indicated "Usually". Producers in both counties indicated that supplemental feed is "Usually" provided away from the stream. Fecal coli-form bacterial is a concern in the Big Sioux River. Direct deposition of livestock manure is thought to be the source. Preventing access of livestock to the stream can help to alleviate this problem in addition to sediment loads caused by stream bank degradation and channel disturbance from livestock tread.

The last two questions (9 & 10) were designed to assess the likelihood that producers will willing adopt a BMP to improve water quality or if a practices has been proven to improve profit even if incentive payments are not provided. There was a wide gap in responses between producers in Brookings and Moody Counties. Producers in Brookings county tended toward "Strongly Agreeing" with these statements while producers in Moody County tended to "Disagree" to "Strongly Disagree". Although producers in Moody County tend to be older than those in Brookings County, there appeared to be no correlation between age and response to these statements (Figure 1.).

As shown in figure 1, no discernable trend is apparent between age and response to these questions. Further study or analysis of these data may provide insight as to the differences noted between these counties.

Task 3. Randomly poll individuals in Brookings and Moody counties to assess their perception of Extension educators and farming system.

It is perceived that producers are more likely to implement a BMP if it is recommended by a credible source. By the same token, recommended practices must provide a benefit as an incentive for implementation. Fifty (50) individuals were selected at random from the South Dakota Private Applicator Certification database provided by the South Dakota Department of Agriculture (https://apps.sd.gov/doa/pat/PAS_Searchlist.asp?cmd=reset). These individuals were asked a series of questions pertaining to the Extension educator in their county as well as generalized questions regarding their farming practices.

Results shown in Table 2 provide an assessment of producer perception of local County Extension Educators. Results for some questions are thought to vary between counties due to tenure difference between Extension educators. The Brookings County Extension educator has held his position for approximately 2 years while the Moody County Extension educator has held his position for 9 years. The Brookings County Extension educator has not had sufficient time to become established and develop a relationship with producers in his county. The Moody County Extension educator has become known and established as a credible source of information for producers.

Table 2. Perception assessment of County Extension Educator			
Brookings County			
Do you know your county Agronomy Extension Educator?	Yes: 11 (22%)	No: 39 (78%)	
Have they ever made a farm visit?	Yes: 10 (20%)	No: 40 (80%)	
Have you ever gone to them for advice?	Yes: 29 (58%)	No: 21 (42%)	
Were you satisfied with the advice? (Percentages of those seeking advice)	Yes: 27 (93%)	No: 2 (7%)	NA: 21
Do you feel that your county Agronomy Extension Educator provides a valuable service?	Yes: 41 (82%)	No: 9 (18%)	
How could you better be served	Commented: 11	No Comment: 39	
Moody County			
Do you know your county Agronomy Extension Educator?	Yes: 42 (84%)	No: 8 (16%)	
Have they ever made a farm visit?	Yes: 14 (28%)	No: 36 (72%)	
Have you ever gone to them for advice?	Yes: 29 (58%)	No: 21 (42%)	
Were you satisfied with the advice? (Percentages of those seeking advice)	Yes: 29 (100%)	No: 0 (0%)	NA: 21
Do you feel that your county Agronomy Extension Educator provides a valuable service?	Yes: 42 (84%)	No: 8 (16%)	NA: 0
How could you better be served	Commented: 10	No Comment: 40	

Producers that have gone to their Extension educator for advice were satisfied in nearly all instances in both counties. Producers felt that an Agronomy Extension educator provides a valuable service by assisting in improving their farming operations. When asked how they could better be served there were similarities in their comments. Comments included:

- Increase number of farm visits (most popular)
- Increase number of educational and informational meetings
- Provide more information on cost share opportunities
- Provide a monthly news letter and/or mailings

With increasing budget cuts, many of the services that Extension service provided in the past have been down-scaled or eliminated. Farm visits and educational and informational meetings have been reduced due to declining travel and facility resources. Extension service has reduced staff, distributing responsibilities among remaining staff, reducing time resource dedication toward specialized activities. Extension educators were made aware of survey results and comments.

Objective 2. Improve the adoption of BMP's by having trained Extension Agronomy Educators personally contact owners/operators of priority crop and pastureland.

Task 1. Recommend and assess adoption of BMP's by landowners/operators that will improve agricultural productivity while providing benefits to water quality.

Sixteen landowners/operators in Brookings and fifteen in Moody County were contacted and visited by Extension educators. Land owners/operators were selected from a list identified as owning/operating priority crop and/or pasture land as selected from the GIS outlined in task 1 of objective 1. The Extension educators had previously assessed the land in question and came prepared to recommend BMP's, provide informational and educational materials, and specifics of the BMP proposed. Extension educators designed recommended BMP's to improve the producer's operation and reduce loading to surface water. One year later, the Extension educator followed-up with the land owner/operator to determine if the recommended BMP(s) was implemented. In total, 5 producers implemented at least one of the recommended BMP's in Brookings and 10 in Moody County. Examples of implemented BMP's include:

- Rock stream crossings for livestock
- Establish and expanding perennial grass in highly erodible areas
- Expanding perennial grass buffer strips along streams
- Continue and add land area to CRP diversion
- Reduce fall tillage and increase residue cover
- Avoid fall tillage of highly erodible areas
- Expand and add grass waterways
- Continued grazing in lieu of diversion to tilled cropland
- Conversion to no-till system
- Installing woody vegetation along stream
- Fall cover crop planting
- Installing remote water source away from stream

Discussion of findings

The GIS based analysis tool identified high risk areas in the Big Sioux River basin. Preliminary scouting by Extension educators indicated that the model selected appropriate land correctly 99% of the time. These results indicate that this and modified versions of this model can help to optimize funds for water quality projects of this type.

Results of interview surveys (Stover, 2009) indicated that most respondents acknowledge some responsibility for water quality problems but are highly critical of activities of other producers. All respondents accepted an obligation to protect water quality for future generations and most agreed that action should be taken with most favoring local control over activities. An overwhelming number of respondents were willing to implement practices on the farm if they were economically neutral and most had a positive attitude toward the USDA-NRCS Conservation Reserve Program (CRP).

A total of thirty one land-owner/operators were contacted by extension educators in Brookings (16) and Moody (15) County. These land-owners/operators were selected from the priority land parcels identified by the GIS model. In all cases, extension educators contacted land-owners personally and were prepared to recommend at least one BMP prior to the visit. Of the 31 land-owners contacted, 16 implemented at least one of the BMP's prescribed by the Extension educator.

A follow-up phone survey was conducted of 100 individuals located in Brookings and Moody Counties. All individuals currently hold a Private Pesticide Applicator Certification (SDDA, 2009). The phone interview was designed to assess the perception of the extension educators by the farm community. It is important to mention that the Brookings County Extension Educator has been an educator <3 years while the Moody County Extension Educator has been an educator >5 years. Of the respondents, 53% knew who their extension educator by name. Twenty-four percent said that they had visited their farm, 58% said that they had asked them for advice and 56% said they were satisfied with that advice. When asked if they felt that their extension educator provided a valuable service, 83% indicated that they did.

In summary, the results of the suite of surveys indicate that producers in the watershed are concerned about water quality and assume at least some responsibility for it. Producers are willing to implement a BMP if it is economically neutral or profitable and are likely to implement the BMP if personally contacted with a prescribed BMP. Cooperative extension service is an appropriate route as many extension educators know producers in their region and have built a relationship with them.

State Agencies and Academia

South Dakota Department of Environment and Natural Resources

- Provided funding through funds made available from section 319 of the Clean Water Act.
- Acted in an advisory capacity for development of written materials.

South Dakota Department of Agriculture

- Acted in an advisory capacity for development of written materials.

South Dakota Agricultural Experiment Station, Southeast Research Center

- Acted in an advisory capacity for development of written materials.

South Dakota Experiment Station and Extension Service

- Acted in an advisory capacity for planning and development.
- Acted in an advisory capacity for development of written materials
- Acted in dissemination of information and education to the public.

Federal Agencies

USDA-CSREES, provided support for activities

United State Department of Agriculture – Natural Resource Conservation Service

- Acted in an advisory capacity for planning and development.
- Acted in an advisory capacity for development of written materials.

Industry and the Public

South Dakota Corn Utilization Council

South Dakota Soybean Association

- Provided additional funding.
- Acted in an advisory capacity for planning and development.
- Acted in an advisory capacity for development of written materials.

East Dakota Water Development District

- Provided funding.
- Acted in an advisory capacity

Aspects of the Project that did not Work Well

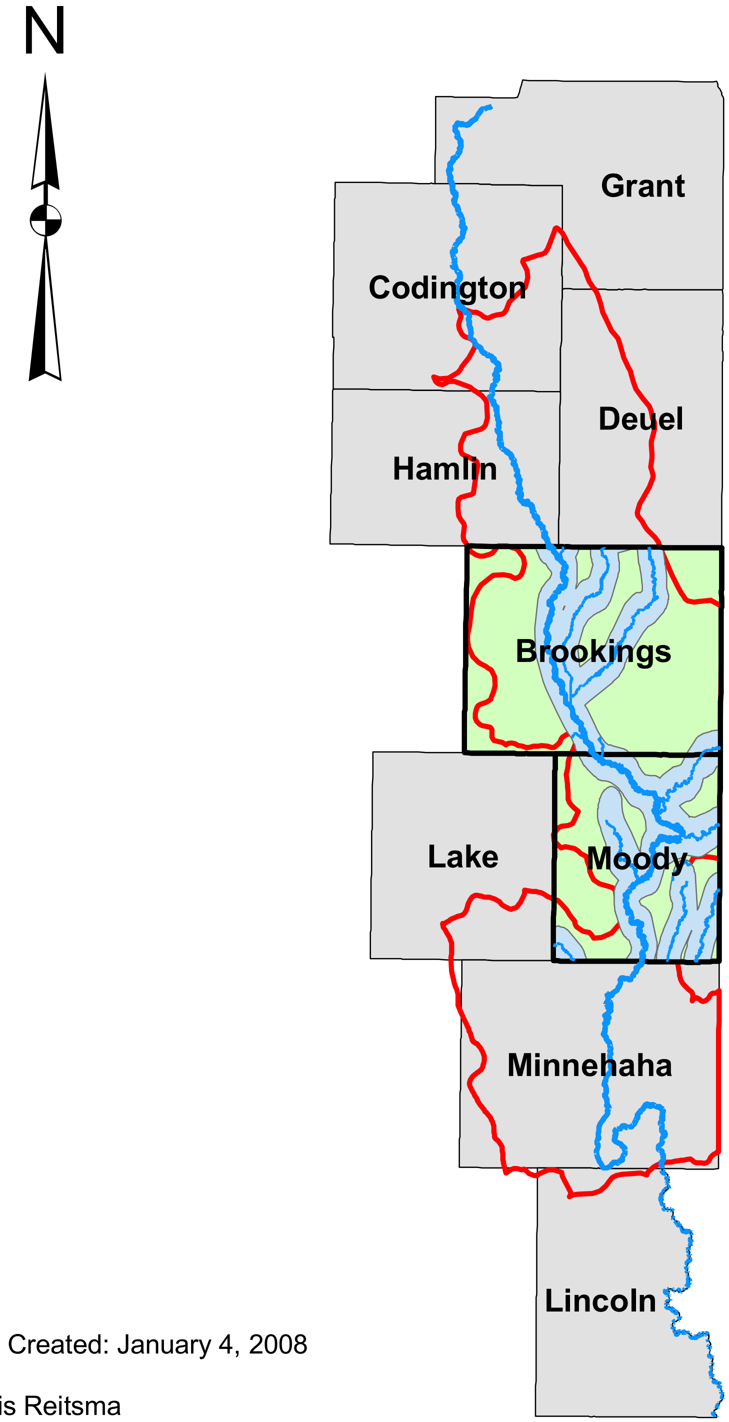
As with many projects, unforeseen obstacles affected several aspects of the project. Retirement of Extension Agronomy educators in Minnehaha and Codington counties prohibited their participation. As these positions are not yet filled, it is unknown if these counties will undertake activities of this type. Obsolete common land unit (CLU) data was used as legislation in the 2005 Farm Bill prohibited the USDA-NRCS from releasing this data with any attributes including "Land Use" which is critical for the GIS model to select priority lands. It is recommended that legislation is changed at the writing of the next Farm Bill to allow USDA-NRCS to release not proprietary and confidential data to government agencies and universities for research, conservation, and economic development purposes. Limited time and travel resources available to the county Extension educators increased the difficulty in contacting more producers in their county.

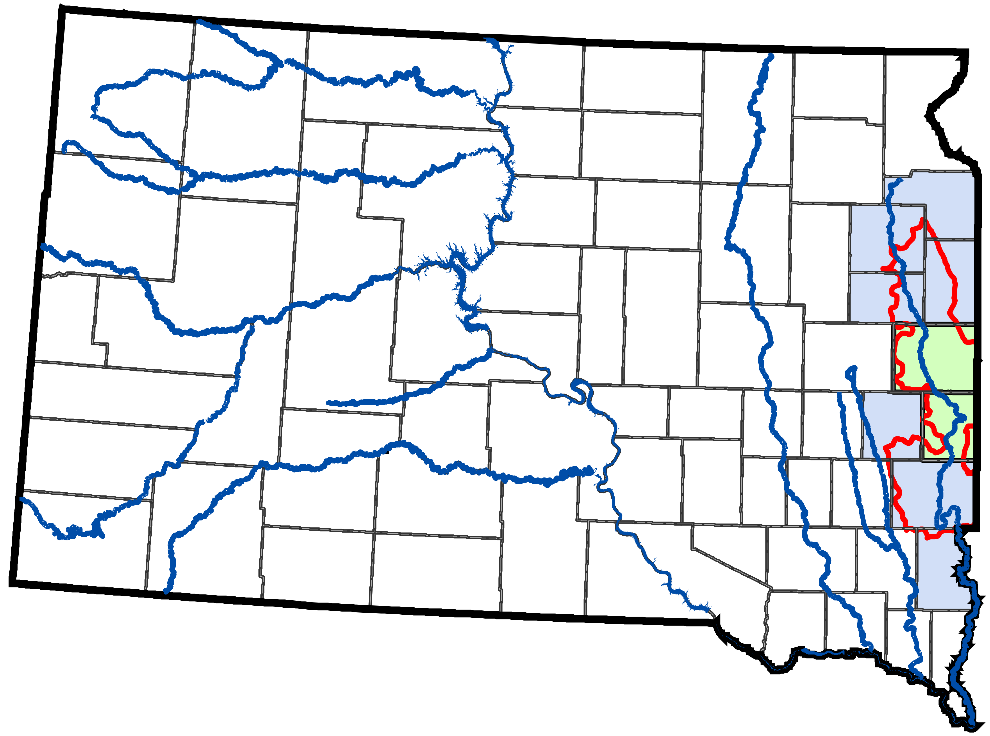
Future Activity Recommendations

The results of this project were positive in that producers adopted BMP's that not only would improve their farming operation but reduce loading to surface waters when contacted by Agronomy Extension educators. It is recommended that Agronomy Extension educators or trained agronomists play a role in watershed projects of this nature to improve BMP adoption and implementation by agricultural producers. It should be noted that the practices adopted (with the exception of CRP) were adopted and implemented without any cost-share provided to the producer. Surveys and studies conducted within this project served to understand that the "human" element plays a significant role in water quality projects and should be included in future projects of this nature. Results of those studies provide a sampling of the obstacles in producer BMP adoption but also indicate that more can be learned.

Appendix 1.

Regional and County Watershed Maps





Watershed Cropland and Pasture Summary			
	Brookings	Moody	Total
	----------acres----------		
County Area	514,829	333,107	847,936
Watershed Area	440,386	251,024	691,410
Watershed - 2 Mile Buffer	150,126	185,523	335,649
Cropland (County)	342,000	262,000	604,000
Cropland - 2 Mile Buffer	107,174	129,176	236,350
Pasture Land (County)	71,000	38,000	109,000
Pasture - 2 Mile Buffer	21,637	31,071	52,708

Legend

- Study County
- Watershed Boundary
- Two Mile Stream Buffer

Map Created: January 4, 2008

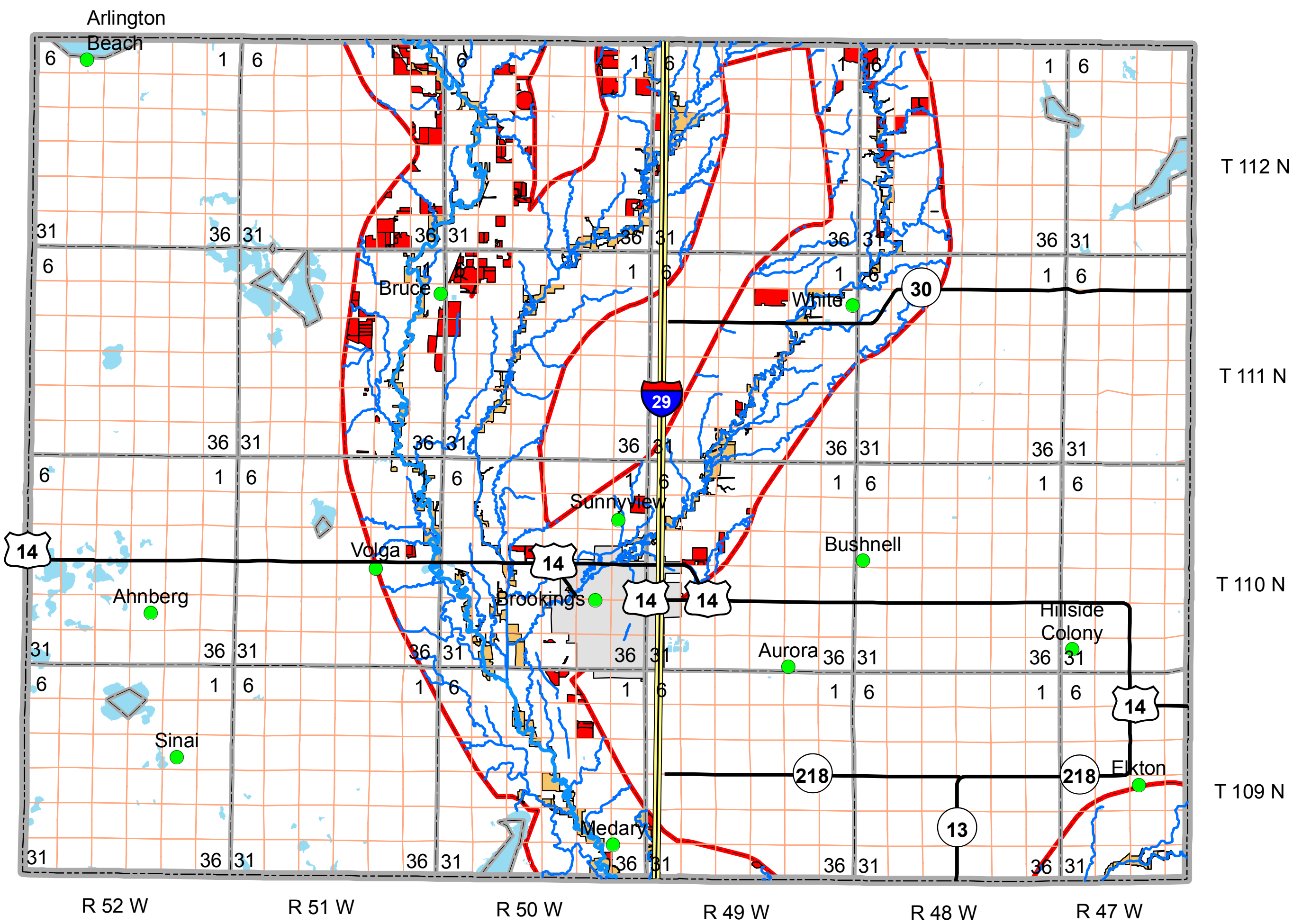
Kurtis Reitsma
South Dakota State University
Plant Science Department
Brookings SD 57007
(605) 688-4594

0 15 30 60 Miles

This Map is for Planning Purposes Only

Although every effort has been made to ensure the accuracy of Information; errors and conditions originating from the physical sources used to develop the database may be reflected in the data supplied. The end user must be aware of the data conditions and ultimately bear responsibility for the appropriate use of the information with respect to possible errors, original map scale, collection methodology, currency of data and other conditions specific to certain data.

Big Sioux Water Quality Project
Brookings County South Dakota - Priority Land



N

Legend

- Interstate Highway
- State and Federal Highway
- Priority Cropland
- Priority Pastureland
- Two (2) Mile Buffer

Watershed Cropland and Pasture Summary	
	---acres---
County Area	514,829
Watershed Area	440,386
Watershed - 2 Mile Buffer	150,126
Cropland (County)	342,000
Cropland - 2 Mile Buffer	107,174
Priority Cropland	6,640
Pasture Land (County)	71,000
Pasture - 2 Mile Buffer	21,637
Priority Pasture Land	9,594

Map Created: March 20, 2008

Kurtis Reitsma
South Dakota State University
Plant Science Department
Brookings SD 57007
(605) 688-4594

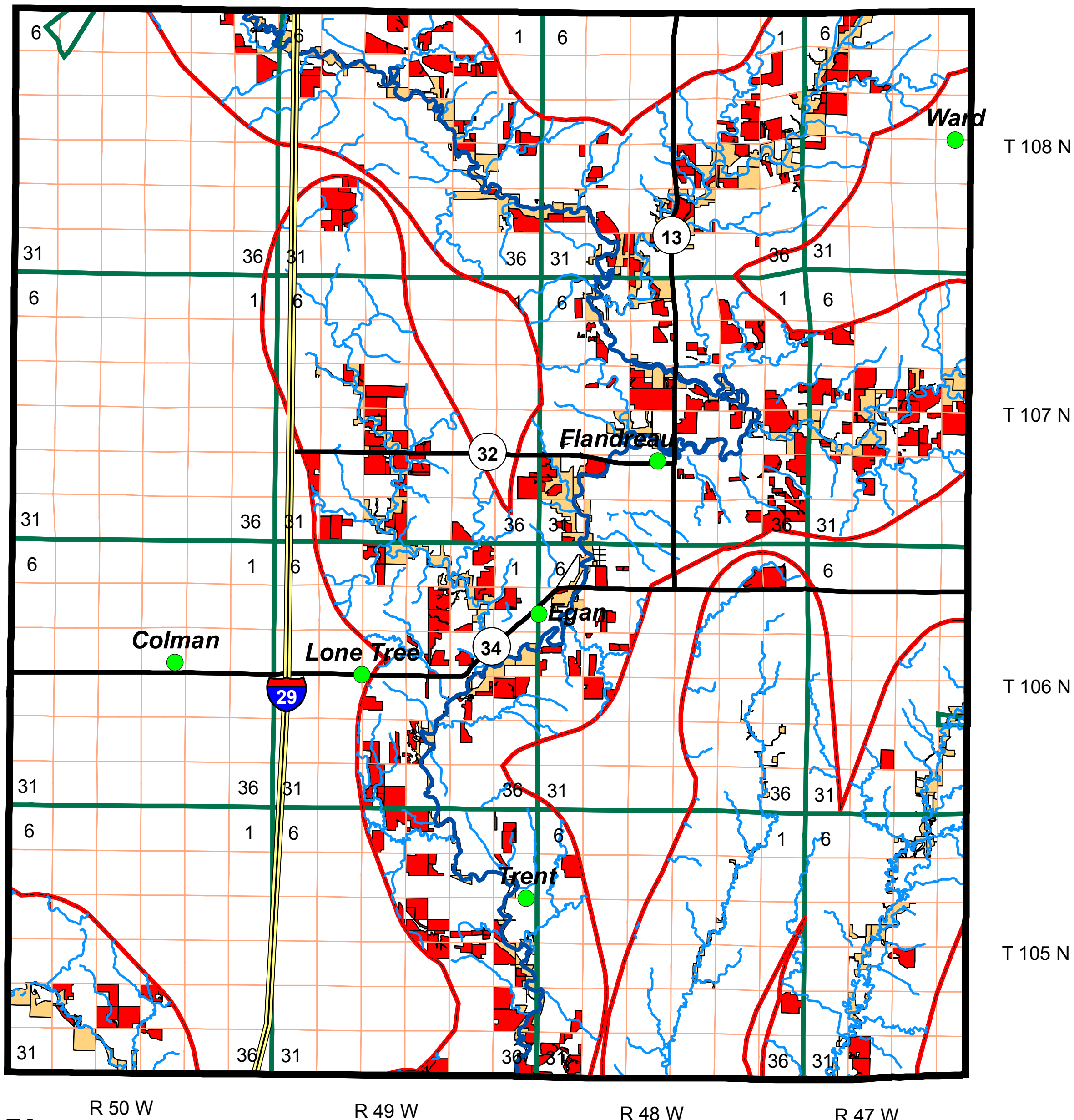
This Map is for Planning Purposes Only

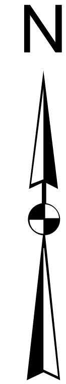
Although every effort has been made to ensure the accuracy of Information; errors and conditions originating from the physical sources used to develop the database may be reflected in the data supplied. The end user must be aware of the data conditions and ultimately bear responsibility for the appropriate use of the information with respect to possible errors, original map scale, collection methodology, currency of data and other conditions specific to certain data.

0 1.5 3 6 9 12 Miles

South Dakota State University

Big Sioux Water Quality Project
Moody County South Dakota - Priority Land





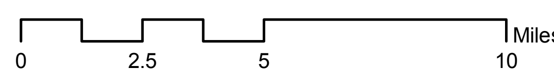
Legend

- Interstate Highway
- State Highway
- Two (2) Mile Buffer
- Priority Cropland
- Priority Pastureland

Watershed Cropland and Pasture Summary	
	---acres---
County Area	333,107
Watershed Area	251,024
Watershed - 2 Mile Buffer	185,523
Cropland (County)	262,000
Cropland - 2 Mile Buffer	129,176
Priority Cropland	28,775
Pasture Land (County)	38,000
Pasture - 2 Mile Buffer	31,071
Priority Pasture Land	12,552

Map Created: January 7, 2008

Kurtis Reitsma
South Dakota State University
Plant Science Department
Brookings SD 57007
(605) 688-4594



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Appendix 2.

Male and female questionnaire; regional assessment of attitudes toward water quality.

Interview Schedulew for Senior Male: Version 1-7

INSTRUCTIONS FOR INTERVIEWERS

BEFORE THE INTERVIEW

1. Review the dossier for this family

2. Know
   a. Producer family background information
      i. Marital status

      ii. Children
         (1) age

         (2) number

         (3) sex

         (4) Are any of them married?

         (5) participation in farming

   b. Producer Farm Information
      i. Farm and/or ranch
      ii. What it produces
      iii. How big it is
      iv. Distance from water
         (1) lake
         (2) Big Sioux River
            (a) drain into
            (b) contiguous

      v. Is the farm over a shallow aquifer?

3. How were these people selected to be interviewed
   a. Listed by Angie Guidry
   b. Snow ball names

4. Anything else extension agents can tell you

5. COMMENT TO INTERVIEWERS:
   a. The stuff in **ITALIC** the interview schedule is for the INTERVIEWER, NOT for the RESPONDENT. Do not read it to them.

   b. If the operation is a farm, use that term. If it is a ranch, use that term.

AT THE BEGINNING OF THE INTERVIEW

1. Have the informant read and sign the SDSU INFORMATION FORM

2. After the respondent has signed the form, cue the tape:
   a. Interviewer=s name
   b. Person being interviewed
   c. Code number of producer operation
   d. Date of interview
   e. Location of interview

INTERVIEW STARTS

HISTORY OF THE FAMILY FARM/RANCH

We would like to begin by asking you a few questions about the history of THIS farm/ranch.

1. First, for how many years have you lived on a farm -- this one or another?

    a. Total number of years living on a farm: ______

    b. Total number living on this one: _________

2. Would you tell me the history of this farm? How long has either your or your wife=s family owned this farm? How did your family end up owing this farm/ranch? Did you or your wife inherit it? Did you add to it by buying other land?

(Probably will take about 15 minutes)

OPERATION OF THIS FARM/RANCH

REVIEW with the operator an over-view of the operation

3. Legal status of farm/ranch: What is the legal status of your farm/ranch?
    a. Independent single family farm/ranch
    b. Multifamily farm/ranch
    c. Corporate farm/ranch
    d. Other (Please Specify) ____________________________
    ____

4. Ownership:

    a. Do you **OWN** all or most of the land of this farm? (M*ay rent some*)

    b. Do you **OWN/RENT** about the same amount of land?

    c. Do you **RENT** most or all of the land of this farm? (*May own some*)

    d. Is any of this land TRIBAL land?

5. Operation:

    a. Do you run/operate it by yourself?

        i. Yes

        ii. No

    b. If you are not operating it by yourself, are you farming with another family member or members such as your spouse, father or father-in-law, or any of your children?

        i. Yes

        ii. No

        iii. If you do, would you tell me what he or she does?

c. If you are not operating it by yourself, do you hire non-family workers to help you operate the farm/ranch?

i. Yes

ii. No

iii. If you do, would you tell me what he of she does?

