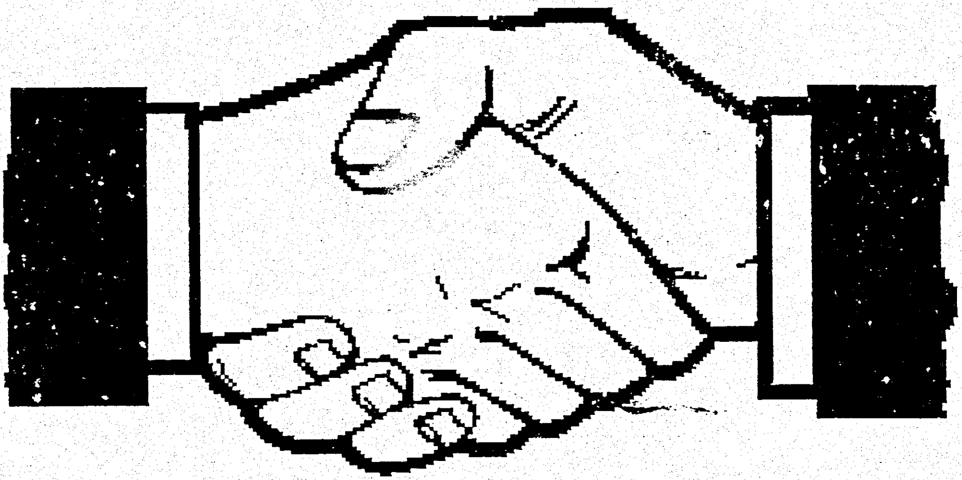
BAD RIVER
PHASE II WATER QUALITY PROJECT

FINAL REPORT

PROJECT SPONSOR
STANLEY COUNTY CONSERVATION DISTRICT



"Partnering Up!!"

REPORT PREPARED BY
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PROJECT PERIOD
MARCH 12, 1990 THROUGH JUNE 30, 1996

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1. EXECUTIVE SUMMARY

The Bad River Phase II Water Quality Project was an EPA 319 Implementation Project designed to implement and evaluate sediment control on the highly erodible croplands and fragile clayey rangelands in the Bad River Watershed of South Dakota. This site was chosen because the soils are typical of much of western South Dakota.

Commodity prices and U.S. Farm Policy of the 1970's encouraged the conversion of large areas of land from rangeland to cropland in western South Dakota. High sediment delivery by the Bad River to the Missouri River was blamed on these changes in land use. Two watershed studies concluded that this was not necessarily the case. The majority of the sediment was coming from the rangeland areas of the watershed.

The implementation of the Conservation Best Management Practices (BMP's) promoted with cost-share and incentive programs to the cooperators in the target sub-watershed, demonstrated that significant sediment reduction could be achieved without jeopardizing the economic stability of the participants. This was the primary goal of the project.

Landowner participation in the Plum Creek Watershed was approximately 90 percent, with approximately 95% of all land under increased management when compared to pre-project conditions. Sediment was reduced in the watershed from a rate of 82.7 tons/Ac.Ft. of runoff in 1990 to and average of 10.2 tons/Ac.Ft. of runoff for the years 1993 through 1995 (USGS Water Resources Data - South Dakota - Years 1990 through 1995).

II. INTRODUCTION

U.S. Farm Policy and the high commodity prices of the 1970's encouraged the conversion of large tracts of native rangeland in western South Dakota to cropland. High sediment delivery by the Bad River to Lake Sharpe, a Missouri River mainstem reservoir, was blamed on the change in land use practices.

The Bad River Watershed is located in west central South Dakota and drains into the Missouri River at Ft. Pierre, South Dakota. The watershed is approximately 3,172 square miles and consists primarily of highly erodible shallow and dense clays. Land ownership is primarily private with Federal ownership concentrated in the Ft. Pierre and Buffalo Gap National Grasslands and Badlands National Park.

Private ownership	1,770,185 acres	87.2%
Federal ownership	244,271 acres	12.0%
State ownership	14,230 acres	0.7%
Cheyenne River Sioux Tribe	1,920 acres	0.1%
TOTAL	2,030,606 acres	100.0%