____

____

6. Production Activities:

a. Crops

i.

ii.

iii.

b. Do you have any acres in organic production?

i. No

ii. Yes

iii. If yes, approximately what proportion is in organic production? ________

c. Livestock

i. Type and approximate number:

ii. Type and approximate number:

iii. Type and approximate number:

iv. Feedlot versus pasture:

(1) Only have pastures

(2) Only have feedlots

(3) Have both

(4) If both, what proportion of the year do they graze? __________

v. Do you raise any livestock organically?

(1) No

(2) Yes

(3) If yes, what proportion?

DECISION MAKING CONCERNING FARM/RANCH OPERATION

7. Who makes the production decisions? (*Open-ended question*)

8. If more than one person is involved in making production decisions, who are they and how are they involved? (Open-ended)

9. On whom do you depend for production information or advice in making production decisions?

10. About the factors used to make production decisions:

    a. What are the factors used to make production decisions? (*Open-ended question*)

    b. Is there ONE that you think is the most important? If there is, what is it? (*Open-ended question*)

    c. Are any of the factors used to make production decisions not related to agriculture? If there are, what are they? *(Open-ended question)*

11. Has there ever been a conflict or inconsistency between the factors that are important for making production decisions on this farm/ranch and factors not related to agriculture? If yes, would you describe that conflict or inconsistency? (Open-ended question)

OPINIONS ABOUT POLLUTION IN THE BIG SIOUX RIVER

12. Do you recreate in the Big Sioux River basin?

    a. No

    b. Yes

    c. If yes, what kind off recreating do you do, and how often? _____________

    ____

13. Have you discussed issues related to the environment with your spouse and/or children?

    a. No

    b. Yes

    c. If yes, what kind off issues have you discussed? _____________

    ____

14. Have your children discussed issues related to the environment with you?

    a. No

    b. Yes

    c. If yes, what kind off issues did they want to discuss? _____________

    ____

15. Have you discussed issues related to the environment with others such as friends, neighbors, or public officials?

    a. No

    b. Yes

    c. If yes, what kind off issues have you discussed? _____________

    ____

16. (SA) To what extent do we have an obligation to protect water quality for future generations?
    a. Quite a bit
    b. Somewhat
    c. Only a little
    d. None at all
    e. Don=t know

17. In your opinion, is the Big Sioux River polluted?
    a. Yes

    b. No

    c. If yes, how polluted is the Big Sioux River?
        i. Very polluted
        ii. Somewhat polluted
        iii. Not very polluted

18. (SA) Would you say the Big Sioux River is more polluted, less polluted or about the same as it was 25 years ago?
    a. More
    b. Less
    c. About the same
    d. Don=t Know

19. If you think the River is more polluted, what is the main cause of the pollution (*Open-ended*)?

    ____

    ____

20. (SA) How concerned are you about the pollution on the Big Sioux River?
    a. Very concerned
    b. Somewhat concerned
    c. Not very concerned
    d. Not at all concerned
    e. Don't know

21. If you are VERY or SOMEWHAT concerned, why? (*Opened Ended Question*)?

    ____

    ____

22. (SA) Water quality in the Big Sioux River is most influenced by which of the following? (**CHOOSE ONLY ONE**)
    a. Land-use practices adjacent to the River
    b. Water quality in the creeks and streams that feed the River
    c. Ground water contributions to the River
    d. Other (**PLEASE SPECIFY**)

    ____

    ____

    e. Don't know

23. (SA) What is the greatest threat to water quality in the Big Sioux River?
    a. Agricultural activities (Go to Question 24)
    b. Urban activities (Go to Question 25)
    c. Industrial/Commercial activities (Go to Question 26)
    d. Other (**PLEASE SPECIFY**)

    ____

    ____

    e. Don't know

24. (SA) If your answer was AGRICULTURAL ACTIVITIES, which of the following represents the greatest threat within this category? (**CHOOSE ONLY ONE**).

a. Erosion
b. Fertilizers
c. Pesticides/herbicides
d. Animal feeding operations
e. Other (**PLEASE SPECIFY**) ________________________________

____

f. Don't Know

25. (SA) If your answer was URBAN ACTIVITIES, which of the following represents the greatest threat within this category? (**CHOOSE ONLY ONE**).

a. Lawn chemicals
b. Construction sites
c. Runoff from street and parking lots
d. Other **(PLEASE SPECIFY**) __________________________________

____

e. Don't Know

26. If your answer was INDUSTRIAL/COMMERCIAL ACTIVITIES, which of the following represents the greatest threat within this category? (**CHOOSE ONLY ONE**).

a. Chemical/fuel storage tanks
b. Industrial wastes
c. Municipal wastes
d. Other (**PLEASE SPECIFY**) __________________________________

____

e. Don't Know

27. Do you think something should be done to clean up the Big Sioux River?

a. Yes
b. No

28. If your answer is Yes, what do you think should be done?

____

____

29. (SA) Who do you think should be most responsible for MAKING DECISIONS about cleaning up the Big Sioux River? **(CHOOSE ONLY ONE)**

a. Local residents
b. Local government
c. State government
d. Federal government
e. Someone else (**PLEASE SPECIFY**): ________________________

____

f. Don=t know

30. (SA) Who do you think should be most responsible for paying the COST of cleaning up the Big Sioux River? **(CHOOSE ONLY ONE)**

a. Local residents
b. Local government
c. State government
d. Federal government
e. Someone else (Please specify): ______________________________________

____

f. Don=t know

POTENTIAL ACTIVITIES TO PROTECT THE WATER QUALITY OF THE BIG SIOUX RIVER

31. (SA) Are you willing to have regulations on the use of private property to protect the water quality in the Big Sioux River?
    a. Yes
    b. No
    c. Don=t know

32. (SA) Are you willing to pay higher taxes to protect water quality in the Big Sioux River?
    a. Yes
    b. No
    c. Don=t know

33. (SA) To what extent would you support or oppose property tax reductions for farmers who use conservation practices?
    a. Strongly support
    b. Support
    c. Oppose
    d. Strongly Oppose
    e. Don=t know

34. (SA) If your answer is Strongly Support or Support property tax reductions to farmers who use conservation practices, would you support property tax reductions even if it means that others would have to pay higher property taxes?
    a. Yes
    b. No
    c. Don=t know

35. (SA) What incentives would YOU need in order to get you to implement additional conservation practices on your farm? **(CHOOSE ONLY ONE)**

a.	Tax credits	Yes	No	Don=t Know
b.	Cost share	Yes	No	Don=t Know
c.	Loans	Yes	No	Don=t Know

d. Other (**PLEASE SPECIFY**) ____________________________________

____

36. (SA) What additional conservation practices would you implement on your farm if acceptable incentives were available? (**ALL THAT APPLY**)

a.	Reduce tillage	Yes	No	Don=t know
b.	Contour farming/terraces	Yes	No	Don=t know
c.	Buffer strips	Yes	No	Don=t Know
d.	Cropland retirement	Yes	No	Don=t Know
e.	Animal waste management	Yes	No	Don=t Know
f.	Other (**PLEASE SPECIFY**)			

____

____

37. Would you implement conservation practices on your farm if there were neither net losses nor net gains in farm income?
    a. No
    b. Yes

38. If you would implement additional economically neutral conservation practices on your farm, what kinds of conservation practices would they be?

    (**PLEASE SPECIFY**)

____

____

BETTER MANAGEMENT PRACTICES

Farming practices can have a significant impact on the water quality of the Big Sioux River. There are several issues pertinent to those practices. We would like to ask about your practices and the reasons for those practices.

FEEDLOT QUESTIONS:

1. About manure:

   a. In a (cow, beef, pig, etc.) production enterprise such as yours, manure is a major concern. When you make decisions about manure, how do you think about it? For example, is it a resource? Is it a liability? Or is it both? Does the definition change from time to time? Do the decisions you make about what to do with manure depend on the season of the year?

   b. Is manure part of your soil fertility program? If so, how?

2. About your feedlots: How do you handle run-off?

a. I do not have feedlots.

b. Are there diversion structures -- either natural or constructed -- that prevent the flow of water into your feedlots?
   i. Yes
   ii. No

c. Do you have a lagoon into which to direct the flow from the feedlot?
   i. Yes
   ii. No

d. Is the water you use in the feedlot regulated?
   i. Yes
   ii. No

e. Do you use covered barns?
   i. Yes
   ii. No

f. Other (**PLEASE SPECIFY**):
   ____

   ____

3. About your pastures:

   a. I do not have pastures.

   b. (Stocking rate) Do you limit the size of the herd and the length of time the animals are allowed to graze a pasture?

   c. Do you have a rule of thumb for the length of time a herd of a certain size is allowed to graze a pasture of a specific size?

   d. Do you ever have problems with over-grazing?

   e. How often do you walk your pastures checking for potential problems?

   f. Do you manage weeds in your pastures? If so, how?

   g. Do you manage rodents in your pastures? If so, how?

4. As part of your equipment maintenance program:

   a. Do you routinely adjust and calibrate your fertilizers and sprayers?

      i. Yes

      ii. No

   b. If you do, why?

   c. On which pieces of equipment do you work, how often, and when?

5. Are any of your fields adjacent to a stream/river?

   a. No

   b. Yes

   c. If any are, do you have a grass buffer between the field and the stream/river?

   d. If you have grass buffers, were they constructed or are they natural?

6. About grass waterways:

   a. Do you have any grass waterways?

      i. No

      ii. Yes

   b. If you have grass waterways, were they constructed or are they natural?

7. Soil compaction in your fields:

   a. Is soil compaction a concern for you?

      i. Yes
      ii. No

   b. If so, what strategies do you use to minimize it?

8. Soil testing:

   a. Do you have your fields tested for available nutrients?

      i. No

      ii. Yes

   b. If so, how often?

   c. If so, how do you use the results?

   d. If you test for Nitrogen, do you take samples to a depth of 24 inches?

Apparently the test for potassium and phosphorous is 6 inches

9. Do you practice conservation tillage methods?

   a. No

   b. Yes

   c. If you do, which ones?

   d. If you do, what advantages do you see with the methods?

   e. If you do, what disadvantages do you see with these methods?

10. About record keeping:

   a. Do you keep records on the history of each of your fields?

   b. If so, what kinds of information do you collect?

11. Crop residue management:

   a. Do you practice crop residue management?

   b. If so, exactly what do you do?

BETTER MANAGEMENT PRACTICES PRODUCER EVALUATION CHART

Please indicate whether you think these methods are simple to implement or not and whether they are costly, have no net cost, or are financially advantageous.

FARMING PRACTICES	SIMPLE TO IMPLEMENT		ECONOMICALLY COSTLY, NEUTRAL OR, ADVANTAGEOUS		
	Yes	No	Costly	Neutral	Advantageous
Conduct annual field nutrient assessment	___	___	____	____	____
Test soil annually	___	___	____	____	____
Use soil testing to make decisions about applying nutrients	____	____	____	____	____
Scout fields to identify problem areas	___	___	____	____	____
Keep records to track field histories	___	___	____	____	____
Ensure farm equipment is accurately calibrated	____	____	____	____	____
Prevent field soil compaction with controlled traffic lanes in fields or by loading/unloading at edge of field	____	____	____	____	____
Maintain grass buffers between fields and stream/river	____	____	____	____	____
Maintain a protective plant residue cover on fields	____	____	____	____	____
Strip farming	____	____	____	____	____
Precision farming	____	____	____	____	____
No-till farming	____	____	____	____	____

Contour plowing	____	____	____	____	____

STOCK RAISING PRACTICES	SIMPLE TO IMPLEMENT		ECONOMICALLY COSTLY, NEUTRAL, or ADVANTAGEOUS		
	YES	NO	Costly	Neutral	Advantageous
Avoid applying manure to grass waterways	____	____	____	____	____
Avoid applying manure to frozen soil or snow covered ground	____	____	____	____	____
Prevent unwanted water flow into feedlot	____	____	____	____	____
Maintain lagoon for excess liquid manure	____	____	____	____	____
Ensure waterers do not produce excess water flow out of feedlot	____	____	____	____	____
Monitor fields to allow adequate time for regrowth	____	____	____	____	____

PERSONAL DEMOGRAPHIC CHARACTERISTICS

12. In what year were you born? __________

13. What is your marital status? ___________

14. What is the highest level of school you have completed? __________

OTHER FAMILIES

15. We are interested in talking with several families about the issue of the water quality of the Big Sioux River. Are there other families living near the Big Sioux River who you think might be willing to help us with our work.

Name	Address	Telephone Number

THANK YOU FOR YOUR ASSISTANCE

Interview Schedule For Senior Female; Version 2-7

INSTRUCTIONS FOR INTERVIEWERS

BEFORE THE INTERVIEW

1. Review the dossier for this family

2. Know
    a. Producer family background information
        i. Marital status
        ii. Children
            (1) age
            (2) number
            (3) sex
            (4) Are any of them married
            (5) participation in farming
    b. Producer farm information
        i. Farm and/or ranch
        ii. What it produces
        iii. How big it is
        iv. Distance from water
            (1) lake
            (2) Big Sioux River
                (a) drain into
                (b) contiguous
        v. Is the farm over a shallow aquifer?

3. How were these people selected to be interviewed
    a. Listed by Angie Guidry
    b. Snow ball names

4. Anything else extension agents can tell you

5. COMMENT TO INTERVIEWERS:
    a. The stuff in ITALIC in the interview schedule is for the INTERVIEWER, NOT for the RESPONDENT. Do not read it to them.
    b. If the operation is a farm, ram

    c. If the operation is a farm, use that term. If it is a ranch, use that term.

AT THE BEGINNING OF THE INTERVIEW

1. Have the informant read and sign the SDSU INFORMATION FORM.

2. After she has signed the form, cue the tape:
   a. Interviewer=s name
   b. Person being interviewed
   c. Code number of producer operation
   d. Date of interview
   e. Location of interview

INTERVIEW STARTS

HISTORY OF THE FAMILY FARM/RANCH

We would like to begin by asking you a few questions about the history of THIS farm/ranch.

1. First, for how many years have you lived on a farm -- this one or another?

   a. Total number of years living on a farm: ______

   b. Total number living on this one: __________

2. Would you tell me the history of this farm? How long has either your or your husband=s family owned this farm? How did your family end up owning this farm/ranch? Did you or your husband inherit it? Did you add to it by buying other land?

(Probably will take about 15 minutes)

DECISION MAKING CONCERNING FARM/RANCH OPERATION

1. Who makes the production decisions? (Open-ended question)

2. If more than one person is involved in making production decisions, who are they and how are they involved? (Open-ended)

3. Do you know the source of production information or advice in making production decisions?

4. About the factors used to make production decisions:

   a. What are the factors used to make production decisions? (*Open-ended question*)

   b. Is there ONE that you think is the most important? If there is, what is it? (*Open-ended question*)

   c. Are any of the factors used to make production decisions not related to agriculture? If there are, what are they? *(Open-ended question)*

5. Has there ever been a conflict or inconsistency between the factors that are important for making production decisions on this farm/ranch and factors not related to agriculture? If yes, would you describe that conflict or inconsistency? (Open-ended question)

OPINIONS ABOUT POLLUTION IN THE BIG SIOUX RIVER

6. Do you recreate in the Big Sioux River basin?

   a. No

   b. Yes

   c. If yes, what kind off recreating do you do, and how often? ____________

   ____

7. Have you discussed issues related to the environment with your spouse and/or children?

   a. No

   b. Yes

   c. If yes, what kind of issues have you discussed? ____________________

   ____

8. Have your children discussed issues related to the environment with you?

   a. No

   b. Yes

   c. If yes, what kind of issues did they want to discuss? ____________

   ____

9. Have you discussed issues related to the environment with others such as friends, neighbors, or public officials?

   a. No

   b. Yes

   c. If yes, what kind of issues have you discussed? ______________________

   ____

10. (SA) To what extent do we have an obligation to protect water quality for future generations?
   a. Quite a bit
   b. Somewhat
   c. Only a little
   d. Not At all
   e. Don=t know

11. In your opinion, is the Big Sioux River polluted?
   a. No

   b. Yes

   c. If yes, how polluted is the Big Sioux River?
      i. Very polluted
      ii. Somewhat polluted
      iii. Not very polluted

12. (SA) Would you say the Big Sioux River is more polluted, less polluted or about the same as it was 25 years ago?
   a. More
   b. Less
   c. About the same
   d. Don=t Know

13. If you think the River is more polluted, what is the main cause of the pollution? (*Open-ended*)

____

____

14. (SA) How concerned are you concerned about the pollution on the Big Sioux River?
    a. Very concerned
    b. Somewhat concerned
    c. Not very concerned
    d. Not at all concerned
    e. Don't know

15. If you are VERY or SOMEWHAT concerned, why? (*Opened Ended Question*)?

____

____

16. (SA) Water quality in the Big Sioux River is most influenced by which of the following? (**CHOOSE ONLY ONE**)
    a. Land-use practices adjacent to the River
    b. Water quality in the creeks and streams that feed the River
    c. Ground water contributions to the River
    d. Other (**PLEASE SPECIFY**)

____

____

    e. Don't know

17. (SA) What is the greatest threat to water quality in the Big Sioux River?
    a. Agricultural activities (Go to Question 18)
    b. Urban activities (Go to Question 19)
    c. Industrial/Commercial activities (Go to Question 20)
    d. Other (**PLEASE SPECIFY**)

    ____

    ____

    e. Don't know

18. If your answer was AGRICULTURAL ACTIVITIES, which of the following represents the greatest threat within this category? (**CHOOSE ONLY ONE)**.

    a. Erosion
    b. Fertilizers
    c. Pesticides/herbicides
    d. Animal feeding operations
    e. Other (**PLEASE SPECIFY**) ____

    ____

    f. Don't Know

19. If your answer was URBAN ACTIVITIES, which of the following represents the greatest threat within this category? (**CHOOSE ONLY ONE**).

    a. Lawn chemicals
    b. Construction sites
    c. Runoff from street and parking lots
    d. Other (**PLEASE SPECIFY**) ____

    ____

    e. Don't Know

20. If your answer was INDUSTRIAL/COMMERCIAL ACTIVITIES, which of the following represents the greatest threat within this category? (**CHOOSE ONLY ONE**).

a. Chemical/fuel storage tanks
b. Industrial wastes
c. Municipal wastes
d. Other (*PLEASE SPECIFY*) ____

____

e. Don’t Know

21. (SA) Do you think something should be done to clean up the Big Sioux River?
a. No

b. Yes

22. If your answer (to question 21) is Yes, what do you think should be done?

____

____

23. (SA) Who do you think should be most responsible for MAKING DECISIONS about cleaning up the Big Sioux River? **(CHOOSE ONLY ONE)**
a. Local residents
b. Local government
c. State government
d. Federal government
e. Someone else (Please specify): ______________________
____

f. Don=t know

24. (SA) Who do you think should be most responsible for paying the COST of cleaning up the Big Sioux River? **(CHOOSE ONLY ONE)**

a. Local residents
b. Local government
c. State government
d. Federal government
e. Someone else (**PLEASE SPECIFY**): ________________________
____

f. Don=t know

POTENTIAL ACTIVITIES TO PROTECT THE WATER QUALITY OF THE BIG SIOUX RIVER

25. (SA) Are you willing to have regulations on the use of private property to protect the water quality in the Big Sioux River?
    a. Yes
    b. No
    c. Don=t know

26. (SA) Are you willing to pay higher taxes to protect water quality in the Big Sioux River?
    a. Yes
    b. No
    c. Don=t know

27. (SA) To what extent would you support or oppose property tax reductions for farmers who use conservation practices?
    a. Strongly support
    b. Support
    c. Oppose
    d. Strongly Oppose
    e. Don=t know

28. (SA) If your answer is that you Strongly Support or Support property tax reductions to farmers who use conservation practices, would you support property tax reductions even if it means that others would have to pay higher property taxes?
    a. Yes
    b. No
    c. Don=t know

29. (SA) What incentives would YOU need in order to have additional conservation practices implemented on your farm? **(CHOOSE ONLY ONE)**

a.	Tax credits	Yes	No	Don=t Know
b.	Cost share	Yes	No	Don=t Know
c.	Loans	Yes	No	Don=t Know

    d. Other (Please specify) ___________________________________
    ____

30. (SA) What additional conservation practices would you want implemented on your farm if acceptable incentives were available? (**CHECK ALL THAT APPLY**)

a.	Reduce tillage	Yes	No	Don=t know
b.	Contour farming/terraces	Yes	No	Don=t know
c.	Buffer strips	Yes	No	Don=t Know
d.	Cropland retirement	Yes	No	Don=t Know
e.	Animal waste management	Yes	No	Don=t Know

f. Other (**PLEASE SPECIFY**)

____

____

31. Would you want additional conservation practices implemented on your farm if there were neither net losses nor net gains in farm income?
a. No
b. Yes

32. If you would want additional economically neutral conservation practices implemented on your farm, what kinds of conservation practices would they be?

(**PLEASE SPECIFY**)

____

____

PERSONAL DEMOGRAPHIC CHARACTERISTICS

33. In what year were you born? __________

34. What is your marital status? ___________

35. What is the highest level of school you have completed? __________

OTHER FAMILIES

36. We are interested in talking with several families about the issue of the water quality of the Big Sioux River. Are there other families who you think might be willing to help us with our project?

Name	Address	Telephone Number

THANK YOU FOR YOUR ASSISTANCE

Appendix 3.

Result summary of regional assessment of attitudes toward water quality.

ATTITUDES TOWARD THE WATER QUALITY OF THE BIG SIOUX RIVER: AN EXECUTIVE SUMMARY

Ron Stover, Ph.D.

INRODUCTION

During the summers of 2007 and 2008, two colleagues and I conducted interviews with producer families, both current and retired, living in the Big Sioux River watershed from Watertown to Brandon. Twenty one families were interviewed. More males were interviewed because several males were not married and several wives were reluctant to be interviewed because of the time demands of their off-farm work schedules. The purpose of the interviews was to investigate the attitudes of the families to water quality of the Big Sioux and indirectly their attitudes to environmental issues in general.

The material in this summary represents an over-view of those attitudes.

1. **ACCEPTANCE OF PRODUCER RESPONSIBILITY FOR WATER QUALITY PROBLEMS**: Many of the male and female respondents accepted that at least some of the water quality problems are due to producer activities and are not happy with those activities. In fact, some of these producers are highly critical of the activities of other producers.

2. **ANGER AT THE HYPOCRACY OF NON-FARMERS**: Many of these producers expressed anger at non-farmers who blamed water quality problems solely on agricultural producers. They insist that many of the water quality problems of the Big Sioux are due to lawn care chemicals, the run-off from golf courses, and urban sewage discharge.

3. **VARIATION IN ENVIRONMENT ATTITUDES**: These respondents are not monolithic in their attitudes toward the environment. At least three positions can be identified. There are producers who can be labeled strong environmentalists. They are supportive of environmentally positive practices even if there are no financial or personal incentives**.** In fact, some are engaged in practices that are costing them money just because they believe these practices are the right thing to do. Environmentalists are those who prefer to act in environmentally positive ways but are not willing to take a financial hit to do so. Non-environmentalists are those who, while not being anti-environmentalists, do not consider environmental issues to be critical in farming practices.

4. **PERCEPTION OF CHANGES IN THE WATER QUALITY OF THE BIG SIOUX RIVER**: All but one of the interviewees responded the Big Sioux River was either somewhat or very polluted. However, there was a great deal of disagreement among these interviewees about changes in the water quality of the River over the last twenty-five years. Only about half of the female respondents and a similar proportion of the male respondents indicated they believed the water quality had gotten worse. A few indicated it was about the same and others suggested it had gotten better. Those suggesting it had gotten worse referred to the increased number of cattle being raised in the watershed and to the increase in urban based pollution, while those indicating it had gotten better referenced changes in farming and cattle producing practices.

5. **FAMILY RECREATING ON THE BIG SIOUX**: In general, these families do not recreate on the Big Sioux. If anyone in the family does, it is the children who might fish or canoe or play in the River with a four wheeler.

6. **OBLIGATION TO PROTECT WATER QUALITY FOR FUTURE GENERATIONS:** All of the interviewees accepted an obligation to protect the water quality for future generations. Some were quiet emphatic about that obligation.

7. **GREATEST THREAT TO THE WATER QUALITY ON THE GREAT SIOUX**: When asked what was the greatest threat, half of the respondents listed agricultural practices such as the use of fertilizers and pesticides and run off from animal production. The others listed the pollution due to industrial/commercial activities such as chemical storage tanks and still others (as noted earlier) listed urban pollution due to the run off from chemicals used in lawn care and golf courses and urban sewage discharge.

8. **SHOULD SOMETHING BE DONE TO CLEAN UP THE BIG SIOUX?** When asked if something should be done to clean up the Big Sioux, only two said no. When asked who should make the decisions about the clean up, only one said it should be the federal government. Most of the others wanted more local control; they wanted the decision to be made by the local residents, the local government, the state government, or some combination of those three. A few wanted all four to cooperate in the decision making process. When asked who should pay, the responses were even more split, with a slight preference for either the federal or state governments paying the cost. However, several respondents indicated that all four possibilities – local individuals, and the local, state, and federal governments – paying the cost.

9. **WILLINGNESS TO ACCEPT REGULATIONS ON THE USE OF PRIVATE PROPERTY TO PROTECT THE WATER QUALITY OF THE BIG SIOUX:** There is no trend at all. Some of the respondents accepted such regulations, others rejected them, and still others were not sure.

10. **WILLINGNESS TO PAY HIGHER TAXES TO PROTECT WATER QUALITY ON THE BIG SIOIUX:** Again, there is no trend. Some of the respondents accepted the taxes, others rejected them, and others were not sure.

11. **WILLINGNESS TO SUPPORT PROPERTY TAX REDUTIONTIONS FOR FARMERS WHO USE CONSERVATION PRACTICES**: There was virtual, but not total, unanimity for this policy. However, that unanimity disappears if the policy requires others to pay higher taxes. Some would accept such a policy, others would not, and still others were not sure.

12. **WILLINGNESS TO IMPLANT ADDITIONAL CONSERVATION PROACTICES IF SUCH PRACTICES WERE ECONONMICALLY NEUTRAL:** When asked if they would want additional conservation practices implemented on the farm, there was a clear preference among these respondents for the practices; the overwhelming majority wanted such practices implemented.

13. **IMPLEMENTATION OF ADDITIONAL CONSERVATION PRACTICES:** Virtually all respondents stated they would implement additional conservation practices even if there were neither net financial gains or losses for those practices. Some respondents were emphatic about such practices; one claimed such implementation was a "no-brainer."

14. **ATTITUDES TOWARD THE CRP PROGRAM (Asked of Males)**: Producer attitudes toward the CRP Program tend to be positive, but their participation varied. Some producers indicated they were abandoning their participation because the financial cost had become too high. They noted earlier CRP payments matched or exceeded the cash rent for the land. They are pulling out of the program because the CRP payments are far below current cash rent. Other producers are continuing their participation with the program but expressed disappointment with the low level of payments. They argue the program should be improved so that producers with land in the CRP Program are not financially hurt.

15. **ATTITUDES TOWARDS WATER QUALITY PROJECTS (Asked of Males)**: Producer attitudes toward water quality projects varied greatly. Some producers were very pleased with the outcomes of the projects. Others, on the other hand, expressed disgust at some of the projects that had been planned and implemented.

16. **DISAGREEMENT BETWEEN HUSBAND AND WIVES**: Not unexpectedly, husbands and wives generally agreed with each other in their responses to the questions asked. In most of the cases where there was disagreement, it was minor. However, there were cases when the response of the wife was very different from that of the husband. It is therefore dangerous to assume the answer of the husband or wife represents the answer of the other.

Appendix 4.

Results and questionnaire; land owner/operator assessment of proportion of land ownership/rental, production enterprise, and attitudes toward adoption of BMP’s.

South Dakota Cooperative Extension Service
Big Sioux River Watershed Producer Survey
ID: County:

This survey is to be conducted with individuals that are the major decision makers for land management practices on the farm. The first part provides some initial information about the producer and the farming operation. Read each statement and ask the producer to indicate the most appropriate response to each statement as given.

Sex: Male **(BG = 16, MY = 15)** Female **(BG = 0, MY = 0)** Age: **(BG = 53, MY = 57)**

Number of Years Farming near the Big Sioux River: **(BG = 35, MY = 31)**

Cropland Owned: **(BG = 485, MY = 358)** Acres Cropland Rented/Leased: **(BG = 540, MY = 175)** Acres

Pastureland Owned: **(BG = 353, MY = 167)** Acres Pastureland Rented/Leased: **(BG = 489, MY = 84)** Acres

Total Land in CRP: **(BG = 162, MY = 62)** Acres Total Land Diverted to Other Purposes **(BG = 54, MY = 28)** Acres

Total Land Holdings **(BG = 1,383, MY = 681)** Acres

Type of Farming Operation: Cash Crop **(BG = 75, MY = 65)**% Crop for Feed **(BG = 25, MY = 34)**%
Livestock **(BG = 40, MY = 37)**%

Farm is Primary Source of Income: Yes **(BG = 12, MY = 13)** No **(BG = 4, MY = 2)**

Children at Home: Yes **(BG = 9, MY = 3)** Ages: **(BG = 14, MY = 16)**

Heir Intends to Continue Farming: Yes **(BG = 6, MY = 2)** No **(BG = 5, MY = 3)** Unknown **(BG = 5, MY = 10)**

1. The amount of fields you usually scout is usually;

   < 20%______ 20 to 40%______ 40 to 60%______ 60 to 80% (BG & MY) > 80%_________

2. The amount of fields you usually soil sample each year is;

   < 20%______ 20 to 40%______ 40 to 60%______ 60 to 80% (BG & MY) > 80%_________

3. Fertilizer and/or manure rates are adjusted according to soil test results?

   NA______ Never______ Sometimes (MY) Usually (BG)______ Always_________

4. Manure rates are based on expected amount of nutrients contained in the manure and/or soil.

   NA______ Never______ Sometimes (MY) Usually (BG) Always_________

5. Tillage is conducted in the spring?

   NA______ Never______ Sometimes (MY) Usually (BG) Always_________

6. The sole source of water for livestock is a stream adjacent to the pasture?

   NA______ Never______ Sometimes (BG & MY) Usually______ Always_________

7. Shade is provided to livestock away from streams adjacent to the pasture?

   NA______ Never______ Sometimes (MY) Usually (BG) Always_________

8. Supplemental feed is provided to livestock away from streams adjacent to the pasture?

   NA______ Never______ Sometimes______ Usually (BG & MY) Always_________

9. I am willing to adopt practices across my entire farm that will improve water quality.

   Strongly Agree Somewhat Agree Strongly Disagree

   1 2 BG 3 4 5 6 7 MY 8 9 10

10. If a practice has been proven to improve profit, incentive payments are not important.

    Strongly Agree Somewhat Agree Strongly Disagree

    1 2 BG 3 4 5 6 7 MY 8 9 10

Appendix 9

SITECODE	DATE	Specimen#	TIME	Stage	WTEMP	ATEMP	CONDUCT	SPECCOND	SALINITY	DO	PH	TURBIDITY	T-Tube	FECAL	E-COLI	T_SUSP_SOL	SDHL Nitrate	EDWDD Nitrate	Total Phosphorus	Total Diss Phos	Comments
				ft	°C	°C	µS/cm	µS/cm	ppt	mg/L		NTU	cm	CFU/100mL	MPN/100mL	mg/L	mg/L	mg/L	(mg/L)	(mg/L)	
R04	10/24/05	E05EC007704	950		4.7	14.0	292	476	0.2	>20	8.00	16		40	24.0	45	1.0				water-lt. brown
R04	04/04/06	E06EC001455	1250		5.2	16.0	558	861	0.4	12.10	7.65	16		10		28		2.1			EDWDD nitrate test
R04	05/01/06	E06EC002272	1215		12.5	14.0	808	1072	0.5	10.33	6.97	9.8		140	248.0	26		0.8			water lt brn, EDWDD nitrate test
R04	06/06/06	E06EC003351	1155		22.0		858	906	0.4	8.23	8.27	61		110	119.0	140		0.9			water lt grn, EDWDD nitrate test
R04	07/11/06	E06EC004426	1150		25.3		745	745	0.4		8.37	84.8		70	45.2	148		nd			water lt brn, EDWDD nitrate test
R04	08/07/06	E06EC005361	1205		25.0		864	863	0.4	12.19	8.56	65		180	13.0	80		1.4			water lt brn, EDWDD nitrate test
R04	09/11/06	E06EC006633	1230		15.2	16.0	354	435	0.2	12.10	8.42	32	24.00	180	80.5	80		0.7			water brn, lots of duckweed moving down the river, EDWDD nitrate test
R04	10/10/06	E06EC007533	1245		11.1	16.0	662	909	0.5	14.44	8.49	32	3.00	70	36.4	70		1.4			EDWDD nitrate test
R04	03/14/07	E07EC002852	1300		1.9	9.0	220		0.2	15.66	7.42	25		750	1550.0						flood conditions due to snow melt, lgt brn
R04	04/02/07	E07EC001406	1430		6.4	13.0	537	837	0.4	10.84	8.08	17		210	411.0	25		1.1			water lgt brn, EDWDD nitrate test
R04	04/17/07	E07EC001945	1015		10.7	10.0	649	892	0.4	15.51	8.25	13	56.70	30	37.3	24		0.8			water lgt brn, EDWDD nitrate test
R04	04/24/07	E07EC002188	1030		13.1	13.0	701	906	0.4	7.40	8.15	11		220	488.0	22					clear, high flows
R04	05/22/07	E07EC003087			19.3	26.0	854	958	0.5	12.37	8.25	21.2	33.00	80		35		0.6			green, EDWDD nitrate test
R04	06/18/07	E07EC003749	1630		24.3	25.0	780	789	0.4	3.02	8.26	38	28.20	400		94		1.0			brown, EDWDD nitrate test
R04	07/17/07	E07EC004685	1225		25.4	31.0	873	864	0.4	10.69	8.47	45		50		88		0.9			light brown, cattling grazin in river upstream, EDWDD nitrate test
R04	08/21/07	E07EC005694	1255		23.8	33.0	779	798	0.4	7.01	8.46	110	7.10	400		198		1.5			brown, EDWDD nitrate test
R04	09/18/07	E07EC006238	1110		19.6	22.9	763	850	0.4	7.23	8.46	21	18.80	620		55		4.1			brown, EDWDD nitrate test
R04	10/10/07	E07EC006711	900		10.5	4.5	609	848	0.4	17.35		45	13.30	240		76		0.6			brown, EDWDD nitrate test
R04	04/10/08	E08EC001644	845		6.9	3.0		931	0.5	12.00	8.09		22.70	10		78		1.3			EDWDD nitrate test
R04	05/07/08	E08EC002347	1415		14.9	22.1		946	0.5	10.60	8.40		32.90	<10		41		0.6			EDWDD nitrate test
R04	06/09/08	E08EC002318	930		18.7	18.9		704	0.3	4.26	7.57	15		200		29					at flood stage
R04	07/10/08	E08EC004557	1200		24.5	27.0		818	0.4	8.43	8.23	65		40		136					
R04	08/13/08	E08EC005727	1530		25.5	31.0		729	0.4	8.96	8.28	100		400		196					cows in river (upstream)
R04	09/10/08	E08EC006544	1345		16.3	24.0		767	0.4	13.40	8.63	26		50		41					
R04	10/07/08	E08EC007432	1315		15.2	16.0		748	0.4	9.41	8.17	50		140		150					heavy rain past 24 hrs
R04	05/20/09	E09EC002543	1315		19.3	31.0			0.47	11.78	8.43	13		10.0		39					
R04	06/22/09	E09EC003364	1330		24.8	32.0			0.41	10.35	8.36	37		90.0		110					specific conductivity 838 ?????
R04	07/21/09	E09EC004036	1300		21.3	24.0		983	0.49	8.38	8.11	70		160.0		152					
R04	08/18/09	E09EC004777	1200		20.4	25.0		823	0.40	10.67	8.32	36		140.0		88					
R04	09/23/09	E09EC005937	1315		17.6	22.0		873	0.43	13.03	8.27	33		150.0		50					
R04	10/20/09	EO9EC006500	1315		8.4	11.0		906	0.45	12.73	8.19	24		90.0		71					
R04	08/24/10	E10EC005316	1315		23.6	25.0		1267	0.63	6.57	8.40	38			39.5	90					

SITECODE	DATE	Specimen#	TIME	Stage	WTEMP	ATEMP	CONDUCT	SPECCOND	SALINITY	DO	PH	TURBIDITY	T-Tube	FECAL	E-COLI	T_SUSP_SOL	Nitrate	Nitrate	Total Phosphorus	Total Diss Phos	Comments
				ft	°C	°C	µS/cm	µS/cm	ppt	mg/L		NTU	cm	CFU/100mL	MPN/100mL	mg/L	mg/L	mg/L	(mg/L)	(mg/L)	
R06	10/24/05	E05EC007705	1130		6.2	11.0	636	997	0.5	18.75	8.50	12		<10	24.0	35	0.9				water-lt. brown
R06	04/04/06	E06EC001456	1330		7.1	19.0	533	802	0.4	13.04	7.38	55		10		118		2.3			clr, EDWDD nitrate test
R06	05/01/06	E06EC002276	1230		12.3	15.0	805	1064	0.5	11.44	7.08	16		250	517.0	43		1.2			lt brn, EDWDD nitrate test
R06	06/06/06	E06EC003352	1225		23.3		886	916	0.4	11.26	8.60	32.9		20	27.5	84		0.6			lt brn, EDWDD nitrate test
R06	07/11/06	E06EC004427	1257		25.6		10	9	0.0	12.00	8.66	85.9		30	18.9	134		nd			lt brn, EDWDD nitrate test
R06	08/07/06	E06EC005363	1225		25.5		728	721	0.4	12.48	8.60	50		3800	>2420	204		nd			lt grn, EDWDD nitrate test
R06	09/11/06	E06EC006634	1245		16.1	20.0	686	826	0.4	13.98	8.64	50	18.00	70	43.7	92		nd			brn, EDWDD nitrate test
R06	10/10/06	E06EC007535	1315		12.4	16.0	743	979	0.5	17.45	8.82	50	25.20	80	33.6	118		nd			lt brn, EDWDD nitrate test
R06	04/17/07	E07EC001949	1200		12.2	16.0	670	886	0.4	16.36	8.59	26	38.40	<10	4.1	62		0.7			brn, EDWDD nitrate test
R06	04/24/07	E07EC002189	1045		13.1	16.0	685	887	0.4	11.42	8.60	23		800	>2420	61					brn, high flows
R06	05/22/07	E07EC003090	1400		20.1	22.0	882	974	0.5	12.74	8.43	24.4	21.20	40		53		0.3			brown, EDWDD nitrate test
R06	06/19/07	E07EC003756	1046		22.1	26.0	856	905	0.4	9.21	8.11	45	20.10	180		98		1.0			brown, EDWDD nitrate test
R06	07/17/07	E07EC004680	1415		29.1	32.0	910	844	0.4	14.16	8.61	55	11.50	220		88		nd			brown, EDWDD nitrate test
R06	08/22/07	E07EC005702	1000		22.8	21.0	684	717	0.4	7.11	8.22	65	10.70	340		92		1.6			brown, EDWDD nitrate test
R06	09/18/07	E07EC006240	1230		19.1	23.0	649	732	0.4	9.57	8.63	50	10.70	110		101		nd			green, EDWDD nitrate test
R06	10/10/07	E07EC006713	1020		11.5	7.4	595	808	0.4	16.57		38	14.20	660		70		0.3			brown, EDWDD nitrate test
R06	04/08/08	E08EC001533	1445		8.3	16.3		773	0.4	12.55	8.16		29.60	<10		38		1.6			EDWDD nitrate test
R06	05/07/08	E08EC002349	1245		14.6	22.0		945	0.5	10.15	8.40	34	19.00	<10		76		0.8			EDWDD nitrate test
R06	06/10/08	E08EC003308	1330		19.8	30.0		702	0.3	6.71	7.82	40		210		102					
R06	07/08/08	E08EC004359	1015		24.5	31.0		823	0.4	9.93	8.45	26		30		46					film on water
R06	08/13/08	E08EC005735	1400		25.9	31.0		688	0.3	12.19	8.59	75		150		122					
R06	09/09/08	E08EC006460	1115		14.3	22.0		727	0.4	12.09	8.72	28		40		44					
R06	10/09/08	E08EC007518	1045		12.0	11.0		699	0.3	10.11	8.28	30		750		38					
R06	05/20/09	E09EC002544	1345		20.9	32.0			0.43	15.93	8.64	14		<10		43					
R06	06/22/09	E09EC003361	1400		26.9	32.0			0.41	14.71	8.65	36		80.0		72					specific conductivity 837 ?????
R06	07/21/09	E09EC004029	1330		21.8	24.0		961	0.47	10.17	8.30	45		<10		76					taken .5 miles south (normal site blocked by road construction)
R06	08/18/09	E09EC004776	1230		21.3	26.0		776	0.38	10.00	8.47	40		140.0		82					sampled .5 miles S. of Egan (Road construction at regular location)
R06	09/23/09	E09EC005938	1345		18.2	24.0		762	0.37	12.87	24.00	34		30.0		59					
R06	10/20/09	E09EC006501	1345		9.0	12.0		898	0.44	13.93	8.28	22		30.0		40					sample .5 miles south of normal site because of construction
R06	08/24/10	E10EC005317	1400		24.8	22.0		1235	0.61	9.31	8.60	32			38.5	57					

SITECODE	DATE	Specimen#	TIME	Stage	WTEMP	ATEMP	CONDUCT	SPECCOND	SALINITY	DO	PH	TURBIDITY	T-Tube	FECAL	E-COLI	T_SUSP_SOL	Nitrate	Nitrate	Total Phosphorus	Total Diss Phos	Comments
				ft	°C	°C	µS/cm	µS/cm	ppt	mg/L		NTU	cm	CFU/100mL	MPN/100mL	mg/L	mg/L	mg/L	(mg/L)	(mg/L)	
R07	10/24/05	E05EC007706	1300		6.5	9.0	662	1022	0.5	16.56	8.59	14		20	18.1	35	1.0				water-lt. green
R07	04/04/06	E06EC001457	1350		5.2	18.0	264	398	0.2	12.24	7.70	60		10	19.7	140		2.3			clr, EDWDD nitrate test
R07	05/01/06	E06EC002273	1245		12.5	15.0	851	1121	0.6	11.92	7.12	19		540	579.0	47		1.2			lt brn, EDWDD nitrate test
R07	06/06/06	E06EC003355	1250		23.1		887	913	0.5	10.38	8.67	42.7		10	26.9	102		0.3			lt brn, EDWDD nitrate test
R07	07/11/06	E06EC004428	1328		26.8		395	382	0.2	12.16	8.73	54.9		100	15.5	108		nd			lt brn, EDWDD nitrate test
R07	08/07/06	E06EC005364	1300		25.0	31.0	781	782	0.4	13.34	8.61	55		3300	980.0	94		nd			lt brn, EDWDD nitrate test
R07	09/11/06	E06EC006635	1315		16.2	18.0	338	405	0.2	11.82	8.62	45	19.50	60	32.5	100		0.1			brn, EDWDD nitrate test
R07	10/10/06	E06EC007536	1400		11.9	12.0	647	862	0.4	17.54	8.88	55	22.80	150	43.1	128		nd			brn, EDWDD nitrate test
R07	04/17/07	E07EC001948	1245		12.1	19.0	700	927	0.5	16.63	8.60	23	37.60	90	153.0	52		0.8			lgt brn, EDWDD nitrate test
R07	04/24/07	E07EC002187	1100		13.3	14.0	716	922	0.5	12.21	8.08	21		850	1120.0	61					brn, high flows
R07	05/23/07	E07EC003129	920		18.6	17.0	876	998	0.5	13.58	8.37	27.3	21.80	70		74		0.5			brown, EDWDD nitrate test
R07	06/19/07	E07EC003757	1250		22.6	23.0	912	956	0.5	9.31	8.38	60	27.00	260		104		1.1			brown, EDWDD nitrate test
R07	07/17/07	E07EC004677	1520		28.8		914	851	0.4	17.90	8.72	55	11.40	410		102		nd			brown, EDWDD nitrate test
R07	08/22/07	E07EC005705	1120		22.3	21.0	687	724	0.4	7.03	8.19	85	7.90	440		168		1.9			brown, EDWDD nitrate test
R07	09/18/07	E07EC006241	1340		20.3	23.5	679	747	0.4	8.72	8.66	27	14.70	190		59		nd			EDWDD nitrate test
R07	10/10/07	E07EC006714	1115		12.1	10.0	607	806	0.4	16.42		60	11.80	340		114		nd			brown, EDWDD nitrate test
R07	04/08/08	E08EC001534	1330		6.8	11.4		827		12.60	7.93		24.10	<10		48		1.8			EDWDD nitrate test
R07	05/07/08	E08EC002338	1130		14.0	22.1		982	0.5	9.90	8.30	31	21.30	<10		76		0.9			EDWDD nitrate test

R07	06/10/08	E08EC003309	1400		20.2	30.5		723	0.4	6.82	7.90	39		210		80					
R07	07/08/08	E08EC004360	1145		24.8	27.0		847	0.4	11.48	8.52	40		80		76					
R07	08/13/08	E08EC005736	1215		24.7	27.0		716	0.4	10.80	8.50	75		30		144					
R07	09/09/08	E08EC006452	1245		15.4	22.0		722	0.4	13.58	8.74	30		<10		48					
R07	10/09/08	E08EC007507	1230		12.5	13.0		727	0.4	11.62	7.59	45		620		80					
R07	05/20/09	E09EC002545	1415		20.2	33.0			0.45	15.85	8.66	13		<10		43					
R07	06/22/09	E09EC003363	1430		26.5	35.0			0.42	13.40	8.60	45		40.0		108					specific conductivity 868 ?????
R07	07/21/09	E09EC004030	1345		22.9	27.0		983	0.48	10.30	8.37	55		40.0		104					
R07	08/18/09	E09EC004785	1245		21.7	28.0		787	0.39	10.47	8.45	37		70.0		78					
R07	09/23/09	E09EC005939	1400		18.0	25.0		780	0.38	14.91	8.47	35		20.0		66					
R07	10/20/09	E09EC006502	1400		9.1	13.0		933	0.46	13.61	8.28	22		10.0		44					
R07	08/24/10	E10EC005318	1415		25.2	23.0		1251	0.62	9.49	8.70	27			40.8	61					

SITECODE	DATE	Specimen#	TIME	Stage	WTEMP	ATEMP	CONDUCT	SPECCOND	SALINITY	DO	PH	TURBIDITY	T-Tube	FECAL	E-COLI	T_SUSP_SOL	Nitrate	Nitrate	Total Phosphorus	Total Diss Phos	Comments
				ft	°C	°C	µS/cm	µS/cm	ppt	mg/L		NTU	cm	CFU/100mL	MPN/100mL	mg/L	mg/L	mg/L	(mg/L)	(mg/L)	
R09	03/14/07	E07WB002851	1330		1.2	9.0	177		0.2	19.66	7.50	190		1100	1550.0						flood conditions due to snow melt, brn

SITECODE	DATE	Specimen#	TIME	Stage	WTEMP	ATEMP	CONDUCT	SPECCOND	SALINITY	DO	PH	TURBIDITY	T-Tube	FECAL	E-COLI	T_SUSP_SOL	Nitrate	Nitrate	Total Phosphorus	Total Diss Phos	Comments
				ft	°C	°C	µS/cm	µS/cm	ppt	mg/L		NTU	cm	CFU/100mL	MPN/100mL	mg/L	mg/L	mg/L	(mg/L)	(mg/L)	
R10	10/24/05	E05EC007707	1350		8.2	16.0	833	1217	0.6	17.69	8.46	16		20	23.5	42	0.7				water-clr to lt brn
R10	04/04/06	E06EC001458	1530		10.5	22.0	888	1252	0.6	13.24	7.95	45		10	28.8	106		2.0			clr, EDWDD nitrate test
R10	05/01/06	E06EC002274	1400		14.1	18.0	1078	1404	0.7	11.96	7.23	18		2500	2420.0	53		1.1			lt brn, EDWDD nitrate test
R10	06/06/06	E06EC003353	1335		25.1		1488	1485	0.7	9.17	8.19	30.1		100	23.9	56		1.1			lt grn, EDWDD nitrate test
R10	07/11/06	E06EC004429	1415		29.1		1492	1385	0.7	9.35	8.33	39.7		90	22.8	43		nd			lt grn, EDWDD nitrate test
R10	08/07/06	E06EC005367	1340		25.8		889	876	0.4	6.85	7.95	150		5600	1730.0	228		nd			brn, EDWDD nitrate test
R10	09/11/06	E06EC006636	1345		16.8	19.0	1068	1267	0.6	13.19	8.27	39	16.00	570	127.0	76		0.3			brn, EDWDD nitrate test
R10	10/10/06	E06EC007537	1445		13.0	17.0	994	1289	0.6	17.02	8.48	27	40.50	120	48.0	51		0.2			lt grn, EDWDD nitrate test
R10	04/18/07	E07EC002037	1225		13.5	25.0	1126	1442	0.7	11.89	8.56	12	36.50	10	23.1	33		0.5			clear, EDWDD nitrate test
R10	04/24/07	E07EC002196	1400		14.2		1185	1492	0.8	10.49	8.25	10		840	1410.0	31					lgt brn, rain event
R10	05/24/07	E07EC003168	1300		17.7	23.0	1379	1604	0.8	11.12	8.14	20.9	22.90	310		56		0.6			clear, EDWDD nitrate test
R10	06/20/07	E07EC003895	1300		24.2	32.5	1042	1057	0.5	7.63	8.10	45	15.50	200		108		1.0			brown, EDWDD nitrate test
R10	07/18/07	E07EC004733	1400		27.6	32.0	1120	1067	0.5	12.41	8.34	31	15.10	2100		64		nd			light brown, EDWDD nitrate test
R10	08/23/07	E07EC005797	1215		20.9	21.0	612	670	0.3	6.63	7.84	70	10.90	11200		110		1.0			light brown, EDWDD nitrate test
R10	09/19/07	E07EC006314	1330		20.0	31.6	1101	1219	0.6	11.68	8.40	8.7	33.00	80		14		0.5			clear, duckweed floating, EDWDD nitrate test
R10	10/11/07	E07EC006779	1120		11.4	14.2	796	1075	0.5	15.23		60	9.90	3800		94					brown
R10	04/07/08	E08EC001472	1245		6.3	17.2			0.7	14.31	8.06		21.60	<10		60		1.5			EDWDD nitrate test
R10	05/05/08	E08EC002226	1245		14.5	26.8		1513	0.8	11.53	8.26	19	30.30	10		50		0.9			EDWDD nitrate test
R10	06/09/08	E08EC003222	1330		20.8	28.9		1287	0.6	7.81	8.11	60		150		128					
R10	07/07/08	E08EC004302	1315		24.3	26.5		1344	0.7	8.27	8.03	26		100		56					
R10	08/12/00	E08EC005599	1200		22.7	26.0		890	0.4	10.13	8.21	23		380		48					lots of duckweed along bank
R10	09/08/08	E08EC006385	1330		18.3	21.0		1021	0.5	13.63	8.20	19		<10		28					
R10	10/06/08	E08EC007307	1330		18.6	25.0		821	0.4	10.65	8.17	23		40		38					
R10	05/20/09	E09EC002546	1500		22.6	33.0			0.62	15.63	8.57	16		<10		31					
R10	06/22/09	E09EC003358	1530		28.6	35.0			0.60	10.53	8.34	65		340.0		102					specific conductivity 1222 ?????
R10	07/21/09	E09EC004028	1430		23.8	27.0		1488	0.75	8.51	8.19	50		100.0		84					
R10	08/18/09	E09EC004783	1415		24.4	29.0		1076	0.53	12.64	8.42	45		100.0		86					
R10	09/23/09	E09EC005940	1500		19.6	22.0		950	0.47	13.74	8.34	15		80.0		36					
R10	10/20/09	E09EC006503	1445		11.2	15.0		1307	0.66	15.29	8.21	17		30.0		30					
R10	08/24/10	E10EC005319	1445		24.1	25.0		1359	0.68	8.08	8.40	50			1120.0	110					

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				ft	°C	°C	µS/cm	µS/cm	ppt	mg/L		NTU	cm	CFU/100mL	MPN/100mL	mg/L	mg/L	mg/L	(mg/L)	(mg/L)	
R11	03/14/07	E07WB002849	1510		4.4	9.0	261	430	0.2	18.20	7.84	110		80	162.0						flood conditions due to snow melt, smells like sewage, brn

SITECODE	DATE	Specimen#	TIME	Stage	WTEMP	ATEMP	CONDUCT	SPECCOND	SALINITY	DO	PH	TURBIDITY	T-Tube	FECAL	E-COLI	T_SUSP_SOL	Nitrate	Nitrate	Total Phosphorus	Total Diss Phos	Comments
				ft	°C	°C	µS/cm	µS/cm	ppt	mg/L		NTU	cm	CFU/100mL	MPN/100mL	mg/L	mg/L	mg/L	(mg/L)	(mg/L)	
R13	10/24/05	E05EC007708	1415		8.5	16.0	745	1089	0.5	15.56	8.46	20		70	56.5	49	3.4				cows grazing up to river
R13	04/04/06	E06EC001459	1630		8.3	19.0	575	854	0.4	14.10	7.63	95		20		182		4.0			clr, EDWDD nitrate test
R13	05/01/06	E06EC002275	1430		12.8	15.0	757	992	0.5	11.72	7.31	45		960	>2420	124		3.0			brn, EDWDD nitrate test
R13	06/06/06	E06EC003356	1402		24.5		950	958	0.5	13.50	8.59	28.4		140	152.0	114		2.9			lt brn, EDWDD nitrate test
R13	07/11/06	E06EC004431	1450		27.6		1005	959	0.5	12.61	8.70	19.5		110	18.1	108		3.3			brn, EDWDD nitrate test
R13	08/07/06	E06EC005371	1405		25.3		705	701	0.3	11.50	8.68	85		1000	148.0	86		1.3			brn, EDWDD nitrate test
R13	09/11/06	E06EC006638	1415		16.7	19.0	760	903	0.4	12.82	8.72	27	31.00	510	140.0	49		2.3			brn, EDWDD nitrate test
R13	10/10/06	E06EC007538	1515		13.2	14.0	831	1073	0.5	15.89	8.79	23	38.60	340	236.0	52		3.5			brn, EDWDD nitrate test
R13	04/18/07	E07EC002038	1310		12.9	19.0	787	1024	0.5	12.57	8.67	20	28.10	130	167.0	99		1.7			clear, EDWDD nitrate test
R13	04/24/07	E07EC002198	1430		14.1		816	1030	0.5	10.39	8.38	45		470	866.0	126					brn, cows on bank accessing river
R13	05/23/07	E07EC003160	1330		19.0	22.0	977	1103	0.5	11.85	8.46	21.3	18.70	250		72		2.1			brown, EDWDD nitrate test
R13	06/20/07	E07EC003896	1330		24.7	34.0	979	980	0.5	9.40	8.34	35	26.30	410		96		3.5			brown, EDWDD nitrate test
R13	07/19/07	E07EC004770	1330		26.6		958	930	0.5	17.25	8.53	23	13.80	350		64		3.4			clear, film along bank, EDWDD nitrate test
R13	08/23/07	E07EC005798	1230		21.3	22.0	765	823	0.4	6.91	8.24	150	7.00	3200		230		3.3			brown, EDWDD nitrate test
R13	09/17/07	E07EC006313	1300		19.0	27.9	888	1007	0.5	9.91	8.55	14	26.00	100		30		3.9			clear, EDWDD nitrate test
R13	10/11/07	E07EC006780	1305		12.9	14.6	675	810	0.4	12.81		37	12.05	1200		80					light brown
R13	04/07/08	E08EC001470	1355		7.0	18.4			0.4	13.20	7.98		29.90	<10		58		3.4			EDWDD nitrate test
R13	05/05/08	E08EC002225	1300		13.1	26.2		1086	0.5	11.47	8.39	55	16.50	10		132		2.3			EDWDD nitrate test
R13	06/09/08	E08EC003224	1400		20.0	29.2		884	0.4	8.36	8.16	85		250		196					
R13	07/07/08	E08EC004303	1345		24.3	31.0		923	0.5	10.63	8.47	28		130		78					
R13	08/12/08	E08EC005602	1230		22.8	29.0		683	0.3	8.36	8.25	75		400		174					cows present with access to river
R13	09/08/08	E08EC006391	1345		17.6	19.0		931	0.5	15.14	8.64	14		20		37					
R13	10/06/08	E08EC007309	1415		18.5	27.0		953	0.5	12.77	8.44	19		10		50					
R13	05/20/09	E09EC002547	1545		21.8	36.0			0.47	16.41	8.72	9		10.0		29					
R13	06/22/09	E09EC003360			27.4	36.0			0.41	11.13	8.54	55		640.0		104					specific conductivity 848 ?????
R13	07/21/09	E09EC004034	1445		23.3	28.0		1087	0.54	10.80	8.45	38		150.0		80					
R13	08/18/09	E09EC004784	1430		23.8	29.0		969	0.46	12.95	8.42	15		20.0		40					
R13	09/23/09	E09EC005941	1515		18.8	22.0		1019	0.51	14.40	8.37	11		120.0		22					
R13	10/20/09	E09EC006504	1515		10.3	15.0		1001	0.50	14.64	8.39	20		70.0		45					
R13	08/24/10	E10EC005320	1600		25.0	28.0		1114	0.55	9.73	8.80	35			687.0	93					

SITECODE	DATE	Specimen#	TIME	Stage	WTEMP	ATEMP	CONDUCT	SPECCOND	SALINITY	DO	PH	TURBIDITY	T-Tube	FECAL	E-COLI	T_SUSP_SOL	Nitrate	Nitrate	Total Phosphorus	Total Diss Phos	Comments
				ft	°C	°C	µS/cm	µS/cm	ppt	mg/L		NTU	cm	CFU/100mL	MPN/100mL	mg/L	mg/L	mg/L	(mg/L)	(mg/L)	
R16	04/04/06	E06EC001460	937		5.3	9.0	346	560	0.3	13.71	7.07	39		10.0	8.4	20		1.20			lt brn, EDWDD nitrate test

R16	05/01/06	E06EC002277	945		10.9	10.0	462	634	0.3	9.33	6.96	14		730.0	1300.0	13		0.30			clr, EDWDD nitrate test
R16	06/06/06	E06EC003357	845		20.4	23.0	710	777	0.4	5.40	7.99	19		240.0	461.0	43		3.16			clr, EDWDD nitrate test
R16	07/11/06	E06EC004432	910		19.2	30.0	945	1051	0.5		7.75	11.8		10000.0	>2420	20		9.20			lt grn, EDWDD nitrate test
R16	08/07/06	E06EC005370	930		19.1	30.0	1052	1188	0.6	8.06	7.72	8.5		1400.0	1990.0	21		>10			clr, EDWDD nitrate test
R16	09/11/06	E06EC006639	1000		15.7	14.0	885	1074	0.5	8.01	7.73	7.2	54.00	140.0	219.0	22		7.90			clr, EDWDD nitrate test
R16	10/10/06	E06EC007541	1015		13.3	7.0	889	1144	0.6	12.53	7.36	7.6		100.0	80.1	14		13.00			clr, EDWDD nitrate test
R16	04/16/07	E07EC001894	1200		12.4	20.0	482	652	0.3	17.08	8.40	6.4		<10	9.7	13					water moving, high water - clear
R16	04/23/07	E07EC002162	1100		11.2	16.0	475	689	0.3	6.54	7.88	24		1200.0	>2420	26					brn, rain event
R16	05/21/07	E07EC003018	1120		18.3	26.0	599	687	0.3	9.04	8.31	6.65	60.00	130.0		6		0.60			clear, EDWDD nitrate test
R16	06/18/07	E07EC003738	1200		22.5	24.0	708	745	0.4	5.89	8.19	4.7	60.00	530.0		6		1.60			clear, EDWDD nitrate test
R16	07/16/07	E07EC004629	1240		23.5	32.0	803	827	0.4	8.86	8.07	6.3	60.00	110.0		10		3.40			clear, duckweed along bank, EDWDD nitrate test
R16	08/20/07	E07EC005654	1115		17.8	19.0	712	829	0.4	8.04	7.81	6.3	60.00	1800.0		8		4.30			clear, EDWDD nitrate test
R16	09/17/07	E07EC006210	1149		17.9	25.5	777	902	0.4	4.85	8.01	8.4	48.00	90.0		51		5.20			clear, EDWDD nitrate test
R16	10/09/07	E07EC006681	1140		13.4	15.3	629	808	0.4	13.14		6	60.00	80.0		9		3.50			clear, EDWDD nitrate test
R16	04/09/08	E08EC001622	1100		5.5	13.4		557	0.27	12.51	7.98		49.90	<10		12		2.20			EDWDD nitrate test
R16	06/12/08	E08EC003532	1145		15.4	24.7		679	0.33	7.90	7.90	8.2		340		4					very high water
R16	07/09/08	E08EC004526	1100		22.9	25.0		649	0.32	7.74	7.96	7.8		90		9					duckweed & submergents
R16	08/11/08	E08EC005567	1145		21.3	24.5		609	0.30	5.35	7.66	13		100		22					heavy rains past 24 hrs (Watertown = 3.33")
R16	09/11/08	E08EC006578	1115		16.8	19.0		730	0.36	8.45	8.09	8.7		100		13					
R16	10/08/08	E08EC007477	1145		14.1	16.0		754	0.37	9.25	8.03	8.9		40		15					
R16	05/20/09	E09EC002548	1000		18.0	22.0			0.36	10.62	8.24	6.4		20		10					
R16	06/22/09	E09EC003359	1100		21.2	27.0			0.36	7.62	8.02	8.8		260		7					specific conductivity 735 ?????
R16	07/21/09	E09EC004031	1030		20.3	24.0		711	0.35	6.83	7.97	13.0		230		22					
R16	08/18/09	E09EC004779	1000		18.8	22.0		725	0.35	7.18	7.86	11.0		110		19					
R16	09/23/09		1045																		construction blocking site, no sample taken
R16	10/20/09		1100																		no access, bridge under construction
R16	08/24/10		1100																		no access, bridge under construction

SITECODE	DATE	Specimen#	TIME	Stage	WTEMP	ATEMP	CONDUCT	SPECCOND	SALINITY	DO	PH	TURBIDITY	T-Tube	FECAL	E-COLI	T_SUSP_SOL	Nitrate	Nitrate	Total Phosphorus	Total Diss Phos	Comments
				ft	°C	°C	µS/cm	µS/cm	ppt	mg/L		NTU	cm	CFU/100mL	MPN/100mL	mg/L	mg/L	mg/L	(mg/L)	(mg/L)	
R17	04/04/06	E06EC001461	1000			9.0					7.13	2		10.0		39		1.60			lt brn, EDWDD nitrate test
R17	05/01/06	E06EC002278	1000		10.7	11.0	478	658	0.3	9.35	6.02	330		360.0	517.0	29		0.80			lt brn, EDWDD nitrate test
R17	06/06/06	E06EC003358	915		20.8	21.0	770	839	0.4	7.40	8.15	26		290.0	411.0	53		2.17			lt grn, small amount of film on the banks, EDWDD nitrate test
R17	07/11/06	E06EC004433	1005		22.6	30.0	902	945	0.5		8.44	20.5		560.0	770.0	44		4.10			brn, EDWDD nitrate test
R17	08/07/06	E06EC005368	955		20.9	31.0	1126	1223	0.6	8.87	8.54	37		1700.0	816.0	68		6.30			grn, EDWDD nitrate test
R17	09/11/06	E06EC006640	1030		13.8	15.0	821	1046	0.5	11.20	8.11	22	25.50	1100.0	>2420	44		6.10			brn, duckweed floating down river and along sides, EDWDD nitrate test
R17	10/10/06	E06EC007542	1045		8.6	8.0	723	1052	0.5	15.83	8.31	13	51.50	520.0	579.0	21		5.80			clr, EDWDD nitrate test
R17	03/14/07	E07EC002855	1115		1.5	5.0	107		0.1	14.80	7.49	18		1900.0	>2420						flood conditions from snow melt, brn
R17	04/02/07	E07EC001409	1100		4.4	12.0	406	635	0.3	17.54	8.00	23		7100.0	>2420	36		1.00			EDWDD nitrate test
R17	04/16/07	E07EC001901	1230		12.5	20.0	491	666	0.3	17.37	8.50	10		10.0	18.7	23					clear
R17	04/23/07	E07EC002163	1115		11.4	17.0	465	628	0.3	7.58	7.92	45		4300.0	>2420	53					brn, rain event
R17	05/21/07	E07EC003019			19.1	24.0	647	728	0.4	13.37	8.36	12	57.50	130.0		23		0.70			clear, canada gees on water, EDWDD nitrate test
R17	06/18/07	E07EC003739	1145		22.7	27.0	750	785	0.4	5.82	8.14	6.8	60.00	320.0		16		1.30			EDWDD nitrate test
R17	07/16/07	E07EC004628	1300		25.7	34.0	866	854	0.4	12.69	8.42	18	27.40	80.0		47		2.30			light brown, cattle grazing upstream of sample, duckweed along banks, EDWDD nitrate test
R17	08/20/07	E07EC005655	1130		18.2	22.0	713	818	0.4	6.77	7.96	17	34.00	1300.0		18		3.70			clear, EDWDD nitrate test
R17	09/17/07	E07EC006211	1210		19.3	26.3	810	908	0.5	12.13	8.54	14	34.10	330.0		20		4.20			clear, mild duckweed, EDWDD nitrate test
R17	10/09/07	E07EC006682	1130		11.8	11.0	630	846	0.4	12.38		11	60.00	390.0		13		3.60			clear, EDWDD nitrate test
R17	04/09/08	E08EC001621	1115		6.9	10.0		617	0.30	12.88	8.13		47.15	<10		22		1.80			EDWDD nitrate test
R17	05/08/08	E08EC002417	1120		12.2	7.7		726	0.36	15.90	8.20		48.40	10		38		0.50			sampled one mile south of usual site (bridge construction), EDWDD nitrate test
R17	06/12/08	E08EC003533	1215		15.2	25.7		678	0.33	6.85	7.83	65		7300		114					water very high lots of debris going by (logs, grasses, sticks)
R17	07/09/08	E08EC004525	1130		23.7	26.0		655	0.32	9.40	8.23	7.6		220		10					
R17	08/11/08	E08EC005563	1200		22.0	24.0		561	0.27	5.95	7.80	25		300		60					heavy rains past 24 hrs (Watertown = 3.33")
R17	09/11/08	E08EC006580	1130		17.5	18.0		783	0.38	8.93	8.15	10		250		17					
R17	10/08/08	E08EC007478	1130		11.9	18.0		738	0.36	10.73	8.13	8		140		13					
R17	05/20/09	E09EC002549	1015		17.1	23.0			0.36	12.80	8.42	9.4		10		17					
R17	06/22/09	E09EC003365	1045		21.6	27.0			0.34	8.62	8.00	8.9		100		13					specific conductivity 697 ?????
R17	07/21/09	E09EC004037	1015		19.9	24.0		622	0.30	6.97	7.84	10.0		1800		17					
R17	08/18/09	E09EC004778	945		17.7	23.0		700	0.34	7.25	7.81	12.0		280		23					
R17	09/23/09	E09EC005936	1030		15.6	17.0		757	0.37	9.30	7.91	25.0		140		12					
R17	10/20/09	E09EC006505	1045		7.7	7.0		781	0.38	12.62	8.03	9.9		20		23					
R17	08/24/10	E10EC005321	1000		20.0	19.0		779	0.38	7.43	8.40	17.0			184.0	29					

SITECODE	DATE	Specimen#	TIME	Stage	WTEMP	ATEMP	CONDUCT	SPECCOND	SALINITY	DO	PH	TURBIDITY	T-Tube	FECAL	E-COLI	T_SUSP_SOL	Nitrate	Nitrate	Total Phosphorus	Total Diss Phos	Comments
				ft	°C	°C	µS/cm	µS/cm	ppt	mg/L		NTU	cm	CFU/100mL	MPN/100mL	mg/L	mg/L	mg/L	(mg/L)	(mg/L)	
R18	04/04/06	E06EC001462	1040		6.2	10.0				13.00	7.03	21		10.0		49		1.60			lt grn, EDWDD nitrate test
R18	05/01/06	E06EC002280	1030		10.9	11.0	569	784	0.4	10.71	6.22	17		190.0	172.0	26		1.30			lt brn, EDWDD nitrate test
R18	06/06/06	E06EC003354	945		20.7	24.0	760	829	0.4	7.75	8.38	31		2000.0	>2420	72		2.03			clr, EDWDD nitrate test
R18	07/11/06	E06EC004435	1020		23.4		766	789	0.4		9.39	55.3		1500.0	980.0	128		nd			brn, EDWDD nitrate test
R18	08/07/06	E06EC005360	1015		21.8	33.0	883	942	0.5	18.19	9.31	140		1300.0	411.0	256		nd			brn, EDWDD nitrate test
R18	09/11/06	E06EC006641	1100		13.8	16.0	806	1029	0.5	12.80	8.35	26	32.75	410.0	548.0	43		4.30			brn, EDWDD nitrate test
R18	10/10/06	E06EC007543	1055		8.5	9.0	710	1036	0.5	17.26	8.07	15	47.60	330.0	326.0	32		3.60			lt brn, EDWDD nitrate test
R18	03/14/07	E07EC002853	1200		0.5	5.0	180		0.2	14.67	7.27	14		160.0	>2420						flood conditions due to snow melt. Water seems to be flowing under ice, lgt brn
R18	04/02/07	E07EC001410	1130		4.4	11.0	480	803	0.4	15.28	8.03	21		3000.0	>2420	62		1.10			EDWDD nitrate test
R18	04/16/07	E07EC001900	1245		11.3	20.0	512	694	0.3	15.68	8.53	12		20.0	12.2	31			0.277	0.177	lgt brn
R18	04/23/07	E07EC002164	1130		12.0	17.0	499	665	0.3	8.28	8.03	37		3100.0	>2420	50			0.396	0.242	rain event
R18	05/21/07	E07EC003020	1220		19.6	27.0	680	756	0.4	12.90	8.33	18.9	35.40	120.0		48		1.00	0.431	0.27	brown, EDWDD nitrate test
R18	06/18/07	E07EC003740	1210		22.3	23.5	743	784	0.4	5.48	8.24	19	41.50	580.0		48		1.00			brown, cattle in water, EDWDD nitrate test
R18	07/16/07	E07EC004627	1315		27.2		898	861	0.4	11.54	8.47	23	22.80	1770.0		34		1.20	0.524		light brown, cattle in stream, edwdd nitrate test
R18	08/20/07	E07EC005660	1155		19.1	22.0	547	617	0.3	6.38	7.97	31	20.60	500.0		62		3.50	0.606	0.498	brown, EDWDD nitrate test
R18	09/17/07	E07EC006212	1230		18.7	25.2	758	862	0.4	13.22	9.17	9.1	45.70	230.0		12		2.80	0.472	0.362	clear, cows and ducks in the water, EDWDD nitrate test
R18	10/09/07	E07EC006683	950		10.9	12.9	336	440	0.2	15.63		23	24.80	1100.0		37		2.90			EDWDD nitrate test
R18	04/09/08	E08EC001620	1130		7.3	19.2		639	0.31	12.47	7.94		33.10	<10		29		1.80			EDWDD nitrate test
R18	05/08/08	E08EC002418	1145		11.6	7.1		750	0.37	16.90	8.30		46.30	10		29		0.60			EDWDD nitrate test
R18	06/12/08	E08EC003534	1230		15.8	27.8		630	0.31	7.55	7.90	33		6800		66					water very high lots of debris floating down river
R18	07/09/08	E08EC004524	1200		24.2	31.0		671	0.33	9.50	8.36	23		2400		52					
R18	08/11/08	E08EC005556	1245		22.1	25.0		447	0.21	5.83	7.79	70		1100		140					sparse duckweed floating down river cows in area w/ access to river (U.S. from bridge)
R18	09/11/08	E08EC006582	1215		17.9	19.0		794	0.39	12.07	8.46	12		190		14					

R18	10/08/08	E08EC007479	1230		13.2	16.0		571	0.28	11.00	8.17	13		480		28					
R18	05/20/09	E09EC002550	1115		17.7	25.0			0.37	11.75	8.76	13.0		10		28					
R18	06/22/09	E09EC003366	1115		22.6	28.0			0.36	9.40	8.30	12.0		310		41					specific conductivity 743 ?????
R18	07/21/09	E09EC004032	1100		20.0	23.0		757	0.37	7.85	8.02	18.0		800		56					
R18	08/18/09	E09EC004782	1030		20.0	18.5		593	0.29	7.80	7.92	17.0		150		32					
R18	09/23/09	E09EC005935	1115		15.5	21.0		767	0.38	10.16	7.85	22.0		6500		51					
R18	10/20/08	E09EC006508	1100		7.7	10.0		796	0.39	12.40	7.97	18.0		140		44					
R18	08/24/10	E10EC005322	1030		20.3	21.5		802	0.39	8.48	8.50	26.0			50.4	53					

SITECODE	DATE	Specimen#	TIME	Stage	WTEMP	ATEMP	CONDUCT	SPECCOND	SALINITY	DO	PH	TURBIDITY	T-Tube	FECAL	E-COLI	T_SUSP_SOL	Nitrate	Nitrate	Total Phosphorus	Total Diss Phos	Comments
				ft	°C	°C	µS/cm	µS/cm	ppt	mg/L		NTU	cm	CFU/100mL	MPN/100mL	mg/L	mg/L	mg/L	(mg/L)	(mg/L)	
R19	04/04/06	E06EC001463	1115		6.3	14.0	486	755	0.4	14.01	6.95	32		10.0		101		1.90			lt grn, edwdd nitrate test
R19	05/01/06	E06EC002281	1115		11.6	12.0	647	879	0.4	11.83	6.64	9.6		90.0	167.0	21		1.20			lt brn
R19	06/06/06	E06EC003359	1020		20.6	31.0	798	869	0.4	7.78	8.45	52.1		240.0	219.0	132		1.52			brn
R19	07/11/06	E06EC004436	1105		23.2		681	706	0.3		9.04	169		450.0	649.0	248		nd			brn
R19	08/07/06	E06EC005369	1100		22.2		831	879	0.4	7.03	8.58	150		150.0	29.3	212		nd			brn
R19	09/11/06	E06EC006642	1115		14.1	16.0	784	990	0.5	14.30	8.61	60	17.00	300.0	124.0	128		1.40			brn
R19	10/10/06	E06EC007544	1145		8.8	9.0	568	820	0.4	>20	8.94	45	25.70	60.0	22.3	104		0.10			lt brn
R19	04/02/07	E07EC001411	1300		4.3	13.0	469	772	0.4	11.49	8.04	36		9200.0	>2420	64		1.10			
R19	04/16/07	E07EC001892	1330		12.6	22.0	574	751	0.4	11.46	8.53	14		20.0	5.2	40			0.3080	0.185	lgt brn
R19	04/23/07	E07EC002166	1230		11.9	18.0	436	582	0.3	7.60	7.87	120		7900.0	<2420	124			0.302	0.371	brn, rain event
R19	05/21/07	E07EC003022	1420		20.7	30.0	730	796	0.4	9.25	8.28	18.9	37.30	40.0		37		1.00	0.39	0.255	clear
R19	06/18/07	E07EC003741	1320		22.7	24.0	759	794	0.4	4.92	8.34	23	32.20	390.0		58		1.00			brown
R19	07/16/07	E07EC004624	1430		26.6	21.0	880	879	0.4	13.71	8.65	75	7.00	230.0		148		0.90	0.506		brown, duckweed along bank, smells like cow crap
R19	08/20/07	E07EC005659	1445		21.9	26.0	572	607	0.3	6.94		95		700.0		148			0.563	0.275	brown
R19	09/17/07	E07EC006213			19.8	31.5	723	802	0.4	12.90	9.06	20	20.40	<10		29		1.10	0.244	0.114	clear
R19	10/09/07	E07EC006684	1355		13.3	13.7	677	871	0.4	14.86		40	17.20	170.0		82		2.00			brown
R19	04/09/08	E08EC001628	1215		8.3	23.5		705	0.35	12.64	8.31		35.10	<10		38		1.80			
R19	05/08/08	E08EC002419	1315		12.1	8.4		801	0.39	17.90	8.40		39.40	10		29		0.50			
R19	06/12/08	E08EC003535	1330		16.7	27.1		766	0.38	8.50	8.10	19		540		33					
R19	07/09/08	E08EC004516	1315		24.8	27.0		700	0.34	10.21	8.39	32		40		72					
R19	08/11/08	E08EC005570	1345		23.1	24.0		595	0.29	6.26	7.98	75		500		155					*raining* duckweed floating downstream
R19	09/10/08	E08EC006541	1015		13.7	14.0		769	0.38	10.05	8.69	22		40		45					
R19	10/07/08	E08EC007425	945		12.7	11.0		775	0.38	8.67	8.16	33		160		44					heavy rain past 24 hrs
R19	05/20/09	E09EC002551	1130		18.0	28.0			0.40	10.94	8.44	23.0		<10		52					
R19	06/22/09	E09EC003367	1145		24.4	30.0			0.39	8.44	8.24	18.0		100		45					specific conductivity 787 ?????
R19	07/21/09	E09EC004033	1130		18.4	23.0		789	0.39	6.08	7.80	29.0		360		61					
R19	08/18/09	E09EC004781	1100		18.8	23.0		752	0.37	8.17	7.98	28.0		190		72					
R19	09/23/09	E09EC005933	1145		16.0	19.5		939	0.47	9.39	7.78	32.0		330		44					
R19	10/20/09	E09EC006506	1130		7.4	10.0		873	0.43	12.38	7.98	21.0		100		52					
R19	08/24/10	E10EC005323	1110		22.9	20.0		1359	0.68	4.24	8.30	14.0			35.9	38					

SITECODE	DATE	Specimen#	TIME	Stage	WTEMP	ATEMP	CONDUCT	SPECCOND	SALINITY	DO	PH	TURBIDITY	T-Tube	FECAL	E-COLI	T_SUSP_SOL	Nitrate	Nitrate	Total Phosphorus	Total Diss Phos	Comments
				ft	°C	°C	µS/cm	µS/cm	ppt	mg/L		NTU	cm	CFU/100mL	MPN/100mL	mg/L	mg/L	mg/L	(mg/L)	(mg/L)	
R20	04/04/06	E06EC001464	1145		6.8	16.0	515	797	0.4	13.67	7.56	34		10.0		92		1.90			clr
R20	05/01/06	E06EC002279	1130		11.7	13.0	635	867	0.4	11.93	6.86	9.5		210.0	178.0	22		0.60			clr
R20	06/06/06	E06EC003360	1047		21.2	27.0	770	865	0.4	8.80	8.54	51.4		270.0	579.0	128		0.80			lt brn
R20	07/11/06	E06EC004437	1127		24.5		693	700	0.3		8.70	91.8		590.0	687.0	164		nd			lt brn
R20	08/07/06	E06EC005359	1115		22.7		734	767	0.4	8.53	8.42	45		130.0	36.8	70		nd			lt brn
R20	09/11/06	E06EC006643	1145		14.4	16.0	727	911	0.5	11.63	8.57	55	22.50	280.0	132.0	118		0.50			brn
R20	10/10/06	E06EC007545	1210		9.5	11.0	527	740	0.4	>20	8.96	45	24.10	50.0	38.8	100		nd			lt brn
R20	03/14/07	E07EC002850	1230		0.7	7.0	108		0.1	17.00	7.29	25		670.0	1550.0						flood conditions due to snow melt, lgt brn
R20	04/02/07	E07EC001412	1330		4.9	14.0	488	788	0.4	11.32	8.11	60		7400.0	>2420	95		1.20			
R20	04/16/07	E07EC001890	1530		13.3	25.0	588	758	0.4	11.27	8.63	15		10.0	16.1	39					clear
R20	04/23/07	E07EC002170	1315		12.8	18.0	560	732	0.4	8.76	8.02	75		2300.0	>2420	130					brn, rain event
R20	05/21/07	E07EC003025	1545		20.6	31.0	636	650	0.3	10.08	8.21	66.2	10.00	1200.0		84		0.60			brown
R20	06/18/07	E07EC003742	1410		22.9	26.0	812	846	0.4	4.58	8.53	12	52.70	420.0		32		0.40			brown
R20	07/16/07	E07EC004621	1505		26.3	22.0	875	852	0.4	12.07	8.70	40	12.60	250.0		70		0.40			brown, duckweed along bank
R20	08/20/07	E07EC005658	1600		23.8	28.0	815	837	0.4	9.45		95	7.30	380.0		184		3.10			brown
R20	09/17/07	E07EC006214	1505		20.9	33.2	719	779	0.4	13.34	8.98	11	23.20	110.0		37		0.30			clear
R20	10/09/07	E07EC006685	1440		14.0	15.8	660	835	0.4	16.82		33	18.20	100.0		63		0.70			brown
R20	04/09/08	E08EC001634	1400		9.4	21.3		753	0.37	12.47	8.17		38.00	<10		48		1.50			
R20	05/08/08	E08EC002420	1345		12.1	9.2		803	0.40	18.00	8.40		34.80	10		34		0.50			
R20	06/11/08	E08EC003472	1445		17.0	22.9		773	0.38	8.93	8.18	37		440		84					water levels very high
R20	07/09/08	E08EC004511	1415		25.6	28.0		718	0.35	10.73	8.34	34		70		102					
R20	08/11/08	E08EC005557	1415		23.0	24.0		662	0.32	8.19	8.21	110		310		228					*raining* duckweed floating downstream
R20	09/10/08	E08EC006548	1100		14.0	19.0		715	0.35	11.50	8.69	12		50		22					
R20	10/07/08	E08EC007426	1015		13.0	12.0		727	0.36	10.03	8.04	14		50		12					heavy rain past 24 hrs
R20	05/20/09	E09EC002552	1200		18.1	28.0			0.41	11.73	8.42	20.0		<10		46					
R20	06/22/09	E09EC003362	1215		22.9	30.0			0.38	10.70	8.35	16.0		270		40					specific conductivity 775 ?????
R20	07/21/09	E09EC004035	1145		19.5	23.0		823	0.40	7.64	7.96	75.0		2000		192					
R20	08/18/09	E09EC004780	1130		19.1	24.0		817	0.40	10.98	8.31	35.0		180		64					
R20	09/23/09	E09EC005934			16.6	20.0		907	0.45	11.30	7.68	16.0		60		32					
R20	10/20/09	E09EC006507	1200		7.4	10.0		877	0.43	12.65	7.99	22.0		120		60					
R20	08/24/10	E10EC005324	1145		23.3	21.0		1326	0.66	6.76	8.50	30.0			32.0	74					

SITECODE	DATE	Specimen#	TIME	Stage	WTEMP	ATEMP	CONDUCT	SPECCOND	SALINITY	DO	PH	TURBIDITY	T-Tube	FECAL	E-COLI	T_SUSP_SOL	Nitrate	Nitrate	Total Phosphorus	Total Diss Phos	Comments
				ft	°C	°C	µS/cm	µS/cm	ppt	mg/L		NTU	cm	CFU/100mL	MPN/100mL	mg/L	mg/L	mg/L	(mg/L)	(mg/L)	
T01	04/06/06	E06EC001580	1230		10.3	11.0	645	895	0.4	9.38	7.94	3		20.0	11.0	7		1.80			clr
T01	05/02/06	E06EC002384	1315		12.0	18.5	739	984	0.5	11.85	6.81	2		130.0	135.0	3		0.60			clr
T01	06/07/06	E06EC003472	1223		23.2		685	712	0.3	7.62	8.36	8		120.0	365.0	14		0.21			clr
T01	07/12/06	E06EC004497	1235		26.8		756	733	0.4	6.40	8.18	16	45.00	1000.0	1050.0	27		nd			lt brn
T01	08/08/06	E06EC005462	1156		23.7		712	727	0.4	9.40	8.54	45	20.50	3300.0	>2420	80		nd			brn
T01	09/12/06	E06EC006723	1115		15.9	24.0	795	963	0.5	10.38	8.13	9	49.00	460.0	243.0	22		0.20			clr
T01	10/25/06	E06EC007914	1000		3.9	8.0	537	901	0.4	15.47	8.24	4	60.00	110.0	161.0	7		0.40			clr
T01	04/16/07	E07EC001889	1545	2.80	12.9	25.0	630	818	0.4	13.29	8.30	4		<10	2.0	<3					clear, bedrod 3.85 meters

T01	05/22/07	E07EC003082	920	2.14	18.6	24.0	721	823	0.4	12.02	8.11	1.7	60.00	100		<3		1.0			clear
T01	06/18/07	E07EC003732	1435	3.88	22.4	26.0	713	749	0.4	2.52	7.87	3.2	60.00	150		4		0.7			clear
T01	07/16/07	E07EC004620	1520		24.8	21.0	780	782	0.4	8.66	8.33	11		340		20					clear
T01	07/17/07	E07EC004690	845	0.89	23.2	26.0	755	782	0.4	4.47	8.11	11	40.70	560		18		nd			light brown
T01	08/21/07	E07EC005690	950	2.11	21.3	28.0	735	790	0.4	6.29	8.29	4.7	60.00	400		7		0.5			clear
T01	09/17/07	E07EC006218	1530	1.19	19.1		716	806	0.4	10.45	8.49	7.5	60.00	10		9		0.1			clear
T01	10/09/07	E07EC006675	1450		13.2	17.9	649	838	0.4	12.73		9.7	47.40	1600		12		0.3			clear
T01	04/09/08	E08EC001632	1415		7.1	21.3		902	0.5	14.22	8.17		>60	<10		5		0.8			
T01	05/07/08	E08EC002342	1515		14.9	22.0		852	0.4	15.70	8.60		>60	<10		5		0.3			
T01	06/11/08	E08EC003469	1415		16.7	23.5		634	0.3	6.75	7.93	75		450		72					water levels very high, stream out of channel
T01	07/10/08	E08EC004554	1000		23.0	27.0		685	0.3	4.03	8.01	8.1		180		7					several carp lots of weeds no gage
T01	08/11/08	E08EC005560	1430		22.5	21.0		626	0.3	6.86	8.22	11		30		20					lots of macrophytes *raining*

SITECODE	DATE	Specimen#	TIME	Stage	WTEMP	ATEMP	CONDUCT	SPECCOND	SALINITY	DO	PH	TURBIDITY	T-Tube	FECAL	E-COLI	T_SUSP_SOL	Nitrate	Nitrate	Total Phosphorus	Total Diss Phos	Comments
				ft	°C	°C	µS/cm	µS/cm	ppt	mg/L		NTU	cm	CFU/100mL	MPN/100mL	mg/L	mg/L	mg/L	(mg/L)	(mg/L)	
T02	10/24/05	E05EC007709	925		4.3	5.0	563	931	0.5	13.95	7.64	4.5		120	206.0	6	0.4				
T02	04/06/06	E06EC001581	1125		10.9	13.0	616	842	0.4	10.26	7.88	9.9		<10	10.9	22		1.2			clr
T02	05/02/06	E06EC002385	1530		13.5	22.0	745	955	0.5	12.15	6.95	5.2		190	179.0	11		0.4			lt brn
T02	06/07/06	E06EC003484			24.6		797	804	0.4	11.70	8.38	8.53		<10	35.9	7		0.1			clr
T02	09/12/06	E06EC006724	1300		17.0	21.0	769	911	0.5	11.13	8.20	6.6		220	172.0	6		0.1			clr
T02	10/25/06	E06EC007915	1130		3.8	6.0	535	899	0.4	15.66	8.19	5.81	60.00	<10	17.3	8		0.4			clr; lots of algae
T02	04/17/07	E07EC001943	945		9.1	12.0	573	822	0.4	10.55	8.13	7.5		20	8.5	14		0.8			clear
T02	04/23/07	E07EC002168	1440		13.3	20.0	622	803	0.4	10.00	8.14	16		970	>2420	36					clear, rain event
T02	05/22/07	E07EC003086	1050		18.6	21.0	681	776	0.4	12.94	8.32	3.11	60.00	400		18		0.1			clear
T02	06/18/07	E07EC003734	1545		24.5	28.0	676	683	0.3	3.26	8.08	8.9	60.00	480		20					clear
T02	07/17/07	E07EC004686	1200																		no sample, no flow
T02	08/21/07	E07EC005691	1220		23.3	33.0	787	814	0.4	7.79	8.03	7.2	60.00	900		8		1.0			clear
T02	09/17/07	E07EC006220	1630		23.3	33.0	976	1009	0.5	9.92	8.33	6.2	60.00	<10		13		nd			clear
T02	10/09/07	E07EC006676	1600		14.7	17.1	606	755	0.4	11.51		11	48.90	460		12		0.5			clear
T02	04/09/08	E08EC001630	1530		10.0	18.3		869	0.4	15.05	8.02		>60	<10		9		0.8			looks like ditch was dug out to remove sediment
T02	05/07/08	E08EC002346	1500		15.8	22.2		846	0.4	13.90	8.40		>60	<10		7		0.3			
T02	06/11/08	E08EC003470	1300		16.5	22.7		691	0.3	7.07	7.88	20		610		40					water levels very high
T02	07/10/08	E08EC004559	1300		26.3	31.0		665	0.3	15.86	8.43	10		<10		14					lots of sand bars & green filamentous algae
T02	08/13/08	E08EC005731	1615		29.1	29.0		642	0.3	17.05	8.57	16		40		17					

SITECODE	DATE	Specimen#	TIME	Stage	WTEMP	ATEMP	CONDUCT	SPECCOND	SALINITY	DO	PH	TURBIDITY	T-Tube	FECAL	E-COLI	T_SUSP_SOL	Nitrate	Nitrate	Total Phosphorus	Total Diss Phos	Comments
				ft	°C	°C	µS/cm	µS/cm	ppt	mg/L		NTU	cm	CFU/100mL	MPN/100mL	mg/L	mg/L	mg/L	(mg/L)	(mg/L)	
T03	04/06/06	E06EC001592	1210	2.58	10.9	12.0	681	934	0.5	13.01	8.19	55		<10	9.7	9		5.4			clr
T03	05/02/06	E06EC002386	1345		11.8	21.0	682	914	0.5	12.88	6.72	3.7		190	517.0	10		5.0			clr
T03	06/06/06	E06EC003483	1243	1.31	25.2		740	740	0.4	18.46	8.72	14.4		10	43.7	33		0.1			lt grn
T03	07/12/06	E06EC004498	1300	1.10	28.4		837	785	0.4	7.96	8.22	10.44	51.50	10	3.1	15		nd			lt grn
T03	08/08/06	E06EC005466	1215	0.90	24.6	33.0	647	654	0.3	11.63	8.72	24	25.00	20	2.0	36		nd			lt grn
T03	09/12/06	E06EC006726	1130	1.35	16.3	23.0	824	992	0.5	8.87	8.23	7.8	60.00	20	25.6	14		1.1			clr
T03	10/25/06	E06EC007916	1030	1.36	4.0	7.0	591	986	0.5	15.80	8.19	3.63	60.00	<10	3.1	8		2.6			clr
T03	04/16/07	E07EC001887	1600	1.93	12.5	24.0	562	741	0.4	12.97	8.42	7.9		<10	23.5	11					clear, bedrod reading 2.98 meters
T03	05/22/07	E07EC003083	940		18.6	21.0	802	914	0.5	11.01	8.05	7.84	60.00	320		9		0.6			clear
T03	06/18/07	E07EC003735	1500	2.10	22.6	25.0	828	868	0.4	3.47	8.02	12	56.00	800		23		6.0			clear
T03	07/17/07	E07EC004689	1000	1.11	24.4	32.0	847	857	0.4	6.07	8.21	18	32.20	40		24		nd			clear, cattle grazing downstream
T03	08/21/07	E07EC005692	1040	1.11	21.7	26.0	849	906	0.4	8.01	8.14	74	60.00	90		13		1.2			clear
T03	09/18/07	E07EC006236	910	1.18	19.2	20.0	739	832		13.22	8.39	8.4	40.90	10		19		nd			clear, cattle grazing along stream
T03	10/09/07	E07EC006677	1510		14.8	20.0	673	840	0.4	14.34		18	30.40	980		25		1.3			clear
T03	04/09/08	E08EC001618	1430		8.2	22.9		856	0.4	15.25	8.15			<10		12					
T03	05/08/08	E08EC002414	1400		11.1	9.0		890	0.4	19.10	8.50			10		17					
T03	06/11/08	E08EC003466	1345		16.2	24.2		702	0.3	8.17	8.10	85		3600		76					water levels very high
T03	07/10/08	E08EC004555	1030		23.8	27.0		689	0.3	9.47	8.09	16		20		20					
T03	08/11/08	E08EC005561	1500		27.7	21.0		655	0.3	6.57	8.09	16		<10		22					*raining*
T03	09/10/08	E08EC006547	1130		15.1	16.0		669	0.3	10.14	8.40	18		<10		36					Bedrod = 3.250
T03	10/07/08	E08EC007427	1100		13.8	13.0		614	0.3	7.87	8.17	20		<10		32					heavy rains past 24 hrs

SITECODE	DATE	Specimen#	TIME	Stage	WTEMP	ATEMP	CONDUCT	SPECCOND	SALINITY	DO	PH	TURBIDITY	T-Tube	FECAL	E-COLI	T_SUSP_SOL	Nitrate	Nitrate	Total Phosphorus	Total Diss Phos	Comments
				ft	°C	°C	µS/cm	µS/cm	ppt	mg/L		NTU	cm	CFU/100mL	MPN/100mL	mg/L	mg/L	mg/L	(mg/L)	(mg/L)	
T04	10/24/05	E05EC007710	850	2.58	4.0	8.0	574	952	0.5	13.56	7.69	3.2		130	214.0	7	3.1				
T04	04/06/06	E06EC001582	1145		10.9	13.0	636	873	0.4	10.70	7.85	7.9		<10	3.1	19		4.2			clr
T04	05/02/06	E06EC002387	1415		12.7	22.0	715	926	0.5	12.08	6.94	4.5		460	980.0	10		3.1			clr
T04	06/07/06	E06EC003476	1349	2.80	24.5		782	790	0.4	11.48	8.35	20.4		430	548.0	22		1.1			lt brn
T04	07/12/06	E06EC004499	1315	2.00	28.0		824	780	0.4	17.25	8.59	17.7	35.00	270	308.0	32		nd			brn
T04	08/08/06	E06EC005463	1240	2.00	24.3		815	825	0.4	8.26	8.22	31	33.00	80	13.9	41		0.1			lt brn
T04	09/12/06	E06EC006727	1200	2.30	15.3	21.0	718	882	0.4	11.00	8.25	9		480	613.0	14		2.0			clr
T04	10/25/06	E06EC007917	1045	2.25	3.7	8.0	531	894	0.4	14.89	8.15	6.03	60.00	60	125.0	10		2.8			lgt brn. Scum on water, green algae present
T04	04/17/07	E07EC001947	900		7.8	8.0	255	377	0.2	18.22	8.29	8.6	59.30	10	6.3	14		3.0			clear, bedrod 3.2 meters
T04	05/22/07	E07EC003084	1010		17.4	20.0	744	869	0.4	12.89	8.10	17.4	32.60	1410		58		1.3			green
T04	06/18/07	E07EC003736	1510		23.0	25.0	614	638	0.3	3.45	7.80	8.9		450		17					clear
T04	07/17/07	E07EC004688	1045	2.16	24.6	30.0	843	849	0.4	5.49	7.85	55	14.60	810		44		0.7			light brown
T04	08/21/07	E07EC005693	1130	2.48	21.9	28.0	761	808	0.4	8.25	8.10	27	19.10	1700		42		2.3			light brown, cows in stream
T04	09/18/07	E07EC006237	955	2.05	19.6	20.6	693	773	0.4	10.37	8.23	17	33.90	2400		29		1.2			brown, cattle grazing in stream
T04	10/09/07	E07EC006678	1550	2.91	14.3	18.3	574	723	0.4	13.95		21	23.10	1300		33		1.7			light brown
T04	04/09/08	E08EC001626	1445	2.53	10.9	22.0		847	0.4	13.56	7.94			<10		31					
T04	05/08/08	E08EC002415	1415	2.72	10.0	8.1		843	0.4	21.00	8.40			20		16					
T04	06/11/08	E08EC003473	1330		16.6	23.7		522	0.3	6.92	7.89	270		4800		200					water levels very high staff gage under water
T04	07/10/08	E08EC004556	1115	2.12	22.5	27.0		707	0.3	6.97	7.97	23		40		32					
T04	08/11/08	E08EC005562	1530	2.09	21.5	22.0		669	0.3	6.07	7.92	90		160		88					
T04	09/10/08	E08EC006546	1230	2.05	14.6	19.0		742	0.4	8.84	8.19	29		190		35					Bedrod = 3.600
T04	10/07/08	E08EC007428	1145		13.3	16.0		709	0.4	8.17	7.79	23		150		34					heavy rains past 24 hrs

SITECODE	DATE	Specimen#	TIME	Stage	WTEMP	ATEMP	CONDUCT	SPECCOND	SALINITY	DO	PH	TURBIDITY	T-Tube	FECAL	E-COLI	T_SUSP_SOL	Nitrate	Nitrate	Total Phosphorus	Total Diss Phos	Comments
				ft	°C	°C	µS/cm	µS/cm	ppt	mg/L		NTU	cm	CFU/100mL	MPN/100mL	mg/L	mg/L	mg/L	(mg/L)	(mg/L)	
T05	10/24/05	E05EC007711	910	1.70	4.9	4.0	611	992	0.5	13.13	7.70	5.2		80	102.0	10	2.4				
T05	04/06/06	E06EC001587	1115	1.38	11.2	14.0	641	869	0.4	9.41	8.02	6.8		<10	5.2	18		3.8			clr
T05	05/02/06	E06EC002388	1515	3.93	13.8	24.0	743	947	0.5	11.34	7.13	5.3		250	387.0	13		2.1			clr
T05	06/07/06	E06EC003473	1420	0.75	24.5		805	708	0.1	10.93	8.43	11.5		190	461.0	32		0.6			clr
T05	07/12/06	E06EC004489	1345		27.6		845	805	0.4	9.82	8.15	4.66	60.00	5700	>2420	6		nd			clr

T05	09/12/06	E06EC006728	1245	0.70	17.2	23.0	756	889	0.4	9.63	8.22	3.8	60.00	280	261.0	8		1.1			clr
T05	10/25/06	E06EC007918	1115	1.60	4.0	8.0	534	891	0.4	15.02	8.25	5.4	60.00	<10	34.1	11		2.0			clr
T05	04/17/07	E07EC001946	930	3.00	9.6	9.0	618	876	0.4	10.23	8.05	7.7	60.00	20	7.4	10		2.8			clear,
T05	04/23/07	E07EC002169	1430	2.36	14.0	24.0	676	854	0.4	9.81	8.11	9.4		980	2420.0	21					clear, rain event, bedrod 2.60 meters
T05	05/22/07	E07EC003085	1030	1.22	19.2	22.0	808	911	0.5	11.86	8.22	6.64	60.00	380		13		0.8			clear
T05	06/18/07	E07EC003737	1535	1.84	24.4		559	565	0.3	3.19	7.79	8.7	51.20	580		13		4.3			brown
T05	07/17/07	E07EC004687	1130	0.46	24.5	31.0	873	881	0.4	9.63	8.24	4.6	60.00	25000		8		0.3			clear, muskrat in creek
T05	08/21/07	E07EC005695		1.18	22.8	31.0	594	620	0.3	7.58	7.91	14	35.40	200		22		0.8			clear
T05	09/18/07	E07EC006239	1040	0.42	18.5	21.7	701	799	0.4	7.08	8.14	4.5	60.00	560		8		0.2			clear
T05	10/09/07	E07EC006679	1355	1.60	15.3	18.2	580	711	0.3	12.34		11	49.10	280		15		1.0			clear
T05	04/09/08	E08EC001631	1515	1.64	9.1	20.1		851	0.4	11.88	7.33			<10		21					
T05	05/07/08	E08EC002343	1445	2.12	23.6	16.1		840	0.4	12.60	8.50		41.60	<10		15		2.3			
T05	06/11/08	E08EC003467	1230		17.3	23.4		532	0.3	5.63	7.83	45		4000		<3					staff gage under water stream is very high out of banks
T05	07/10/08	E08EC004558	1230	0.78	26.3	30.0		705	0.3	8.93	8.21	5.3		20		6					
T05	08/13/08	E08EC005728	1545	0.61	28.3	30.0		677	0.3	11.67	8.52	4.4		20		5					
T05	10/07/08	E08EC007431	1200	2.28	13.7	15.0		313	0.2	7.91	7.87	26		300		28					heavy rains past 24 hrs

SITECODE	DATE	Specimen#	TIME	Stage	WTEMP	ATEMP	CONDUCT	SPECCOND	SALINITY	DO	PH	TURBIDITY	T-Tube	FECAL	E-COLI	T_SUSP_SOL	Nitrate	Nitrate	Total Phosphorus	Total Diss Phos	Comments
				ft	°C	°C	µS/cm	µS/cm	ppt	mg/L		NTU	cm	CFU/100mL	MPN/100mL	mg/L	mg/L	mg/L	(mg/L)	(mg/L)	
T11	10/24/05	E05EC007712	1025	0.95	3.2	8.0	562	962	0.5	13.73	8.33	8		130	272.0	13	3.4				
T11	04/06/06	E06EC001583	1025		10.9	14.0	585	803	0.4	10.30	8.12	12		40	60.1	27		3.8			clr
T11	05/02/06	E06EC002389	1545	3.72	15.4	22.0	667	822	0.4	12.35	7.25	14		520	1410.0	25		2.3			lt brn
T11	06/07/06	E06EC003478	1510	1.08	25.9		768	755	0.4	9.91	8.33	20.1		1600	2420.0	25		2.5			lt brn
T11	07/12/06	E06EC004490	1435		29.0		816	756	0.4	5.13	7.89	904	2.25	4000	>2420	1020		0.1			black
T11	08/08/06	E06EC005467	1343	0.35	25.8		785	773	0.4	6.82	8.08	65	12.00	15000	>2420	78		2.0			brn
T11	09/12/06	E06EC006729	1400	0.18	18.7	22.0	620	705	0.3	13.00	8.64	11	49.00	720	248.0	15		3.9			lt brn
T11	10/24/06	E06EC007898	1130	0.20	2.9	6.0	415	724	0.4	19.21	8.36	8.5	60.00	140	152.0	12		5.1			clr
T11	04/02/07	E07EC001407	1500	2.00	7.9	14.0	508	768	0.4	10.40	8.22	22		2200	1730.0	41					lgt
T11	04/17/07	E07EC001942	1045	0.79	9.6	11.0	565	801	0.4	17.19	8.40	7	60.00	20	4.1	15		2.7			clear
T11	05/22/07	E07EC003088	1200	0.05	19.2	21.0	676	760	0.4	13.19	8.33	11.7	60.00	3500		39		2.6			clear
T11	06/19/07	E07EC003759	840	1.20	18.9	22.0	724	820	0.4	8.26	8.13	16	38.40	740		32		3.1			brown
T11	07/17/07	E07EC004682	1300	0.02	26.7	32.0	774	748	0.4	8.65	8.10	25	23.20	630		33		2.5			light brown
T11	08/21/07	E07EC005697	1315	1.70	23.2	32.0	674	698	0.3	5.97	8.08	40	15.90	7300		56		1.9			brown
T11	09/18/07	E07EC006242	1135	0.28	19.5	22.2	580	649	0.3	6.47	8.14	14	34.30	1200		17		3.6			light brown
T11	10/10/07	E07EC006715	930	1.44	10.4	5.4	453	630	0.3	13.97		40	14.80	6300		56		1.2			brown
T11	04/10/08	E08EC001645	915	0.36	4.9	2.8		915	0.5	13.01	8.30		44.20	10		14		3.8			
T11	05/07/08	E08EC002340	1345	0.51	15.7	21.4		825	0.4	18.20	8.70	5.4	>60	10		14		3.6			
T11	06/11/08	E08EC003474	1145	0.96	17.4	20.3		760	0.4	7.76	8.08	23		770		41					
T11	07/08/08	E08EC004361	915	0.11	22.4	24.0		648	0.3	5.07	7.92	13		60		13					
T11	08/13/08	E08EC005732	1445	0.59	24.7	30.0		652	0.3	6.39	8.07	140		1400		146					lots of uprooted sedges-somewhat blocking flow MANY cows in area; stream bulls present
T11	09/09/08	E08EC006461	930	0.08	11.5	15.0		682	0.3	10.84	8.37	18		20		17					upstream cattle had access to water/stream bed-crossing site north of bridge
T11	10/09/08	E08EC007513	915	1.40	10.1	6.5		648	0.3	9.86	8.30	22		1200		24					bedrod = 3.335

SITECODE	DATE	Specimen#	TIME	Stage	WTEMP	ATEMP	CONDUCT	SPECCOND	SALINITY	DO	PH	TURBIDITY	T-Tube	FECAL	E-COLI	T_SUSP_SOL	Nitrate	Nitrate	Total Phosphorus	Total Diss Phos	Comments
				ft	°C	°C	µS/cm	µS/cm	ppt	mg/L		NTU	cm	CFU/100mL	MPN/100mL	mg/L	mg/L	mg/L	(mg/L)	(mg/L)	
T12	10/24/05	E05EC007713	1050	1.40	3.9	7.0	541	887	0.4	15.26	8.31	6.7		100	204.0	14	2.3				
T12	04/06/06	E06EC001584	1000	3.40	10.5	13.0	572	758	0.4	10.80	8.17	15		30	39.1	37		3.7			
T12	05/02/06	E06EC002390	1615	3.82	14.6	20.0	622	775	0.4	12.70	7.31	9.5		140	291.0	20		2.5			clr
T12	06/07/06	E06EC003480	1537	1.40	25.2		780	774	0.4	13.84	8.57	15.5		2600	>2420	19		1.1			lt brn
T12	07/12/06	E06EC004491	1500	0.60	30.0		699	787	0.4	10.52	8.20	28.1	51.50	8400	>2420	18		0.6			lt grn
T12	08/08/06	E06EC005468	1400	1.30	26.7		874	848	0.4	13.13	8.63	24	57.00	380	95.7	54		nd			lt grn
T12	09/12/06	E06EC006730	1415	0.75	19.0	24.0	742	836	0.4	12.80	8.42	39	19.00	2000	1730.0	264		1.2			gray, lots of black algae foating, lots of duckweed
T12	10/24/06	E06EC007899	1145	0.60	3.5	3.0	472	801	0.4	17.13	8.35	12	45.90	100	95.8	15		2.0			lgt brn, smells like cow poop
T12	04/02/07	E07EC001408	1515	4.12	6.7	11.0	443	684	0.3	10.46	8.07	17		120	122.0	37		2.7			clr
T12	04/17/07	E07EC001941	1100	2.44	9.9	12.0	481	675	0.3	16.40	8.48	11	56.00	60	56.3	23		2.2			lgt brn
T12	05/22/07	E07EC003089	1240	2.16	18.1	22.0	662	763	0.4	13.52	8.39	11.98	60.00	410		20		0.7			clear, float mas sof green and orange algae
T12	06/19/07	E07EC003760	940	1.40	19.1	21.0	689	777	0.4	7.94	8.20	6.5	60.00	400		12		1.3			clear
T12	07/17/07	E07EC004681		0.88	27.8	34.0	820	778	0.4	12.94	8.36	13	40.60	380		19		nd			clear, lots of duckweed and black floating filaments
T12	08/21/07	E07EC005696	1400	1.78	24.8	33.0	766	769	0.4	5.52	7.90	38	14.20	800		64		0.9			brown, black clumps of floating stuff with duckweed
T12	09/18/07	E07EC006243	1150	0.94	19.7	24.1	666	740	0.4	7.28	8.38	11	42.80	620		18		0.5			clear, duckweed along bank and black floating stuff
T12	10/10/07	E07EC006716	945	1.52	10.1	5.4	669	935	0.5	16.35		45	13.00	1700		68		0.4			brown
T12	04/08/08	E08EC001536	1500	1.58	9.3	19.8		669	0.3	13.74	8.29		>60	<10		15		1.7			
T12	05/07/08	E08EC002348	1315	1.65	15.6	23.1		757		16.20	8.50	5.8	>60	20		11		1.4			
T12	06/11/08	E08EC003471	1115	2.32	17.2	19.3		725	0.4	8.02	8.19	22		960		34					
T12	07/08/08	E08EC004362	945	1.28	22.7	24.0		644	0.3	6.85	7.98	3		50		<3					
T12	08/13/08	E08EC005729	1430	1.05	25.8	30.0		711	0.4	12.40	8.35	9.1		230		11					lots of duckweed & green/brown clumps of algae
T12	09/09/08	E08EC006457	1000		11.8	20.0		736	0.4	9.06	8.12	7.4		190		8					visable flow but lots of duckweed collecting under bridge
T12	10/09/08	E08EC007512	1000	1.28	10.0	10.0		867	0.4	8.87	8.12	39		1700		44					bedrod = 4.030

SITECODE	DATE	Specimen#	TIME	Stage	WTEMP	ATEMP	CONDUCT	SPECCOND	SALINITY	DO	PH	TURBIDITY	T-Tube	FECAL	E-COLI	T_SUSP_SOL	Nitrate	Nitrate	Total Phosphorus	Total Diss Phos	Comments
				ft	°C	°C	µS/cm	µS/cm	ppt	mg/L		NTU	cm	CFU/100mL	MPN/100mL	mg/L	mg/L	mg/L	(mg/L)	(mg/L)	
T13	10/24/05	E05EC007714	1200	1.45	4.5	9.0	868	1412	0.7	12.88	8.19	5.4		10	121.0	12	1.0				
T13	04/06/06	E06EC001593	920	2.90	11.5	13.0	941	1270	0.6	9.68	8.10	7.7		20	31.8	20		1.6			clr
T13	05/02/06	E06EC002391	1645	3.42	15.4	22.0	1108	1359	0.7	11.80	7.35	7.8		160	345.0	19		1.3			clr
T13	06/08/06	E06EC003490	825	1.40	20.0	22.0	681	622	0.4	7.52	8.06	13.2		330	197.0	32		0.5			brn
T13	07/13/06	E06EC004546	925	1.30	23.0	28.0				2.63	7.99	23.1	27.50	760	649.0	45		nd			lt grn
T13	08/09/06	E06EC005555	933	1.00	23.2	32.0	967	1001	0.5	5.34	8.33	17	28.50	3700	>2420	43		nd			lt brn
T13	10/10/06	E06EC007539																			no sample, no flow
T13	04/17/07	E07EC001951	1215	2.78	11.4	18.0	863	1166	0.6	18.23	8.38	6		10	10.9	8		0.5			clear
T13	05/22/07	E07EC003091	1420	1.35	19.0	21.0	1043	1179	0.6	11.09	8.30	6	60.00	190		12		0.5			green, large log jam
T13	06/19/07	E07EC003761	1040	1.56	20.4	26.0	1290	1416	0.7	10.64	8.00	5.4	60.00	640		25		1.1			clear
T13	07/17/07	E07EC004679	1445																		no flow, no sample
T13	08/22/07	E07EC005703	1015	1.90	22.2	22.0	974	1029	0.5	3.74	7.78	17	27.10	1000		25		1.5			light brown, duckweed, very slow flow under bridge
T13	09/18/07	E07EC006244	1245	1.02	19.7	23.2	1043	1160	0.6	6.76	8.11	6.6	49.00	260		10		0.4			light green, duckweed along banks
T13	10/10/07	E07EC006717	1035	1.49	10.9	7.9	793	1090	0.5	12.10		11	40.40	2400		16		0.7			green
T13	04/08/08	E08EC001537	1415	1.82	7.8	13.6		1340	0.7	16.20	8.23		>60	<10		4		1.1			
T13	05/07/08	E08EC002350	1245	1.85	14.6	20.8		1408	0.7	15.40	8.40	3.2	>60	20		6		0.8			
T13	06/10/08	E08EC003313	1300	2.90	19.3	29.3		1101	0.6	7.44	8.03	20		1700		42					
T13	07/08/08	E08EC004363	1045	1.27	23.0	31.0		1086	0.5	5.41	8.01	6		150		7					
T13	08/13/08	E08EC005734	1330	1.48	24.6	29.0		1037	0.5	8.11	8.08	20		160		38					
T13	09/09/08	E08EC006462	1130		13.1	24.0		1051	0.5	8.03	8.00	8.5		10		10					low flow-film visable on water-no Q taken
T13	10/09/08	E08EC007517	1100	1.54	10.5	11.0		1141	0.6	8.20	7.92	13		810		21					

SITECODE	DATE	Specimen#	TIME	Stage	WTEMP	ATEMP	CONDUCT	SPECCOND	SALINITY	DO	PH	TURBIDITY	T-Tube	FECAL	E-COLI	T_SUSP_SOL	Nitrate	Nitrate	Total Phosphorus	Total Diss Phos	Comments
				ft	°C	°C	µS/cm	µS/cm	ppt	mg/L		NTU	cm	CFU/100mL	MPN/100mL	mg/L	mg/L	mg/L	(mg/L)	(mg/L)	
T14	10/24/05	E05EC007715	1215		6.0	8.0	1074	1682	0.9	16.41	8.31	3.3		60	75.7	10	4.0				

T14	04/05/06	E06EC001522	900		8.0	13.0	907	1347	0.7	11.92	7.63	18		60	40.4	50		3.3			lt brn
T14	05/03/06	E06EC002398	937		12.6	12.0	1252	1638	0.8	9.94	7.42	11		190	148.0	39		2.4			clr
T14	06/08/06	E06EC003498	850		18.7	21.0	1395	1586	0.8	8.29	8.07	14.8		5900	>2420	22		2.6			lt grn
T14	07/12/06	E06EC004492	1535		30.1		1247	1153	0.6	19.63	9.19	140	5.50	6000	>2420	224		nd			brn
T14	08/09/06	E06EC005558	1000	1.50	22.0	32.0	1253	1327	0.7	8.56	8.02	28	32.00	2600	1550.0	71		1.8			lt grn
T14	09/13/06	E06EC006771	945	1.25	14.9	17.0	1168	1445	0.7	10.40	8.04	14	43.50	1300	1990.0	24		2.4			brn
T14	10/10/06	E06EC007540	1340	1.63	11.5	14.0	1245	1677	0.9	15.08	8.27	6.4	60.00	550	816.0	8		2.4			clr
T14	04/17/07	E07EC001944	1230	3.02	11.4	15.0	1055	1423	0.7	17.41	8.26	16	42.20	10	9.7	43		2.6			lgt brn
T14	05/22/07	E07EC003081	1510	1.74	18.5	24.0	1654	1891	1.0	9.07	8.31	17.1	35.00	460		36		2.6			green
T14	06/19/07	E07EC003762	1155	1.76	20.6	25.0	1466	1600	0.8	12.64	7.99	4.7	60.00	340		11					clear
T14	07/17/07	E07EC004678	1440	1.22	27.4	35.0	1809	1730	0.9	15.47	8.34	17	45.70	400		39		1.1			light brown
T14	08/22/07	E07EC005704	1050	1.34	20.7	22.0	1300	1414	0.7	4.90	7.95	17	28.40	570		28		2.0			light brown
T14	09/18/07	E07EC006245	1305	1.24	19.0	26.1	1132	1275	0.6	8.40	8.13	7.6	45.90	800		10		0.9			clear
T14	10/10/07	E07EC006718	1055	1.56	10.5	7.8	1010	1395	0.7	13.80		15	30.00	900		27		2.4			clear
T14	04/08/08	E08EC001538	1345	1.76	7.9	13.2		1546	0.8	14.00	8.05		>60	<10		16		3.2			
T14	05/07/08	E08EC002337	1145	2.02	13.5	21.0		1700	0.9	14.00	8.30	8.9		<10		10		2.9			
T14	05/14/08	E08WB005303	945	2.66	9.7	23.8		1670	0.9	11.90	8.00	12		<10							
T14	05/21/08	E08WB005599	1400	1.95	16.6	27.1		1761	0.9	18.39	8.59	7.4		<10							
T14	05/29/08	E08WB005905	945	1.69	14.1	18.2		1866	1.0	9.51	8.16	8.3		120							
T14	06/04/08	E08WB006282	1400	2.20	19.1	27.5		1637	0.8	10.44	8.14	16		150							reset OTT from 1.83 to 2.20
T14	06/10/08	E08EC003314	1415	3.06	19.4	30.9		1337	0.7	7.91	7.96	40		240		96					
T14	06/25/08	E08WB007771	1500	1.65	24.1	25.0		1440	0.7	13.98	8.23	22		80							reset OTT from 2.67 to 1.65
T14	07/02/08	E08WB008113	930	1.52	20.3	25.0		1451	0.7	8.52	8.11	12		530							reset OTT from 1.78 to 1.52
T14	07/08/08	E08EC004364	1100	1.39	22.7	27.0		1491	0.8	11.41	8.17	3.9		50		6					
T14	07/16/08	E08WB009217	1100	1.27	23.2	32.0		1463	0.7	9.66	8.01	5.2		110							
T14	07/23/08	E08WB009693	1030	1.33	21.4	24.0		1560	0.8	8.53	8.05	11		150							kitchen garbage in water (onions, potatoes, carrots, etc)
T14	07/31/08	E08WB010118	1345	1.46	25.4	28.0		1411	0.7	9.26	8.11	15		1400							
T14	08/07/08	E08WB010725	1100	1.25	22.0	25.5		1344	0.7	12.14	8.05	9.4		1500							
T14	08/13/08	E08EC005741	1245	1.35	22.9	29.0		1247	0.6	14.54	8.20	8.5		190		14					film on water
T14	08/21/08	E08EC006001	1530	1.09	21.4	21.0		1186	0.6	14.08	8.41	17		70							reset OTT from 1.60 to 1.09
T14	08/27/08	E08EC006190	1530	1.06	21.0	25.0		1203	0.6	13.38	8.23	14		130							OTT read 1.12 ft (did not reset-pc was dead)
T14	09/04/08	E08WB012183	1300	1.02	18.3	22.0		1211	0.6	18.73	8.06	10		60							OTT read 1.16 =>restrung OTT (was backwards) reset to 1.02
T14	09/09/08	E08EC006451	1215	1.02	13.4	25.0		1169	0.6	11.89	7.98	8.6		40		8					
T14	09/17/08	E08WB012827	1345	1.02	18.0	29.0		1189	0.6	11.02	7.84	10		180							OTT reading 1.01 ft (not reset)
T14	09/23/08	E08WB013028	1430	1.00	20.0	23.0		955	0.5	8.72	7.97	13		80							
T14	10/09/08	E08EC007516	1145	1.32	10.5	12.0		1204	0.6	10.53	7.95	25		300		26					

SITECODE	DATE	Specimen#	TIME	Stage	WTEMP	ATEMP	CONDUCT	SPECCOND	SALINITY	DO	PH	TURBIDITY	T-Tube	FECAL	E-COLI	T_SUSP_SOL	Nitrate	Nitrate	Total Phosphorus	Total Diss Phos	Comments
				ft	°C	°C	µS/cm	µS/cm	ppt	mg/L		NTU	cm	CFU/100mL	MPN/100mL	mg/L	mg/L	mg/L	(mg/L)	(mg/L)	
T15	05/03/06	E06EC002399	915	3.95	12.4	10.0	1486	1956	1.0	8.75	7.17	2.7		190	225.0	6		0.6			clr; add 0.65 to all stage readings
T15	06/08/06	E06EC003500	1030		20.6	26.0	1516	1656	0.8	4.15	7.88	36.5		4400	>2420	48		0.7			clr
T15	07/13/06	E06EC004547	1025	2.65	25.2	29.0	1636	1629	0.8	4.98	7.73	18.6	31.00	310	411.0	27		nd			clr
T15	08/08/06	E06EC005469	1445	2.68	25.3		1740	1731	0.9	8.17	7.91	11	56.50	320	173.0	26		nd			lt grn
T15	09/13/06	E06EC006772	1130																		no sample taken because water was stagnant. Lots of duckweed
T15	10/25/06	E06EC007919	1245	3.99	4.9	10.0	1296	2142	1.1	14.14	8.09	4.52		30	95.9	10		1.6			lgt brn, staff gauge under water
T15	04/18/07	E07EC002039	950	4.29	10.1	12.0	1166	1631	0.8	12.21	8.16	3.5	60.00	<10	5.2	5		0.5			clear, staff gauge under water, bedrod 1.01 meters
T15	04/24/07	E07EC002190	1130		12.4	15.0	753	992	0.5	12.69	7.73	8.5		2900	>2420	10					clear, staff gauge under water
T15	05/24/07	E07EC003161	1040	3.33	15.8	13.0	1289	1565	0.8	14.95	8.02	4.35	60.00	250		6		0.5			clear
T15	06/20/07	E07EC003889	915	2.70	20.0	22.0	1545	1708	0.9	8.57	8.07	11	60.00	700	582.0	16		0.9			clear
T15	07/18/07	E07EC004741	945																		no sample, no flow, duckweed and oily sheen
T15	08/23/07	E07EC005799	900																		no flow, no sample
T15	09/24/07	E07EC006396	940	2.37	19.1	25.0	1362	1533	0.8	3.68	7.60	24	23.00	110		39		0.2			light brown, duckweed along banks
T15	10/11/07	E07EC006790	920																		no flow, no sample
T15	04/07/08	E08EC001462	940	2.97	0.7	-1.0			0.9	15.35	8.35		>60	<10		15		0.8			
T15	05/05/08	E08EC002222	930	3.48	11.5	26.2		1894	1.0	10.57	8.47	2.7	>60	20		8		0.3			
T15	06/09/08	E08EC003219	1015		17.5	20.9		1757	0.9	6.61	7.81	2.8		40		<3					staff gage under water
T15	07/07/08	E08EC004304	945	1.48	23.6	23.0		1666	0.8	3.52	7.87	6.9		<10		9					barely any flow

SITECODE	DATE	Specimen#	TIME	Stage	WTEMP	ATEMP	CONDUCT	SPECCOND	SALINITY	DO	PH	TURBIDITY	T-Tube	FECAL	E-COLI	T_SUSP_SOL	Nitrate	Nitrate	Total Phosphorus	Total Diss Phos	Comments
				ft	°C	°C	µS/cm	µS/cm	ppt	mg/L		NTU	cm	CFU/100mL	MPN/100mL	mg/L	mg/L	mg/L	(mg/L)	(mg/L)	
T19	10/25/05	E05EC007769	930	1.05	2.5	5.0	722	1262	0.6	15.30	8.28	16		240	579.0	26	5.6				
T19	04/05/06	E06EC001528	430	3.49	14.6	27.0	939	1168	0.6	14.08	8.45	23		10	31.3	53		2.7			
T19	05/03/06	E06EC002400	1450	3.43	15.6	20.5	992	1211	0.6	13.19	6.66	20		220	387.0	55		2.2			clr
T19	06/08/06	E06EC003491	1120	1.20	19.7	28.0	1063	1238	0.6	9.05	8.30	70.9		2600	2420.0	98		7.5			lt grn
T19	07/13/06	E06EC004548	1152	0.40	27.1	29.0	1180	1135	0.6	8.54	8.21	86.3	16.50	1300	1990.0	112		0.3			lt brn
T19	08/09/06	E06EC005564	1400	0.80	24.1	33.0	1220	1241	0.6	6.23	8.08	150	6.50	4800	>2420	200		1.5			brn
T19	09/13/06	E06EC006773	1200	1.70	18.3	26.0	1044	1221	0.6	10.12	8.25	40	13.00	4400	>2420	59		2.0			brn
T19	10/25/06	E06EC007920	1315	0.70	6.2	10.0	792	1236	0.6	18.45	8.39	12	53.70	180	127.0	20		3.1			clr
T19	04/18/07	E07EC002042	1030	3.30	10.1	11.5	810	1132	0.6	15.54	8.25		45.40	20	33.2	28		1.9			clear
T19	04/24/07	E07EC002191	1200	3.85	11.9	15.0	826	1101	0.5	9.07	7.94	10		320	326.0	24					lgt brn, staff gauge under water, bedrod 3.19 meters
T19	05/24/07	E07EC003162	1120	1.68	15.4	12.0	970	1185	0.6	14.86	8.21	40	12.50	1340		80		3.5			clear, cow along creek
T19	06/20/07	E07EC003890	1010	1.72	20.2	24.0	932	1025	0.5	8.35	7.83	160	5.90	2900	4610.0	304		2.6			brown, cows in stream by bridge
T19	07/18/07	E07EC004740	1005	0.64	26.0	31.0	1075	1056	0.5	6.53	8.07	100	6.50	900		120		1.1			brown, cattle in stream up stream of sample
T19	08/23/07	E07EC005800	935	2.11	19.1	19.0	766	864	0.4	12.11	8.09	210	4.40	7800		292		1.6			brown
T19	09/24/07	E07EC006397	1010	0.94	19.1	25.3	1107	1248	0.6	7.94	8.03	34	14.90	1100		48		2.2			light brown
T19	10/11/07	E07EC006781	940	2.00	9.9	8.5	819	1150	0.6	16.92		35	15.50	800		63		2.6			light brown
T19	04/07/08	E08EC001463	1015	2.48	1.6	1.1			0.6	14.60	7.98		32.10	<10		51		2.6			
T19	05/05/08	E08EC002231	1015	3.00	11.5	19.5		1190	0.6	11.35	8.12	13	39.00	20		21		2.5			bulls grazing pasture
T19	06/09/08	E08EC003226	1045		16.9	21.0		1141	0.6	8.02	7.94	33		270		66					water too deep & bulls grazing in area - no Q taken
T19	07/07/08	E08EC004305	1030	0.96	22.2	24.0		1093	0.5	6.91	8.21	140		840		184					cows present
T19	08/12/08	E08EC005601	945	0.84	19.9	22.0		952	0.5	7.15	8.15	210		700		184					carcass with lots of maggots upstream of bridge cows in stream area (U.S. and D.S.)
T19	09/08/08	E08EC006386	1045	0.59	14.7	16.0		925	0.5	9.92	7.82	60		140		54					Bedrod = 4.18 m cattle with access to creek on both sides of bridge manure smell in area
T19	10/06/08	E08EC007314	1030	0.58	16.4	20.0		892	0.4	9.38	7.91	55		70		62					shoreline badly eroded

SITECODE	DATE	Specimen#	TIME	Stage	WTEMP	ATEMP	CONDUCT	SPECCOND	SALINITY	DO	PH	TURBIDITY	T-Tube	FECAL	E-COLI	T_SUSP_SOL	Nitrate	Nitrate	Total Phosphorus	Total Diss Phos	Comments
				ft	°C	°C	µS/cm	µS/cm	ppt	mg/L		NTU	cm	CFU/100mL	MPN/100mL	mg/L	mg/L	mg/L	(mg/L)	(mg/L)	
T20	10/25/05	E05EC007768	945	0.90	3.7	6.0	986	1665	0.8	14.18	7.77	5.3		310	365.0	11	1.0				
T20	04/05/06	E06EC001535	1545	1.69	13.6	25.0	1374	1750	0.9	13.64	8.24	7.7		40	85.7	18		1.9			
T20	05/03/06	E06EC002403	1440	1.75	15.6	21.0	1403	1710	0.9	14.68	6.34	7.3		50	196.0	14		1.1			clr
T20	06/08/06	E06EC003492	1135	3.70	20.9	28.0	1494	1620	0.8	11.53	8.24	42.8		1900	980.0	98		1.6			brn
T20	07/13/06	E06EC004558	1215	1.70	27.3	31.0	1438	1379	0.7	8.78	8.39	67	13.50	5300	>2420	132		nd			lt brn
T20	08/09/06	E06EC005565	1350	1.00	23.8	33.0	1499	1533	0.8	6.15	7.91	65	14.00	1400	980.0	150		1.5			brn
T20	09/13/06	E06EC006774	1230	1.38	17.8	25.0	1409	1633	0.8	11.05	8.27	14	38.00	300	461.0	22		1.9			lt brn
T20	10/25/06	E06EC007922	1330	0.82	6.0	11.0	1099	1727	0.9	18.64	8.24	10	53.10	40	144.0	27		2.5			clr
T20	04/18/07	E07EC002045	1045	1.78	10.4	13.0	1155	1602	0.8	15.70	8.31	12	60.00	50	61.3	19		1.0			clear

T20	04/24/07	E07EC002192	1215	2.30	12.7	15.0	1156	1510	0.8	8.92	7.85	7.9		460	866.0	19					clear, rain event
T20	05/24/07	E07EC003163		1.28	15.6	13.0	1435	1751	0.9	9.50	8.26	6.54	60.00	790		12		1.6			green
T20	06/20/07	E07EC003891	1100	0.92	21.9	26.0	1510	1609	0.9	14.25	8.32	22		20	31.6	41					brown
T20	07/18/07	E07EC004739	1045	0.80	26.6	32.0	1209	1173	0.6	10.64	8.43	170	5.50	15000		200		nd			brown
T20	08/23/07	E07EC005801	1010	1.10	19.4	18.0	1284	1438	0.7	5.24	7.93	120	11.10	33000		88		2.4			brown
T20	09/24/07	E07EC006398	1030	0.78	20.0	25.6	1347	1490	0.8	6.92	7.84	11	37.20	180		21		0.5			clear
T20	10/11/07	E07EC006782	1000	1.04	9.9	8.9	1295	1819	0.9	12.35		17	35.40	250		28		1.8			light brown
T20	04/07/08	E08EC001466	1045	1.46	2.4	2.1			0.9	15.24	8.20		40.40	10		34		1.6			
T20	05/05/08	E08EC002232	1100	1.72	12.1			1733	0.9	12.03	8.13	6.5	>60	30		17		1.4			
T20	06/09/08	E08EC003227	1115	1.82	17.7	24.2		1636	0.8	7.87	7.97	25		220		58					water to deep to do Q
T20	07/07/08	E08EC004306	1100	0.92	23.0	25.0		1394	0.7	7.22	7.92	10		60		19					lots of debris caught on fence across stream
T20	08/12/08	E08EC005605	1000	0.90	20.7	22.0		1244	0.6	7.11	7.98	11		280		15					horses in stream area (D.S.)
T20	09/08/08	E08EC006384	1130	0.75	15.6	22.0		1182	0.6	10.12	7.86	9.8		50		10					OTT reset from 0.9 tp 0.75
T20	10/06/08	E08EC007310	1100	0.74	16.7	21.0		1264	0.6	7.66	7.89	16		40		21					8-10 horses grazing - grass in good condition except at crossing

SITECODE	DATE	Specimen#	TIME	Stage	WTEMP	ATEMP	CONDUCT	SPECCOND	SALINITY	DO	PH	TURBIDITY	T-Tube	FECAL	E-COLI	T_SUSP_SOL	Nitrate	Nitrate	Total Phosphorus	Total Diss Phos	Comments
				ft	°C	°C	µS/cm	µS/cm	ppt	mg/L		NTU	cm	CFU/100mL	MPN/100mL	mg/L	mg/L	mg/L	(mg/L)	(mg/L)	
T21	10/25/05	E05EC007767	1010	2.15	4.7	8.0	940	1536	0.8	15.55	8.46	9.1		60	84.2	37		0.9			
T21	04/05/06	E06EC001533	1510	3.94	12.6	27.0	1030	1352	0.7	12.38	8.09	33		20	21.8	74		1.6			lt brn
T21	05/03/06	E06EC002404	1400		15.6	16.0	1247	1476	0.6	11.79	6.43	18		100	155.0	46		0.9			clr
T21	06/08/06	E06EC003501	1205	3.00	21.7	29.0	1409	1504	0.8	8.90	8.30	47.4		160	13.3	72		1.5			grn
T21	07/13/06	E06EC004559	1250	1.50	27.7	31.0	1407	1338	0.7	9.75	8.51	88.3	10.00	250	51.2	120		nd			lt brn
T21	08/09/06	E06EC005560	1315	1.90	24.2	35.0	1168	1183	0.6	7.76	8.13	150	8.00	6100	>2420	212		0.4			brn
T21	09/13/06	E06EC006775	1245	1.68	18.3	29.0	1200	1377	0.7	11.67	8.42	110	10.00	660	235.0	140		1.1			drk brn
T21	10/25/06	E06EC007923	1345	1.88	6.7	12.0	973	1500	0.8	19.21	8.44	12	47.40	80	32.7	34		1.1			lt brn, pipeline being put in across stream
T21	04/18/07	E07EC002046	1115	4.04	12.5	16.0	1139	1498	0.8	14.42	8.12	16		<10	18.9	40		0.4			clear, bedrod reading 3.53 meters
T21	04/24/07	E07EC002194	1300	4.23	14.0	14.0	1196	1512	0.8	9.63	8.24	12		400	727.0	28					clear, rain event, bedrod 3.47 meters
T21	05/24/07	E07EC003164		3.02	17.9	16.0	1398	1620	0.8	11.45	8.21	18.7	29.50	370		46		0.7			brown
T21	06/20/07	E07EC003892	1145	2.38	23.2	28.0	1211	1255	0.6	8.83	7.98	45	16.80	230		78		1.1			brown
T21	07/18/07	E07EC004738	1130	1.59	28.0	31.0	1162	1099	0.5	9.28	8.36	60	11.20	380		92		nd			brown
T21	08/23/07	E07EC005802	1050		20.9	20.0	914	1000	0.5	5.84	8.12	180	5.50	5000		212		1.5			brown
T21	09/19/07	E07EC006322	1500	2.50	20.8	28.9	1025	1115	0.6	8.82	8.57	34	19.40	160		40		0.6			clear
T21	10/11/07	E07EC006783	1025	1.14	10.7	11.4	841	1148	0.6	9.35		75	8.30	1500		102		1.5			brown
T21	04/07/08	E08EC001467	1120		4.0	3.3			0.7	14.20	8.20		16.90	<10		98		1.6			
T21	05/05/08	E08EC002233	1130		13.2			1551	0.8	10.85	7.84	24	25.00	10		64		0.9			
T21	06/09/08	E08EC003225	1145		19.4	24.0		1379	0.7	8.07	7.62	55		270		120					water too high to do Q
T21	07/07/08	E08EC004295	1130	2.10	24.2	25.0		1473	0.7	7.06	8.14	80		70		108					
T21	08/12/08	E08EC005597	1045	1.62	21.9	23.0		1194	0.6	10.88	8.39	23		90		26					
T21	09/08/08	E08EC006394	1215	1.30	17.0	20.0		999	0.5	11.91	8.34	45		20		66					bedrod=4.37
T21	10/06/08	E08EC007316	1145	1.20	17.5	20.0		1023	0.5	9.93	8.24	65		50		72					

SITECODE	DATE	Specimen#	TIME	Stage	WTEMP	ATEMP	CONDUCT	SPECCOND	SALINITY	DO	PH	TURBIDITY	T-Tube	FECAL	E-COLI	T_SUSP_SOL	Nitrate	Nitrate	Total Phosphorus	Total Diss Phos	Comments
				ft	°C	°C	µS/cm	µS/cm	ppt	mg/L		NTU	cm	CFU/100mL	MPN/100mL	mg/L	mg/L	mg/L	(mg/L)	(mg/L)	
T22	10/25/05	E05EC007775	1100		1.8	9.0	483	876	0.4	15.40	8.37	21		260	488.0	55	2.3				
T22	04/05/06	E06EC001523	1445		13.0	26.0	672	868	0.3	13.28	8.30	16		<10	20.1	36		1.8			clr
T22	05/03/06	E06EC002405	1345	3.05	15.6	22.0	753	918	0.5	13.42	6.52	15		140	142.0	30		1.6			clr
T22	06/08/06	E06EC003493	1220		20.4	29.0	758	830	0.4	15.08	8.48	31.1		570	1050.0	54		3.6			lt grn
T22	07/13/06	E06EC004549	1315	0.91	27.9	28.0	884	837	0.4	9.21	8.23	34.1	15.50	210	228.0	55		1.5			lt grn
T22	08/09/06	E06EC005562	1320	2.78	24.0	33.0	471	480	0.2	6.49	7.99	25	30.00	1100	770.0	41		nd			lt brn
T22	09/13/06	E06EC006776	1300		19.5	31.0	782	875	0.4	16.05	8.61	15	37.00	350	461.0	20		1.3			lt brn
T22	10/25/06	E06EC007924	1415		6.9	14.0	624	954	0.5	17.41	8.46	16	39.70	110	249.0	31		1.9			lgt brn, fall trees blocking stream water smells like petroleum, clumps of brown algae
T22	04/18/07	E07EC002048	1140	2.98	11.8	21.0	657	881	0.4	>20	8.36	15	42.80	10	35.9	36		1.6			clear, bedrod 2.87 meters
T22	04/24/07	E07EC002193	1245	2.55	12.2	16.0	691	915	0.5	11.77	8.30	8.1		50	79.8	16					clear, bedrod 3.01 meters, rain event
T22	05/24/07	E07EC003165	1210	1.21	15.0	15.0	756	935	0.5	13.65	8.17	14	42.00	980		21		3.3			clear, cows along creek
T22	06/20/07	E07EC003893	1200	3.57	22.2	29.0	581	613	0.3	8.85	7.84	45	20.50	300		92					brown
T22	07/18/07	E07EC004736	1200	0.70	26.5	30.0	904	879	0.4	9.87	8.31	37	16.80	750		58		3.7			light brown
T22	08/23/07	E07EC005803	1110	1.83	20.2	21.0	622	685	0.3	6.28	8.05	160	7.30	8200		212		1.0			brown
T22	09/17/07	E07EC006319	1440		21.2	29.6	741	800	0.4	10.61	8.62	45	20.60	200		26		1.5			clear
T22	10/11/07	E07EC006784	1035	2.75	10.4	11.9	440	602	0.3	13.15		80	6.90	3700		134		0.3			brown
T22	04/07/08	E08EC001468	1140		3.3	4.5			0.4	14.00	8.05		30.40	20		44		2.0			
T22	05/05/08	E08EC002227	1200		13.4			867	0.4	13.30	8.18	8.7	>60	<10		17		1.8			
T22	06/09/08	E08EC003228	1215		18.8	28.3		870	0.4	7.52	8.01	50		210		98					too deep to do Q
T22	07/07/08	E08EC004296	1215		22.3	27.0		801	0.4	8.70	8.18	34		200		44					tile draining in upstream
T22	08/12/08	E08EC005600	1100		20.5	24.0		806	0.4	8.28	8.26	75		650		95					cows in straem area
T22	09/08/08	E08EC006387	1245		16.0	20.0		1197	0.6	9.13	8.12	85		270		78					bedrod = 3.58
T22	10/06/08	E08EC007311	1215		17.5	20.0		804	0.4	10.88	8.34	120		290		152					bedrod = 3.590

SITECODE	DATE	Specimen#	TIME	Stage	WTEMP	ATEMP	CONDUCT	SPECCOND	SALINITY	DO	PH	TURBIDITY	T-Tube	FECAL	E-COLI	T_SUSP_SOL	Nitrate	Nitrate	Total Phosphorus	Total Diss Phos	Comments
				ft	°C	°C	µS/cm	µS/cm	ppt	mg/L		NTU	cm	CFU/100mL	MPN/100mL	mg/L	mg/L	mg/L	(mg/L)	(mg/L)	
T23	10/25/05	E05EC007776	1115		6.2	12.0	993	1548	0.8	15.51	7.94	9.5		10	95.9	18	0.8				
T23	04/05/06	E06EC001530	1420		12.1	27.0	978	1295	0.7	11.88	8.20	40		30	24.3	96		1.7			lt brn
T23	05/03/06	E06EC002406	1315		15.9	17.0	735	892	0.4	11.50	6.51	19		100	184.0	35		0.9			clr
T23	06/08/06	E06EC003494	1245		22.0	30.0	1391	1476	0.7	9.23	8.12	38.3		540	125.0	69		1.3			lt grn
T23	07/13/06	E06EC004550	1335		27.3	27.0	1387	1330	0.7	10.55	8.31	68	10.00	30000	>2420	100		nd			lt brn
T23	08/09/06	E06EC005563	1340		23.9	31.0	1034	1057	0.5	6.95	8.05	120	8.50	1100	770.0	168		0.1			lt brn
T23	09/13/06	E06EC006777	1315		19.5	29.0	1234	1375	0.7	11.54	8.42	75	12.00	320	71.0	112		1.0			brn
T23	10/25/06	E06EC007925	1430		6.7	14.0	932	1445	0.7	17.52	8.35	6.5	54.30	10	17.5	8		0.9			clr
T23	04/18/07	E07EC002050	1200		13.1	20.0	1097	1423	0.7	11.19	8.49	12	43.50	60	18.5	34		0.5			clear
T23	04/24/07	E07EC002195	1330		14.6	15.0	1174	1474	0.7	9.89	8.22	11		560	1050.0	30					lgt brn
T23	05/24/07	E07EC003166	1230		18.0	14.0	1386	1606	0.8	8.40	8.16	23.2	26.70	300		56		0.6			light brown
T23	06/20/07	E07EC003894	1245		23.7	32.0	856	1059	0.5	7.46	8.03	40	15.60	300		84		0.8			brown
T23	07/18/07	E07EC004735	1230		26.8	30.0	1167	1127	0.6	10.14	8.01	28	13.60	340		54		nd			light brown, light drizzle
T23	08/23/07	E07EC005805	1140		20.9	20.0	810	879	0.4	6.76	8.05	230	4.40	5500		292		1.5			brown
T23	09/19/07	E07EC006315	1415		19.9	28.5	1066	1180	0.6	9.29	8.35	29	14.90	130		35		0.5			clear, duckweed floating
T23	10/11/07	E07EC006785	1100		11.7	14.7	814	1090	0.5	15.40		45	11.90	2100		55		1.1			light brown
T23	04/07/08	E08EC001469	1150		4.7	12.2			0.6	14.20	8.02		16.20	10		76		1.6			
T23	05/05/08	E08EC002229	1215		13.4			1480	0.8	10.82	8.22	21	25.60	<10		54		0.9			
T23	06/09/08	E08EC003221	1300		20.3	29.0		1280	0.6	8.01	8.12	55		160		140					
T23	07/07/08	E08EC004297	1245		24.0	28.0		1365	0.7	7.70	7.97	50		100		72					
T23	08/12/08	E08EC005604	1145		22.7	27.0		1076	0.5	10.52	7.87	21		290		34					film on water
T23	09/08/08	E08EC006390	1315		17.6	20.0		1128	0.6	9.37	8.05	55		40		80					
T23	10/06/08	E08EC007312	1245		17.7	23.0		1258	0.6	8.23	7.57	60		30		72					

SITECODE	DATE	Specimen#	TIME	Stage	WTEMP	ATEMP	CONDUCT	SPECCOND	SALINITY	DO	PH	TURBIDITY	T-Tube	FECAL	E-COLI	T_SUSP_SOL	Nitrate	Nitrate	Total Phosphorus	Total Diss Phos	Comments
				ft	°C	°C	µS/cm	µS/cm	ppt	mg/L		NTU	cm	CFU/100mL	MPN/100mL	mg/L	mg/L	mg/L	(mg/L)	(mg/L)	
T27	10/25/05	E05EC007773	1345	1.70	7.7	14.0	654	972	0.5	>20	8.43	3		50	67.0	26	5.1				

T27	04/05/06	E06EC001524		3.66	9.2		543	777	0.4	12.50		24		20	42.6	53		4.8			lt brn
T27	05/03/06	E06EC002408	1100	3.69	14.2	19.0	669	846	0.4	11.25	7.54	12		80	411.0	30		3.4			clr
T27	06/08/06	E06EC003502	1340	1.60	23.1	33.0	841	873	0.4	9.13	8.35	29.8		480	41.9	57		4.4			
T27	07/13/06	E06EC004551	1420	1.00	26.2	24.0	679	664	0.3	3.68	8.73	27	18.75	500	517.0	52		0.8			lt brn
T27	08/09/06	E06EC005561	1115	0.70	23.2	31.0	585	606	0.3	7.86	8.10	45	34.00	3000	>2420	94		1.5			lt brn
T27	09/13/06	E06EC006779	1430		21.0	29.0	663	719	0.3	17.68	8.58	35	28.50	600	770.0	102		2.7			brn
T27	10/24/06	E06EC007900	1300		5.6	5.0	486	747	0.4	19.40	8.38	4.8	60.00	50	35.9	8		3.6			clr
T27	04/18/07	E07EC002052	1455	2.48	15.4	24.0	708	868	0.4	14.31	8.62	6.9	60.00	10	7.4	25		3.6			clear
T27	05/23/07	E07EC003133	1230	1.88	20.1	31.0	731	806	0.4	11.60	8.31	17	35.60	690		38		4.0			light brown
T27	06/21/07	E07EC003933	1100	2.40	23.9	30.0	912	930	0.5	8.06	8.22	27	24.70	1700		75		3.6			brown
T27	07/19/07	E07EC004776	1100	1.48	23.9	31.0	720	736	0.4	9.56	8.26	33	15.00	3200		56		2.5			light brown
T27	08/22/07	E07EC005708	1320	1.40	21.4	21.5	694	745	0.4	5.98	8.13	60	11.30	1100		100		2.9			brown, light drizzle while sampling
T27	09/19/07	E07EC006325	1050	1.68	15.8	21.0	619	755	0.4	11.39	9.37	11	36.00	200		15		2.1			clear
T27	10/10/07	E07EC006719	1230	2.11	11.9	10.6	586	781	0.4	16.25		15	40.50	340		26		2.4			clear
T27	04/08/08	E08EC001539	1145	2.14	6.4	11.8		846	0.4	14.60	8.31		>60	<10		13		3.9			
T27	05/07/08	E08EC002341	1015	2.25	13.5	18.5		903	0.5	11.10	8.30	10	52.20	10		26		3.8			
T27	06/10/08	E08EC003311	1500	2.49	21.3	35.3		885	0.4	8.37	8.21	31		200		88					
T27	07/08/08	E08EC004365	1330	1.38	27.2	30.0		769	0.4	11.83	8.34	21		40		28					
T27	08/13/08	E08EC005739	1000	1.67	21.5	30.0		573	0.3	8.23	8.04	18		560		27					
T27	09/09/08	E08EC006454	1515		19.0	24.0		578	0.3	19.25	8.85	35		110		100					no gage stage reading taken
T27	10/09/08	E08EC007508	1415	1.86	12.6	14.0		644	0.3	11.61	8.27	27		900		38					

SITECODE	DATE	Specimen#	TIME	Stage	WTEMP	ATEMP	CONDUCT	SPECCOND	SALINITY	DO	PH	TURBIDITY	T-Tube	FECAL	E-COLI	T_SUSP_SOL	Nitrate	Nitrate	Total Phosphorus	Total Diss Phos	Comments
				ft	°C	°C	µS/cm	µS/cm	ppt	mg/L		NTU	cm	CFU/100mL	MPN/100mL	mg/L	mg/L	mg/L	(mg/L)	(mg/L)	
T28	10/25/05	E05EC007771	1500		8.0	14.0	693	1024	0.5	14.12	8.23	6		50	90.9	11	9.5				
T28	04/05/06	E06EC001526	937	4.95	8.2	11.0	572	843	0.4	11.16	7.60	37		10	27.5	27		8.5			lt brn
T28	05/03/06	E06EC002407	1005		12.8	12.0	716	933	0.5	10.46	7.68	8.6		300	411.0	21		7.8			
T28	06/08/06	E06EC003495	917	2.20	19.3	24.0	799	855	0.4	7.64	8.18	23.8		420	435.0	65		8.0			brn
T28	07/13/06	E06EC004552	1005	1.40	23.9	27.0	758	777	0.4	6.75	8.11	25.7	23.00	300	345.0	56		2.9			clr
T28	08/09/06	E06EC005557	1020	1.45	23.2	32.0	778	805	0.4	7.10	8.13	85	10.00	3400	>2420	132		1.4			brn
T28	09/13/06	E06EC006780	1030	0.86	15.2	21.0	624	770	0.4	11.49	8.36	37	19.25	3000	2420.0	50		2.1			brn
T28	10/24/06	E06EC007901	1200		3.5	2.0	453	768	0.4	17.40	8.16	6.7	52.30	90	192.0	13		3.9			clr
T28	04/02/07	E07EC001413	1530	3.06	6.9	11.0	581	891	0.4	10.10	8.34	20		670	1050.0	45		5.5			clr, heavy rains in that last 2 days
T28	04/17/07	E07EC001940	1315	2.86	12.1	19.0	697	926	0.5	16.87	8.26	22	37.60	10	14.6	46					lgt brn
T28	05/23/07	E07EC003130	1000	1.78	17.1	17.0	872	1026	0.5	13.27	8.24	40.4	20.00	460		74		5.3			light brown
T28	06/21/07	E07EC003939	945	1.60	22.6	25.0	762	797	0.4	9.45	8.23	8.8	60.00	750		34		3.9			clear, cows in stream under bridge
T28	07/19/07	E07EC004778	930	1.28	21.5	24.0	707	758	0.4	7.01	8.00	65	7.50	2700		104		0.4			brown, cattle grazing in creak upstream and downstream, duckweed along bank
T28	08/22/07	E07EC005706	1145	1.58	22.0	22.0	659	699	0.3	5.94	8.05	75	9.60	1200		124		3.6			brown, duckweed along bank, cattle grazing downstream
T28	09/19/07	E07EC006316	940	1.46	14.3	13.1	518	651	0.3	13.28	8.30	21	26.30	1100		36		2.2			light brown, duckweed floating
T28	10/10/07	E07EC006720	1140	1.83	10.4	9.2	516	716	0.4	11.64		65	10.30	1300		98		3.2			brown, cattle grazing downstream
T28	04/08/08	E08EC001541	1245	1.96	6.8	14.6		956	0.5	11.70	7.91		43.55	<10		31		4.0			
T28	05/07/08	E08EC002336	1100	2.26	12.8	18.5		958	0.5	11.70	8.45	20	27.80	<10		67		6.7			
T28	06/11/08	E08EC003468	1100		17.1	20.4		851	0.4	7.47	8.16	28		1400		54					staff gage under water
T28	07/08/08	E08EC004366	1230	1.76	24.9	26.0		748	0.4	7.04	8.12	27		90		46					
T28	08/13/08	E08EC005737	1130	1.59	22.7	28.5		661	0.3	6.91	8.07	90		1000		128					cows with access to stream (upstream cows) high voltage fence on both sides of bridge
T28	09/09/08	E08EC006453	1315	1.28	16.8	22.0		715	0.4	12.83	8.27	55		300		63					electric fence both sides of bridge-bedrod 3.555
T28	10/09/08	E08EC007510	1245		11.1	14.0		835	0.4	10.94	8.21	95		670		104					bedrod = 3.435

SITECODE	DATE	Specimen#	TIME	Stage	WTEMP	ATEMP	CONDUCT	SPECCOND	SALINITY	DO	PH	TURBIDITY	T-Tube	FECAL	E-COLI	T_SUSP_SOL	Nitrate	Nitrate	Total Phosphorus	Total Diss Phos	Comments
				ft	°C	°C	µS/cm	µS/cm	ppt	mg/L		NTU	cm	CFU/100mL	MPN/100mL	mg/L	mg/L	mg/L	(mg/L)	(mg/L)	
T29	10/25/05	E05EC007770	1345	1.58	8.5	16.0	757	1098	0.5	15.60	8.19	16		40	44.3	5	7.9				
T29	04/05/06	E06EC001529	1005		8.6	13.0	502	730	0.4	10.83	8.08	19		30	12.1	45		6.7			lt brn
T29	05/03/06	E06EC002409			13.1	12.0	355	466	0.2	11.00	7.65	15		70	167.0	54		6.3			clr
T29	06/08/06	E06EC003496	947	1.87	19.6	24.0	895	998	0.5	7.49	8.32	49.5		380	23.5	94		6.6			lt grn
T29	07/13/06	E06EC004553	1025		24.8	29.0	384	260	0.2	8.02	8.38	24	18.50	600	488.0	46		2.4			lt brn
T29	08/09/06	E06EC005553	1100		23.8	31.0	827	844	0.4	8.59	8.20	95	9.50	990	687.0	132		1.2			brn
T29	09/13/06	E06EC006781	1100	0.86	16.2	21.0	650	782	0.4	8.48	8.35	60	11.00	1100	980.0	78		1.0			brn
T29	10/24/06	E06EC007902	1245	0.38	4.8	3.0	471	766	0.4	19.06	8.34	12	36.00	80	41.9	81		2.2			lgt brn
T29	04/02/07	E07EC001414	1600		7.3	12.0	571	866	0.4	9.41	8.19	28		980	1550.0	75		4.2			lght brn
T29	04/17/07	E07EC001950	1345		13.6	19.0	751	961	0.5	12.40	8.43	24	27.80	50	13.1	60		5.2			lgt brn
T29	05/23/07	E07EC003131	1115	1.40	18.2	20.0	843	968	0.5	12.55	8.27	54.5	12.50	470		106		5.1			brown
T29	06/21/07	E07EC003936	1010	1.10	23.1	29.0	982	1018	0.5	7.56	8.16	25	20.60	730		65		4.9			brown
T29	07/19/07	E07EC004777	1025	0.34	23.5	26.0	806	830	0.4	11.57	8.24	14	33.20	270		19		0.7			clear
T29	08/22/07	E07EC005707	1230	0.84	22.1	21.0	596	631	0.3	9.06	8.36	140	5.70	600		184		1.5			brown, two clumps of foam in water, ducks in water upstream from bridge
T29	09/19/07	E07EC006326	1025	0.81	15.5	16.7	584	713	0.3	12.07	8.41	34	20.40	470		54		nd			clear
T29	10/10/07	E07EC006722	1205	1.13	11.4	8.5	518	699	0.3	15.12		36	17.40	260		56		1.8			brown
T29	04/08/08	E08EC001542	1220		6.5	14.0		941	0.4	12.33	8.13		30.70	<10		44		4.1			
T29	05/07/08	E08EC002339	1030		13.0	18.4		985	0.5	12.11	8.40	17	24.40	10		42		5.5			
T29	06/11/08	E08EC003475	1030		18.5	18.3		844	0.4	6.86	8.08	21		130		58					
T29	07/08/08	E08EC004367	1245		25.7	28.0		783	0.4	7.67	8.22	32		90		56					no gage
T29	08/13/08	E08EC005740	1100		23.2	29.0		704	0.3	9.53	8.30	25		70		29					
T29	09/09/08	E08EC006455	1415		20.0	22.0		686	0.3	12.43	8.45	39		40		39					bedrod 4.710
T29	10/09/08	E08EC007509	1345		11.8	15.0		615	0.3	11.02	8.26	90		470		116					bedrod 4.575

SITECODE	DATE	Specimen#	TIME	Stage	WTEMP	ATEMP	CONDUCT	SPECCOND	SALINITY	DO	PH	TURBIDITY	T-Tube	FECAL	E-COLI	T_SUSP_SOL	Nitrate	Nitrate	Total Phosphorus	Total Diss Phos	Comments
				ft	°C	°C	µS/cm	µS/cm	ppt	mg/L		NTU	cm	CFU/100mL	MPN/100mL	mg/L	mg/L	mg/L	(mg/L)	(mg/L)	
T31	10/25/05	E05EC007772	1310		7.8	12.0	671	1001	0.5	12.35	8.43	10		30	49.5	17	6.3				
T31	04/05/06	E06EC001534	1115		9.3	19.0	250	358	0.3	13.53	8.22	38		10	36.4	87		6.2			lt brn
T31	05/03/06	E06EC002410	1115	3.05	13.8	21.0	686	872	0.4	11.30	7.58	18		120	179.0	42		5.1			
T31	06/08/06	E06EC003497	1327	1.70	22.9	33.0	787	817	0.4	13.30	8.67	28		70	242.0	75		4.2			grn
T31	07/13/06	E06EC004554	1442	1.10	26.9	25.0	750	724	0.4	6.61	8.50	23	25.50	2500	2420.0	43		2.7			lt grn
T31	08/09/06	E06EC005554	1130	1.70	23.6	30.0	529	604	0.3	7.71	8.21	50	19.50	2000	1730.0	90		1.7			lt brn
T31	09/13/06	E06EC006782	1400	1.18	19.6	29.0	579	645	0.3	15.53	8.63	21	36.00	80	67.6	43		1.7			lt brn
T31	10/10/06	E06EC007546	1620	1.28	12.8	12.0	429	563	0.5	12.00	8.91	30	35.90	160	48.8	60		1.6			lt brn
T31	04/02/07	E07EC001416	1630		6.9	14.0	431	658	0.3	7.72	8.32	40		2700	2420.0	78		4.0			brn
T31	04/18/07	E07EC002044	1420	2.70	13.6	19.0	624	796	0.4	14.97	8.71	17	48.70	<10	12.0	50		4.0			clear
T31	05/23/07	E07EC003126	1310	1.86	21.7		751	799	0.4	9.03	8.32	20.2	33.00	3700		39					light brown
T31	06/21/07	E07EC003934	1115	1.90	24.2	32.0	944	958	0.5	7.91	8.29	31	23.50	560		65		4.4			light brown
T31	07/19/07	E07EC004775	1130	1.38	25.2	31.0	703	699	0.3	11.02	8.46	33	12.60	1800		67		1.3			light brown
T31	08/22/07	E07EC005709	1345	1.36	22.3	23.0	553	582	0.3	6.86	8.31	45	13.10	1300		90		1.6			light brown
T31	09/19/07	E07EC006324	1115	1.26	17.2	33.6	530	623	0.3	9.82	8.38	21	24.70	190		29		1.0			clear
T31	10/10/07	E07EC006723	1245	1.68	12.7	12.6	576	753	0.4	14.46		12	44.90	810		18		1.9			light green
T31	04/08/08	E08EC001543	1115	2.08	6.2	11.8		863	0.4	15.24	7.97		>60	<10		8		3.6			
T31	05/07/08	E08EC002351	1000	2.34	13.7	19.0		842	0.4	10.20	8.30	20	28.00	50		34		4.6			
T31	06/10/08	E08EC003310	1515		21.2	31.1		758	0.4	8.18	8.19	60		350		120					staff gage under water
T31	07/08/08	E08EC004368	1400	1.53	26.5	32.0		751	0.4	8.25	8.29	24		<10		42					

SITECODE	DATE	Specimen#	TIME	Stage	WTEMP	ATEMP	CONDUCT	SPECCOND	SALINITY	DO	PH	TURBIDITY	T-Tube	FECAL	E-COLI	T_SUSP_SOL	Nitrate	Nitrate	Total Phosphorus	Total Diss Phos	Comments
T31	08/13/08	E08EC005738	930	1.85	22.5	30.0		606	0.3	6.98	8.18	31		3300		52					electric fence up across river
T31	09/09/08	E08EC006456	1545		18.8	21.0		507	0.3	17.96	9.05	39		<10		88					couldn't read stage ~1ft
T31	10/09/08	E08EC007511	1500	1.56	13.2	15.0		633	0.3	10.98	8.26	24		690		34					

SITECODE	DATE	Specimen#	TIME	Stage	WTEMP	ATEMP	CONDUCT	SPECCOND	SALINITY	DO	PH	TURBIDITY	T-Tube	FECAL	E-COLI	T_SUSP_SOL	Nitrate	Nitrate	Total Phosphorus	Total Diss Phos	Comments
				ft	°C	°C	µS/cm	µS/cm	ppt	mg/L		NTU	cm	CFU/100mL	MPN/100mL	mg/L	mg/L	mg/L	(mg/L)	(mg/L)	
T32	10/25/05	E05EC007777	1245	1.60	6.8	14.0	562	862	0.4	13.47	8.20	17		60	128.0	39	7.1				water-lt. brn
T32	04/05/06	E06EC001527	1145	3.70	9.3	18.0	535	766	0.4	12.13	8.20	90		30	63.3	224		9.5			brn
T32	05/03/06	E06EC002411	1145	3.80	13.5	21.0	632	812	0.4	12.04	7.64	39		190	248.0	122		11.0			lt brn
T32	06/06/06	E06EC003361	1445	1.85	21.4		974	884	0.4	9.36	8.35	26.5		250	345.0	72		8.4			
T32	07/13/06	E06EC004555	1515	1.55	26.1	32.0	923	905	0.4	8.17	8.25	50	17.00	630	272.0	106		7.0			brn
T32	08/07/06	E06EC005366	1500	2.20	25.6	31.0	747	736	0.4	8.05	8.20	60	14.00	2700	1990.0	118		4.1			brn
T32	09/11/06	E06EC006644	1500	1.50	15.6	16.0	718	876	0.4	11.93	8.30	10		550	649.0	21		3.9			clr
T32	10/10/06	E06EC007547	1550	1.54	12.6	14.0	699	916	0.5	13.85	8.35	11	50.90	130	260.0	20		5.8			clr
T32	04/18/07	E07EC002047	1350	2.52	12.5	24.0	601	785	0.4	11.22	8.29	39	11.40	<10	14.6	147		7.4			clear
T32	05/23/07	E07EC003127	1400	1.72	20.6	28.0	804	876	0.4	10.79	8.28	8.39	22.50	510		82		6.9			clear
T32	06/21/07	E07EC003937	1145	1.36	22.8	31.0	859	896	0.4	8.65	8.11	33	17.50	5000		158		6.7			clear
T32	07/19/07	E07EC004774	1200	1.78	23.6	35.0	751	771	0.4	8.95	8.10	45	6.00	40000		296		2.5			light brown
T32	08/22/07	E07EC005710	1415	1.40	21.3	24.0	803	864	0.4	7.63	8.25	40	14.70	870		98		3.8			light brown
T32	09/19/07	E07EC006323	1205	1.32	17.9	31.3	751	867	0.4	12.47	8.34	7	48.00	60		8		3.4			clear
T32	10/11/07	E07EC006786	1350	2.30	12.8	17.5	700	813	0.5	9.01		25	11.60	620		113		7.0			light brown
T32	04/07/08	E08EC001471	1510	2.20	7.8	20.6			0.4	12.01	8.27		19.70	<10		114		6.1			
T32	05/05/08	E08EC002224	1345	2.77	14.4	29.5		815	0.4	10.91	8.08	17	21.10	<10		86		7.9			
T32	06/09/08	E08EC003220	1430	3.47	18.8	29.0		801	0.4	8.43	8.05	80		390		196					water very high
T32	07/07/08	E08EC004298	1445	1.51	24.8	34.0		790	0.4	8.61	8.23	38		80		76					
T32	08/12/08	E08EC005598	1345	1.99	22.9	27.0		751	0.4	9.56	8.19	70		9000		216					
T32	09/08/08	E08EC006393	1445	1.06	18.1	21.0		748	0.4	11.06	8.20	7.8		<10		19					OTT read 1.16 reset to 1.06
T32	10/06/08	E08EC007317	1315	1.28	19.1	19.0		876	0.4	11.88	8.34	12		10		39					small rain squal while sampling

SITECODE	DATE	Specimen#	TIME	Stage	WTEMP	ATEMP	CONDUCT	SPECCOND	SALINITY	DO	PH	TURBIDITY	T-Tube	FECAL	E-COLI	T_SUSP_SOL	Nitrate	Nitrate	Total Phosphorus	Total Diss Phos	Comments
				ft	°C	°C	µS/cm	µS/cm	ppt	mg/L		NTU	cm	CFU/100mL	MPN/100mL	mg/L	mg/L	mg/L	(mg/L)	(mg/L)	
T33	10/25/05	E05EC007774	1235	0.88	5.3	13.0	539	863	0.4	14.78	8.36	12		70	148.0	26	6.6				
T33	04/05/06	E06EC001532	1310	3.15	10.3	26.0	558	778	0.4	12.69	8.23	110		60	59.8	252		8.9			
T33	05/03/06	E06EC002412	1215	3.38	13.6	26.0	647	827	0.4	11.04	7.68	50		250	436.0	156		9.1			
T33	06/06/06	E06EC003362	1420	3.41	24.7		876	886	0.4	9.06	8.32	42.9		570	1120.0	112		7.5			lt brn
T33	07/13/06	E06EC004556	1530	0.92	27.2		853	885	0.4	8.08	8.31	27	13.50	640	649.0	94		6.7			lt grn
T33	08/07/06	E06EC005362	1430	1.87	25.2		700	698	0.3	8.14	8.20	90	10.50	340	16.1	78		3.4			brn
T33	09/11/06	E06EC006645	1515	0.77	16.0	18.0	709	857	0.4	11.56	8.14	7.8		460	649.0	11		3.3			clr
T33	10/10/06	E06EC007548	1525	0.92	12.3	16.0	693	914	0.5	10.95	8.46	8.1	50.30	220	228.0	16		5.3			clr
T33	04/18/07	E07EC002049	1335	2.36	12.5	24.0	626	796	0.4	14.70	8.51	50	10.10	10	25.9	162		7.0			lgt brn, bedrod 3.77 meters
T33	05/23/07	E07EC003128	1510	1.51	21.5	32.0	796	853	0.4	10.63	8.23	35.6	16.70	3600		94		6.4			brown
T33	06/21/07	E07EC003935	1245	1.24	23.6	28.0	842	866	0.4	7.86	7.94	60	11.10	740		84		6.3			brown
T33	07/19/07	E07EC004772	1400	0.93	26.2	33.0	823	805	0.4	11.51	8.11	16		350		40					clear
T33	08/22/07	E07EC005712	1515	1.15	22.2	25.0	775	818	0.4	8.38	8.35	60	9.90	1000		156		3.2			light brown, light drizzle
T33	09/19/07	E07EC006312	1240	0.79	17.8	27.2	733	849	0.4	10.80	8.40	6.8	53.50	90		10		3.2			clear
T33	10/11/07	E07EC006787	1325	1.77	12.3	20.9	677	894	0.4	12.02		50	8.90	1300		124		6.2			brown
T33	04/07/08	E08EC001464	1420		7.0	20.1			0.4	12.51	8.09		14.80	<10		154		6.0			
T33	05/05/08	E08EC002223	1315		13.5	25.6		833	0.4	10.91	8.26	45	17.60	20		86		7.4			
T33	06/09/08	E08EC003223	1415		18.7	28.5		795	0.4	8.90	8.10	100		630		228					levellogger is missing
T33	07/07/08	E08EC004300	1415		23.8	35.0		770	0.4	9.17	8.29	50		220		108					levellogger is gone
T33	08/12/08	E08EC005603	1315		22.8	29.0		803	0.4	10.05	8.30	40		430		108					
T33	09/08/08	E08EC006392	1415		17.0	19.0		835	0.4	10.78	8.26	5.2		10		17					bedrod = 4.305
T33	10/06/08	E08EC007308	1430		19.0	25.0		858	0.3	10.55	8.27	8.8		<10		22					

SITECODE	DATE	Specimen#	TIME	Stage	WTEMP	ATEMP	CONDUCT	SPECCOND	SALINITY	DO	PH	TURBIDITY	T-Tube	FECAL	E-COLI	T_SUSP_SOL	Nitrate	Nitrate	Total Phosphorus	Total Diss Phos	Comments
				ft	°C	°C	µS/cm	µS/cm	ppt	mg/L		NTU	cm	CFU/100mL	MPN/100mL	mg/L	mg/L	mg/L	(mg/L)	(mg/L)	
T35	04/06/06	E06EC001585	1530	2.60	7.3	8.0	391	591	0.3	12.00	7.77	25		120.0	238.0	41		0.40			clr
T35	05/02/06	E06EC002392	1000	2.77	11.3	19.5	486	660	0.3	8.85	7.67	13		10.0	35.9	72		0.10			lt brn
T35	06/07/06	E06EC003486	910	2.42	20.5		627	686	0.3	3.25	7.83	9.3		450.0	461.0	12		0.23			clr
T35	07/12/06	E06EC004502	1005	1.80	24.3		582	590	0.3	1.78	8.09	24	25.00	1200.0	1730.0	30		0.20			lt grn
T35	08/08/06	E06EC005458	940	1.20	19.8	31.0	580	645	0.3	2.19	7.64	20	29.00	2500.0	>2420	25		0.20			lt grn
T35	09/11/06	E06EC006646	930																		no sample taken bacause no water movement. Lot sof duckweed, stagnant water
T35	10/10/06	E06EC007549																			no sample, no flow
T35	04/16/07	E07EC001896	1045	3.27	7.2	14.0	350	533	0.3	12.89	8.47	4.7		10.0	7.4	10					clear
T35	05/21/07	E07EC003016	1020	3.06	16.9	27.0	516	609	0.3	9.76	8.37	9.8	39.60	300.0		11		0.20			clear
T35	06/18/07	E07EC003743	930	3.00	22.1	21.0	566	600	0.3	4.65	7.93	15	31.90	170.0		22		0.20			clear
T35	07/16/07	E07EC004632	1140																		no flow, no sample
T35	08/20/07	E07EC005668	1030																		no flow, no sample
T35	09/17/07	E07EC006222	1018																		no flow, no sample
T35	10/09/07	E07EC006686	1235	1.36	11.9	14.5	461	615	0.3	11.87		26	31.60	230.0		44		0.60			only SE culvert flowing, clear
T35	4/9/008	E08EC001635	1015	1.37																	no flow, no sample
T35	05/08/08	E08EC002423	1015	2.94	11.4	7.5		625	0.31	12.00	7.80		38.60	<10		23		0.20			
T35	06/12/08	E08EC003540	1015	3.34	14.1	21.4		457	0.22	4.13	7.37	55		5200		36					water very high
T35	07/09/08	E08EC004519	1000	3.03	22.4	23.0		539	0.26	1.62	7.69	4.2		120		4					duckweed
T35	08/11/08	E08EC005568	1045	2.45	22.8	25.0		524	0.25	1.84	7.83	6.9		170		9					duckweed, low flow (only 1 culvert with flow) Heavy rains past 24 hrs cows in area

SITECODE	DATE	Specimen#	TIME	Stage	WTEMP	ATEMP	CONDUCT	SPECCOND	SALINITY	DO	PH	TURBIDITY	T-Tube	FECAL	E-COLI	T_SUSP_SOL	Nitrate	Nitrate	Total Phosphorus	Total Diss Phos	Comments
				ft	°C	°C	µS/cm	µS/cm	ppt	mg/L		NTU	cm	CFU/100mL	MPN/100mL	mg/L	mg/L	mg/L	(mg/L)	(mg/L)	
T36	04/06/06	E06EC001588	1600		10.1	7.0	667	930	0.5	14.07	8.29	5.7		<10	15.5	16		1.40			clr
T36	05/02/06	E06EC002393	1100		11.5	18.5	658	907	0.4	11.65	7.34	5		17000.0	2420.0	9		0.50			clr
T36	06/07/06	E06EC003485	949		21.0	31.0	797	862	0.4	6.46	8.12	4.5		1800.0	>2420	9		0.04			lt grn
T36	07/12/06	E06EC004495	955		24.1	33.0	889	902	0.4	5.14	7.95	5.75	60.00	25000.0	>2420	7		0.20			lt grn
T36	08/08/06	E06EC005459	925		21.4	30.0	940	1010	0.5	5.25	7.83	7.5	60.00	8000.0	>2420	10		0.10			clr
T36	09/11/06	E06EC006647	945		13.6	13.0	854	1076	0.5	6.97	7.75	4	60.00	260.0	86.9	11		0.30			clr
T36	10/10/06	E06EC007550	955		10.0	15.0	804	1137	0.6	14.16	7.51	3.1	60.00	250.0	148.0	2		0.10			clr
T36	04/16/07	E07EC001895	1115		9.1	19.0	410	588	0.3	16.23	8.37	11		<10	61.3	14					lgt brn
T36	04/23/07	E07EC002161	1030		10.9	19.0	445	617	0.3	9.45	8.10	36		2400.0	>2420	49					brn, rain event
T36	05/21/07	E07EC003017	1100		17.7	26.0	661	761	0.4	10.61	8.32	5.73	60.00	130.0		11		0.20			clear
T36	06/18/07	E07EC003744	1015		22.0	23.0	677	718	0.4	6.26	7.92	14		700.0		29		0.70			clear
T36	07/16/07	E07EC004630	1220		25.1	32.0	844	843	0.4	11.75	8.35	7.8	34.50	320.0		15		0.70			clear, duckweed along banks
T36	08/20/07	E07EC005651	1000		17.0	17.0	782	924	0.5	6.73	7.88	16	25.30	1300.0		26		1.40			clear
T36	09/17/07	E07EC006215	1040		17.7	22.0	870	1012	0.5	6.35	7.90	15	43.80	170.0		13		0.70			light brown, duckweed along banks, cows in stream

T36	10/09/07	E07EC006687	1210		12.0	18.4	719	956	0.5	14.59		8.9	53.80	120.0		14		0.50			clear
T36	4/9/008	E08EC001624	1045		6.9	20.1		905	0.45	15.23	8.43		>60	<10		11		0.80			
T36	05/08/08	E08EC002424	1045		11.6	6.1		815	0.40	16.70	8.40			10		11		0.10			
T36	06/12/08	E08EC003541	1115		14.0	23.7		441	0.21	6.49	7.65	95		8700		100					
T36	07/09/08	E08EC004521	1030		22.9	27.0		642	0.31	6.48	7.99	9		220		14					
T36	08/11/08	E08EC005566	1115		22.2	24.0		720	0.35	8.11	8.18	5.3		140		11					heavy rains past 24 hrs (Watertown 3.33") cows in stream downstream from bridge
T36	09/11/08	E08EC006583	1045		15.6	21.0		942	0.47	4.80	7.87	5.8		30		6					Bedrod = 3.745
T36	10/08/08	E08EC007482			10.9	17.0		995	0.49	8.41	8.29	4.9		10		4					bedrod = 3.725

SITECODE	DATE	Specimen#	TIME	Stage ft	WTEMP °C	ATEMP °C	CONDUCT µS/cm	SPECCOND µS/cm	SALINITY ppt	DO mg/L	PH	TURBIDITY NTU	T-Tube cm	FECAL CFU/100mL	E-COLI MPN/100mL	T_SUSP_SOL mg/L	Nitrate mg/L	Nitrate mg/L	Total Phosphorus (mg/L)	Total Diss Phos (mg/L)	Comments
T37	04/06/06	E06EC001594	1350	2.80	10.9	13.0	784	1074	0.5	11.11	8.29	6.7		10.0	46.4	15		2.50			clr
T37	05/02/06	E06EC002394	1130	2.80	11.3	19.0	923	1257	0.6	11.34	7.06	7.8		210.0	579.0	12		0.50			
T37	06/07/06	E06EC003479	1041	2.17	22.7	33.0	486	509	0.2	8.64	8.32	17.4		800.0	1300.0	40		0.12			lt grn
T37	07/12/06	E06EC004496	1118	1.80	25.4		524	320	0.3	11.61	8.48	27	21.50	1200.0	2420.0	48		nd			lt brn
T37	08/08/06	E06EC005464	1045	1.90	22.0	30.0	958	1014	0.5	11.34	9.04	85	13.00	420.0	308.0	116		nd			brn
T37	09/12/06	E06EC006731	1000	1.95	14.7	15.0	852	1060	0.5	7.92	8.08	14	41.00	100.0	42.0	33		0.40			lt brn
T37	10/25/06	E06EC007926	930	1.98	3.5	5.0	670	1123	0.5	14.08	8.33	9.45	36.60	30.0	5.2	26		1.20			clr
T37	03/14/07	E07EC002854	1140		0.9	5.0	148		0.1	16.45	7.29	16		1300.0	>2420						flood conditions due to snow melt, brn
T37	04/16/07	E07EC001893	1300	2.98	10.6	22.0	697	959	0.5	13.80	8.36	5.4		<10	10.9	10					clear
T37	04/23/07	E07EC002165	1145		11.1	18.0	577	787	0.4	9.33	8.01	35		7300.0	>2420	34					brn, rain event, water over staff gauge
T37	05/21/07	E07EC003021	1245	2.28	20.1	29.0	918	1013	0.5	13.61	8.62	17.9	24.00	90.0		44		nd			brown
T37	06/18/07	E07EC003745	1225		22.4	22.0	1035	1089	0.5	5.86	8.50	25		90.0		58					brown
T37	07/16/07	E07EC004626	1335	1.96	26.6	35.0	1058	1027	0.5	18.38	8.81	20	23.60	140.0		30		0.80			light green
T37	08/20/07	E07EC005656	1215	2.68	19.9	35.0	837	928	0.5	10.28	8.74	20	18.90	60.0		44		1.80			brown
T37	09/17/07	E07EC006216	1255	2.52	17.3	25.4	852	999	0.5	11.24	8.74	26	20.40	60.0		37		1.50			clear
T37	10/09/07	E07EC006688	930	3.18	12.9	12.1	447	590	0.3	10.75		22	23.70	70.0		44		0.30			clear
T37	04/09/08	E08EC001627	1200	2.45	7.3	18.0		932	0.46	16.05	8.14		>60	<10		12		0.80			
T37	05/08/08	E08EC002425	1230	2.67	11.5	8.7		1016	0.51	18.50	8.40		>60	<10		17		0.50			
T37	06/12/08	E08EC003542	1245	3.12	16.6	27.5		1029	0.51	8.64	8.08	10		320		17					
T37	07/09/08	E08EC004527	1215	2.20	23.2	27.5		890	0.44	7.80	8.02	16		410		26					
T37	08/11/08	E08EC005569		2.68	23.1	24.5		852	0.42	8.90	8.16	25		160		60					
T37	09/11/08	E08EC006584	1245	2.66	17.2	19.0		1065	0.53	8.07	8.28	19		<10		34					
T37	10/08/08	E08EC007483	1300		13.6	17.0		974	0.48	13.88	8.64	23		30		38					

SITECODE	DATE	Specimen#	TIME	Stage ft	WTEMP °C	ATEMP °C	CONDUCT µS/cm	SPECCOND µS/cm	SALINITY ppt	DO mg/L	PH	TURBIDITY NTU	T-Tube cm	FECAL CFU/100mL	E-COLI MPN/100mL	T_SUSP_SOL mg/L	Nitrate mg/L	Nitrate mg/L	Total Phosphorus (mg/L)	Total Diss Phos (mg/L)	Comments
T40	04/06/06	E06EC001589	1740	4.60	7.3	9.0	449	679	0.3	12.31	8.09	5.2		<10	2.0	15		0.40			clr
T40	05/02/06	E06EC002395	915		10.4	19.5	580	807	0.4	5.58	7.45	4.9		20.0	7.4	7		0.40			clr
T40	06/07/06	E06EC003471	823	3.51	19.8	31.0	696	798	0.4	2.08	7.68	7.03		250.0	613.0	13		0.05			clr
T40	07/12/06	E06EC004493	1040	2.14	20.2		1099	1207	0.6	2.01	7.43	10.06	60.00	1600.0	>2420	6		0.30			lt brn
T40	08/08/06	E06EC005461	1015	0.33	18.6	30.0	1266	1434	0.7	2.49	7.75	6	60.00	7700.0	>2420	8		0.20			lt brn
T40	09/12/06	E06EC006732	930																		sample not taken because water not moving
T40	10/10/06	E06EC007551	900																		no sample taken, no flow
T40	04/16/07	E07EC001897	1000	5.27	8.3	16.0	410	615	0.3	7.50	8.65	5		<10	7.4	13					lgt brn
T40	05/21/07	E07EC003015	945	4.86	17.4	23.0	632	742	0.4	6.26	8.02	7.11	60.00	100.0		9		0.30			clear
T40	06/18/07	E07EC003746		4.93	21.8	23.0	745	793	0.4	7.18	7.70	3.4	60.00	660.0		8		0.20			clear
T40	07/16/07	E07EC004631	1130																		no flow, no sample
T40	08/20/07	E07EC005669	1330																		no flow, no sample
T40	09/17/07	E07EC006223	940																		no flow, no sample
T40	10/09/07	E07EC006689	1310																		no flow, no sample
T40	04/09/08	E08EC001625	930		3.6	6.7		884	0.43	8.94	7.88		>60	10		7		0.30			
T40	05/08/08	E08EC002426	945		11.3	9.8		703	0.34	11.20	7.70		>38.8	<10		8		0.20			
T40	06/12/08	E08EC003543	930		15.2	23.7		665	0.33	3.94	7.45	4.2		120		6					very high flow low *DO
T40	07/09/08	E08EC004517	930		21.8	24.0		651	0.32	1.82	7.82	3.9		30		6					
T40	09/11/08	E08EC006585	930		16.3	19.5		939	0.47	0.38	7.75	9.5		20		7					very minimal flow-abundant duckweed-Bedrod = 3.210

SITECODE	DATE	Specimen#	TIME	Stage ft	WTEMP °C	ATEMP °C	CONDUCT µS/cm	SPECCOND µS/cm	SALINITY ppt	DO mg/L	PH	TURBIDITY NTU	T-Tube cm	FECAL CFU/100mL	E-COLI MPN/100mL	T_SUSP_SOL mg/L	Nitrate mg/L	Nitrate mg/L	Total Phosphorus (mg/L)	Total Diss Phos (mg/L)	Comments
T41	04/06/06	E06EC001590	1315	2.18	9.8	10.0	616	865	0.4	12.79	8.24	13		10.0	22.8	34		1.20			clr
T41	05/02/06	E06EC002396	1200	2.29	11.5	17.0	764	1031	0.5	11.84	6.90	9.2		2100.0	>2420	25		0.50			lt brn
T41	06/07/06	E06EC003474	1120	0.10	22.6		860	900	0.4	13.26	8.45	11		200.0	517.0	19		0.34			clr
T41	07/12/06	E06EC004494	1145		25.5		883	875	0.4	12.57	8.84	7.73	60.00	270.0	365.0	18		nd			clr
T41	09/12/06	E06EC006733	1030	0.82	15.4	17.0	731	897	0.4	11.36	8.35	7.2	60.00	1200.0	1120.0	11		0.10			lt brn
T41	10/10/06	E06EC007552	1125	0.74	10.1	9.0	356	526	0.5	11.90	7.34	9.9	43.40	140.0	150.0	16		0.20			lt grn
T41	04/16/07	E07EC001899	1400	2.58	12.4	23.0	551	729	0.4	13.46	8.44	17		30.0	22.6	42					lgt brn
T41	04/23/07	E07EC002172	1200	4.32	11.7	17.0	642	859	0.4	9.61	8.13	65		3700.0	>2420	160					brn, rain event
T41	05/21/07	E07EC003027	1330	1.75	20.7	30.0	749	814	0.4	14.20	8.56	7.21	60.00	50.0		14		0.10			
T41	06/18/07	E07EC003747	1255	1.86	22.7	22.0	926	968	0.5	5.21	8.28	6.4	60.00	230.0		15		1.60			clear
T41	07/16/07	E07EC004625	1415	0.84	26.5	21.0	911	886	0.4	9.90	8.33	6.8	60.00	410.0		13		0.20			clear, duckweed along bank
T41	08/20/07	E07EC005657	1500	0.77	22.9	33.0	886	930	0.5	9.16		11	60.00	800.0		11		1.10			clear, ducks in water, frogs
T41	09/17/07	E07EC006217	1335	0.59	18.4	28.2	878	1040	0.5	11.41	8.32	13	38.80	150.0		16		0.60			clear, duckweed in water
T41	10/09/07	E07EC006690	1340	0.92	13.7	14.3	679	724	0.2	14.26		9.3	50.00	220.0		15		0.60			clear, duckweed floating down
T41	04/09/08	E08EC001629	1300	1.87	9.7	21.2		948	0.47	11.74	8.07		32.80	<10		49		0.80			
T41	05/08/08	E08EC002427	1245	1.89	11.1	9.0		809	0.40	20.00	8.50		>60	<10		20		0.40			
T41	06/12/08	E08EC003536	1315	3.98	16.4	29.0		670	0.33	8.02	7.97	65		7000		88					water very high
T41	07/09/08	E08EC004515	1300		24.9	27.0		755	0.37	10.36	8.26	11		150		14					
T41	08/11/08	E08EC005555	1330		23.5	26.0		796	0.39	7.85	8.13	37		410		68					duckweed floating downstream *raining*
T41	09/10/08	E08EC006545	945		13.0	15.0		881	0.44	5.55	8.04	9.6		80		14					Bedrod = 4.695 mimimal flow lots of duckweed no Q taken
T41	10/07/08	E08EC007429	915		13.3	12.5		847	0.42	8.13	8.20	28		710		28					

SITECODE	DATE	Specimen#	TIME	Stage ft	WTEMP °C	ATEMP °C	CONDUCT µS/cm	SPECCOND µS/cm	SALINITY ppt	DO mg/L	PH	TURBIDITY NTU	T-Tube cm	FECAL CFU/100mL	E-COLI MPN/100mL	T_SUSP_SOL mg/L	Nitrate mg/L	Nitrate mg/L	Total Phosphorus (mg/L)	Total Diss Phos (mg/L)	Comments
T42	04/06/06	E06EC001591	1255	1.09	9.8	11.0	668	930	0.5	11.68	7.92	2.5		<10	7.4	1		0.70			clr
T42	05/02/06	E06EC002397	1245	1.58	12.4	22.0	745	997	0.5	11.51	7.00	3.1		40.0	44.1	7		0.10			clr
T42	06/07/06	E06EC003475	1150	1.87	22.2		824	870	0.4	4.50	7.95	115		8700.0	>2420	92		0.04			lt brn
T42	07/12/06	E06EC004500	1210	0.55	24.7		803	800	0.4	9.01	8.08	5.84	60.00	390.0	770.0	12		nd			clr
T42	09/12/06	E06EC006760	1100																		sample not taken because no flow
T42	04/16/07	E07EC001891	1430	1.44	13.5	24.0	630	807	0.4	19.12	8.68	3.2		10.0	<1	3					clear
T42	04/23/07	E07EC002171	1300	2.46	12.5	22.0	686	899	0.4	10.16	8.18	9.4		610.0	1300.0	4					clear, rain event

T42	05/21/07	E07EC003023	1450		22.2	29.0	814	860	0.4	13.07	8.07	4.69	60.00	400.0		5	nd	clear
T42	06/18/07	E07EC003748	1345	1.58	23.2	23.0	822	851	0.4	4.19	7.92	2.1	60.00	480.0		<3	0.40	clear
T42	07/16/07	E07EC004622	1445	0.86	21.0	22.0	770	834	0.4	3.99	7.94	30	38.50	10800.0		29	nd	brown
T42	08/20/07	E07EC005667	1545															no flow, no sample
T42	09/17/07	E07EC006224	1449															no flow, no sample
T42	10/09/07	E07EC006691	1415	1.32	13.7	16.0	715	914	0.5	13.97		3.4	60.00	1300.0	2420.0	3	0.10	clear
T42	04/09/08	E08EC001633	1345	1.34	9.2	20.8		934	0.46	15.75	8.20		>60	<10		<3	0.10	
T42	05/08/08	E08EC002428	1320	1.36	10.5	8.7		913	0.45	17.70	8.20		>60	<10		7	nd	
T42	05/14/08	E08EC005302	1100	1.58	10.2	18.2		896	0.44	13.40	8.10	2.4		<10				
T42	05/21/08	E08EC005598	1530	1.31	18.2	24.6		873	0.43	13.40	8.26	4.4		130				
T42	05/29/08	E08EC005904	1100	1.15	14.7	21.0		910	0.45	8.45	8.10	8.7		260				
T42	06/04/08	E08EC006283	1530	1.32	19.6	31.8		808	0.40	12.64	8.31	6.2		430				
T42	06/12/08	E08EC003537	1345	2.92	18.1	28.3		704	0.34	8.53	8.09	7.1		1000		4		water is very high
T42	06/25/08	E08EC007770	1200	1.20	22.2	20.7		764	0.37	10.94	7.91	1.7		130				
T42	07/02/08	E08EC008112	1130	1.34	20.9	21.0		745	0.36	8.67	7.97	1.8		360				
T42	07/09/08	E08EC004514	1345	1.14	24.1	27.0		770	0.38	8.54	8.00	3.2		60		4		cattails up - flow very slow
T42	07/16/08	E08EC009218	1245	1.00	28.3	31.0		737	0.36	9.86	8.18	9.3		140				looks stagnant/barbed wire on both sides of bridge (flow downstream from bridge)
T42	07/23/08	E08EC009694	930	0.92	22.6	24.0		732	0.36	6.49	7.90	6.5		1200				too shallow for Q cows in stream area

SITECODE	SITENAME	DATE	Specimen#	TIME	FECAL	E-COLI	T_SUSP_SOL
					CFU/mL	MPN	mg/L
Blank	Blank	04/05/06	E06EC001531	1030	<10	<1	<1
Blank	Blank	04/06/06	E06EC001586	1350	<10	<1	<1
Blank	Blank	05/01/06	E06EC002282	1445	<10	<1	<1
Blank	Blank	05/03/06	E06EC002401	1530	<10	<1	<1
Blank	Blank	06/07/06	E06EC003482		<10	<1	<1
Blank	Blank	06/07/06	E06EC003477	1510	<10	<1	<1
Blank	Blank	06/08/06	E06EC003499	1415	<10	<1	<1
Blank	Blank	07/11/06	E06EC004434	1450	<10	<1	<1
Blank	Blank	07/12/06	E06EC004503	1700	<10	<1	<1
Blank	Blank	07/13/06	E06EC004560	1600	<10	<1	<1
Blank	Blank	08/07/06	E06EC005358	1520	<10	<1	<1
Blank	Blank	08/08/06	E06EC005465	1530	<10	<1	<1
Blank	Blank	08/09/06	E06EC005559		<10	<1	<1
Blank	Blank	09/11/06	E06EC006632	1345	<10	<1	<1
Blank	Blank	09/12/06	E06EC006722	1600	<10	<1	<1
Blank	Blank	09/13/06	E06EC006769	1445	<10	<1	<1
Blank	Blank	10/10/06	E06EC007553	1630	<10	<1	<1
Blank	Blank	04/02/07	E07EC001405	1700	<10	<1	<3
Blank	Blank	04/16/07	E07EC001898	1615	<10	<1	<3
Blank	Blank	04/18/07	E07EC002040	950	<10	<1	<3
Blank	Blank	04/18/07	E07EC002051	1450	<10	<1	<3
Blank	Blank	04/23/07	E07EC002160	1630	<10	<1	<3
Blank	Blank	04/24/07	E07EC002199	1430	<10	<1	<3
Blank	Blank	05/21/07	E07EC003026	1615	<10		<3
Blank	Blank		E07EC003093		<10		<3
Blank	Blank	05/23/07	E07EC003125	1545	<10		<3
Blank	Blank	05/24/07	E07EC003169	1400	<10		<3
Blank	Blank	06/18/07	E07EC003750	1600	<10		<3
Blank	Blank	06/19/07	E07EC003763	1330	<10		<3
Blank	Blank	06/20/07	E07EC003898	1345	<10		<3
Blank	Blank	06/21/07	E07EC003940	1200	<10		<3
Blank	Blank	07/16/07	E07EC004619	1700	<10		<3
Blank	Blank	07/17/07	E07EC004683	1300	<10		<3
Blank	Blank	07/18/07	E07EC004734	1400	<10		<3
Blank	Blank	07/19/07	E07EC004771	1330	<10		<3
Blank	Blank	08/20/07	E07EC005653	1630	<10		<3
Blank	Blank	08/21/07	E07EC005698	1400	<10		<3
Blank	Blank	08/22/07	E07EC005701	1000	<10		<3
Blank	Blank	08/23/07	E07EC005806	1145	<10		<3
Blank	Blank	09/17/07	E07EC006221	1500	<10		<3
Blank	Blank	09/19/07	E07EC006318	940			<3
Blank	Blank	09/19/07	E07EC006320	1500	<10		<3
Blank	Blank	10/09/07	E07EC006680	1450	<10		<3
Blank	Blank	10/10/07	E07EC006712	1245	<10		<3
Blank	Blank	10/11/07	E07EC006789	1120	<10		<3
Blank	Blank	04/07/08	E08EC001473	1245	<10		<3
Blank	Blank	04/08/08	E08EC001535	1330	<10		<3
Blank	Blank	04/09/08	E08EC001619	1200	<10		<3
Blank	Blank	05/05/08	E08EC002228	1215	<10		<3
Blank	Blank	05/07/08	E08EC002344	1445	<10		<3

SITECODE	SITENAME	DATE	Specimen#	TIME	FECAL	E-COLI	T_SUSP_SOL
					CFU/mL	MPN	mg/L
Blank	Blank	05/08/08	E08EC002421	1345	<10		3.0
Blank	Blank	06/10/08	E08EC003316	1300	<10		<3
Blank	Blank	06/10/08	E08EC003315	1415	<10		<3
Blank	Blank	06/12/08	E08EC003538	1015	<10		7
Blank	Blank	06/12/08	E08EC003545	930	<10		<3
Blank	Blank	07/07/08	E08EC004299	1415	<10		<3
Blank	Blank	07/09/08	E08EC004522	1100	<10		<3
Blank	Blank	07/09/08	E08EC004512	1415	<10		<3
Blank	Blank	07/09/08	E08EC004520	1000	<10		<3
Blank	Blank	08/11/08	E08EC005559	1415	<10		<3
Blank	Blank	08/11/08	E08EC005564	1115	<10		<3
Blank	Blank	08/13/08	E08EC005730	1330	<10		<3
Blank	Blank	08/13/08	E08EC005742	1245	<10		<3
Blank	Blank	09/08/08	E08EC006389	1215	<10		<3
Blank	Blank	09/09/08	E08EC006458	1000	<10		<3
Blank	Blank	09/10/08	E08EC006543	1015	<10		<3
Blank	Blank	09/11/08	E08EC006581	1130	<10		<3
Blank	Blank	10/06/08	E08EC007313	1245	<10		3
Blank	Blank	10/07/08	E08EC007430	945	<10		3
Blank	Blank	10/08/08	E08EC007481	1230	<10		<3
Blank	Blank	10/09/08	E08EC007514	1145	<10		<3

SITECODE	SITENAME	DATE	Specimen#	TIME	Stage	WTEMP	ATEMP	CONDUCT	SPECCOND	SALINITY	DO	PH	TURBIDITY	FECAL	E-COLI	T_SUSP_SOL
					ft	°C	°C	µS/cm	µS/cm	ppt	mg/L		NTU	CFU/mL	MPN	mg/L
T27	Duplicate	04/05/06	E06EC001525	1030	3.80	9.2	17.0	543	777	0.4	12.50	8.32	24	40.0	21.3	51
T37	Duplicate	04/06/06	E06EC001595	1350	2.80	10.9	13.0	784	1074	0.5	11.11	8.29	7	<10	52.9	13
T13	Duplicate	05/02/06	E06EC002383	1700	3.42	15.4	22.0	1108	1359	0.7	11.80	7.35	8	270.0	308.0	18
T20	Duplicate	05/03/06	E06EC002402	1440	1.75	15.6	21.0	1403	1710	0.9	14.68	6.34	7	120.0	178.0	14
T12	Duplicate	06/07/06	E06EC003470	1537	1.40	25.2	37.0	780	774	0.4	13.84	8.57	16	1800.0	>2420	23
T35	Duplicate	06/07/06	E06EC003481	910	2.42	20.5	37.0	627	686	0.3	3.25	7.83	9	280.0	308.0	14
T28	Duplicate	06/08/06	E06EC003503	917	2.20	19.3	24.0	799	855	0.4	7.64	8.18	24	380.0	161.0	64
R10	Duplicate	07/11/06	E06EC004430	1415		29.1	56.0	1492	1385	0.7	9.35	8.33	40	110.0	52.0	36
T36	Duplicate	07/12/06	E06EC004501	955		24.1	33.0	889	902	0.4	5.14	7.95	6	38000.0	>2420	6
T13	Duplicate	07/13/06	E06EC004557	925	1.30	23.0	28.0				2.63	7.99	23	510.0	457.0	36
R10	Duplicate	08/07/06	E06EC005365	1340		25.8	42.0	889	876	0.4	6.85	7.95	150	2700.0	1990.0	192
T36	Duplicate	08/08/06	E06EC005460	925		21.4	30.0	940	1010	0.5	5.25	7.83	8	7600.0	>2420	10
T13	Duplicate	08/09/06	E06EC005556	933	1.00	23.2	32.0	967	1001	0.5	5.34	8.33	17	4200.0	>2420	43
R10	Duplicate	09/11/06	E06EC006637	1345		16.8	19.0	1068	1267	0.6	13.19	8.27	39	440.0	112.0	76
T02	Duplicate	09/12/06	E06EC006725	1300		17.0	21.0	769	911	0.5	11.13	8.20	7	200.0	147.0	6
T23	Duplicate	09/13/06	E06EC006778	1315		19.5	29.0	1234	1375	0.7	11.54	8.42	75	380.0	64.1	118
R04	Duplicate	10/10/06	E06EC007534	1245		11.1	16.0	662	909	0.5	14.44	8.49	32	30.0	40.2	72
T02	Duplicate	10/25/06	E06EC007921	1135		3.8	6.0	535	899	0.4	15.66	8.19	6	140.0	13.4	5
T29	Duplicate	04/02/07	E07EC001415	1610		7.3	12.0	571	866	0.4	9.41	8.19	28	200.0	1300.0	78
T3	Duplicate	04/16/07	E07EC001888	1600		12.5	24.0	562	741	0.4	12.97	8.42	8	<10	18.7	8
T15	Duplicate	04/18/07	E07EC002041	950	1.01	10.1	12.0	1166	1631	0.8	12.21	8.16	4	10.0	6.3	5
T27	Duplicate	04/18/07	E07EC002043	1455	2.48	15.4	24.0	708	868	0.4	14.31	8.62	7	20.0	9.7	21
R19	Duplicate	04/23/07	E07EC002167	1230		11.9	18.0	436	582	0.3	7.60	7.87	120	11000.0	>2420	128
R10	Duplicate	04/24/07	E07EC002197	1400		14.2		1185	1492	0.8	10.49	8.25	10	530.0	1550.0	33
R20	Duplicate	05/21/07	E07EC003024	1545										1200.0		84
T14	Duplicate	05/22/07	E07EC003092											510.0		38
T27	Duplicate	05/23/07	E07EC003132	1230										750.0		42
R10	Duplicate	05/24/07	E07EC003167											280.0		60
R20	Duplicate	06/18/07	E07EC003733											460.0		27
R07	Duplicate	06/19/07	E07EC003758	1250										280.0		74
R10	Duplicate	06/20/07	E07EC003897	1300										300.0		100
T32	Duplicate	06/21/07	E07EC003938	1245										4600.0		151
T42	Duplicate	07/16/07	E07EC004623	1445										10800.0		26
R04	Duplicate	07/17/07	E07EC004684	1225										130.0		104
T22	Duplicate	07/18/07	E07EC004737	1200										800.0		61
T33	Duplicate	07/19/07	E07EC004773	1400										400.0		38
T36	Duplicate	08/20/07	E07EC005652	1000										1800.0		26
R04	Duplicate	08/21/07	E07EC005699	1255										500.0		180
T33	Duplicate	08/22/07	E07EC005711	1515										1200.0		160
T22	Duplicate	08/23/07	E07EC005804	1110										12000.0		168
T01	Duplicate	09/17/07	E07EC006219	1530										20.0		9
T28	Duplicate	09/19/07	E07EC006317	940										1000.0		43
T21	Duplicate	09/19/07	E07EC006321	1500										190.0		46
T42	Duplicate	10/09/07	E07EC006692	1415										1200.0		4

SITECODE	SITENAME	DATE	Specimen#	TIME	Stage	WTEMP	ATEMP	CONDUCT	SPECCOND	SALINITY	DO	PH	TURBIDITY	FECAL	E-COLI	T_SUSP_SOL
					ft	°C	°C	µS/cm	µS/cm	ppt	mg/L		NTU	CFU/mL	MPN	mg/L
T28	Duplicate	10/10/07	E07EC006721	1140										1800.0		98
T33	Duplicate	10/11/07	E07EC006788	1325										900.0		126
T15	Duplicate	04/07/08	E08EC001465	940		0.7	-1.0			0.9	15.35	8.35		<10		16
T27	Duplicate	04/08/08	E08EC001540	1145	2.14	6.4	11.8		846	0.4	14.6	8.31		<10		12
T36	Duplicate	04/09/08	E08EC001623	1109		6.94	20.1		905	0.45	15.23	8.43		<10		10
T19	Duplicate	05/05/08	E08EC002230	1015										10		23
T02	Duplicate	05/07/08	E08EC002345	1500		15.8	22.2		846	0.42	13.9	8.4		<10		8
T35	Duplicate	05/08/08	E08EC002422	1015										10		25
T13	Duplicate	06/10/08	E08EC003317	1300	2.9	19.31	29.3		1101	0.55	7.44	8.03	20	1500		34
T14	Duplicate	06/10/08	E08EC003312	1405	3.06	19.42	30.9		1337	0.67	7.91	7.96	40	270		88
T35	Duplicate	06/12/08	E08EC003539	1015	3.34	14.09	21.4		457	0.22	4.13	7.37	55	5800		24
T40	Duplicate	06/12/08	E08EC003544	930		15.16	23.7		665		3.94	7.45	4.2	60		<3
T33	Duplicate	07/07/08	E08EC004301	1415		23.81	35		770		9.17	8.29	50	220		102
R16	Duplicate	07/09/08	E08EC004523	1100		22.9	25		649	0.32	7.74	7.96	7.8	70		8
R20	Duplicate	07/09/08	E08EC004513	1415		25.55	28		718	0.35	10.73	8.34	34	60		110
T35	Duplicate	07/09/08	E08EC004518	1000	3.03	22.4	23		539	0.26	1.62	7.69	4.2	70		<3
R20	Duplicate	08/11/08	E08EC005558	1415		23	24		662	0.32	8.19	8.21	110	120		220
T36	Duplicate	08/11/08	E08EC005565	1115		22.21	24		720	0.35	8.11	8.18	5.3	170		8
T13	Duplicate	08/13/08	E08EC005733	1330	1.48	24.6	29		1037	0.51	8.11	8.08	20	260		39
T14	Duplicate	08/13/08	E08EC005743	1245	1.35	22.9	29		1247		14.54	8.2	8.5	200		11
T21	Duplicate	09/08/08	E08EC006388	1215	1.3	17.02	20		999	0.5	11.91	8.34	45	10		70
T12	Duplicate	09/09/08	E08EC006459	1000	0.94	11.79	20		736	0.36	9.06	8.12	7.4	50		4
R19	Duplicate	09/10/08	E08EC006542	1015		13.69	14		769	0.38	10.05	8.69	22	120		50
R17	Duplicate	09/11/08	E08EC006579	1130		17.53	18		783	0.38	8.93	8.15	10	210		26
T23	Duplicate	10/06/08	E08EC007315	1245		17.66	23		1258	0.63	8.23	7.57	60	30		60
R19	Duplicate	10/07/08	E08EC007424	945		12.72	11		775	0.38	8.67	8.16	33	90		48
R18	Duplicate	10/08/08	E08EC007480	1230		13.18	16		571	0.28	11	8.17	13	630		24
T14	Duplicate	10/09/08	E08EC007515	1145	1.32	10.52	12		1204		10.53	7.95	25	1600		29