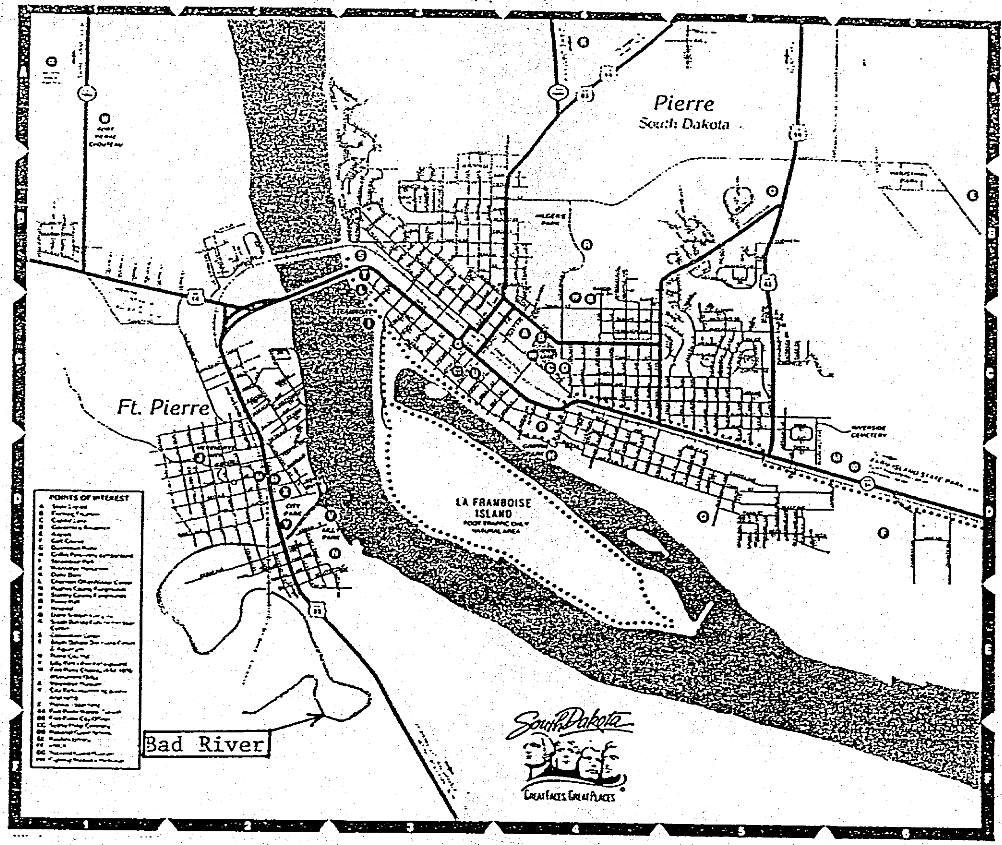
Livestock grazing is the dominant land use. The remaining land is used for tame hayland and cropland. Major crops are winter wheat, grain sorghum and alfalfa. Oats, barley, millet and forage sorghum are also significant crops. Farm and ranch size varies from 3,000 to 35,000 acres.

Rangeland	1,330,560 acres	65.5%
Cropland	692,046 acres	34.0%
Water	6,000 acres	0.0%
Other	2,000 acres	0.2%
TOTAL	2,030,606 acres	100.0%

The Bad River does not support its assigned beneficial uses primarily because of sediment. The Bad River sediment delivery of 3,25 million tons per year severely impacts the Lake Sharpe impoundment of the Missouri River. The sport fishery in the Missouri River/Lake Sharpe at Pierre contributes about $2.5 million annually when not impaired by turbidity from the Bad River. When the Bad River is carrying heavy loads of sediment the value essentially goes to zero.

The Bad River sediment settles in the Missouri River near Pierre and Ft. Pierre and has significantly reduced the channel capacity. This has increased flooding in the municipalities and surrounding area. It has also caused the Corps of Engineers to reduce releases from the Oahe Reservoir during periods of extreme cold because of flooding problems. This results in lost power revenues of $12.5 million annually.

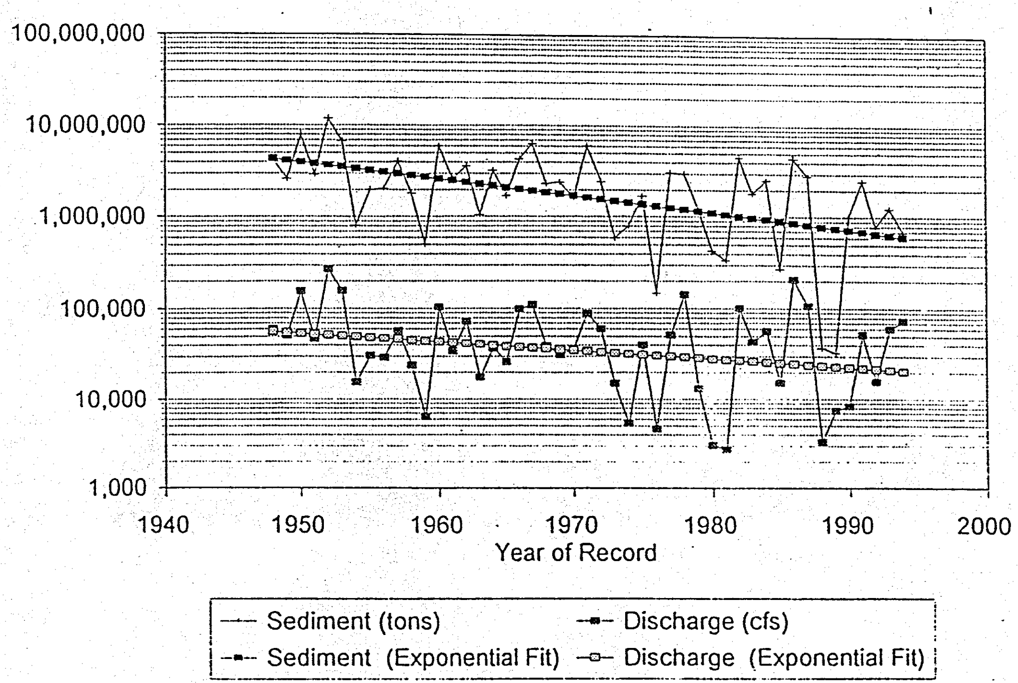
The Bad River enters the Missouri River within the city limits of the city of Ft. Pierre, SD directly across the Missouri River from Pierre, SD (see Map 1). The Bad River has a notorious past due to its unpredictability of flow and the sediment it transports during runoff events. The U.S. Geological Survey has monitored the mouth of the Bad River for rate of discharge and sediment delivery since 1948. The average annual sediment delivery has been slowly decreasing over that period of time when compared to discharge. (See Figure 1, page 4).



MAP #1

Bad River Sediment vs. Discharge

Figure #1



A task force composed of federal and state agency personnel and local citizens was organized to investigate the problem and determine what alternatives were viable to remedy the problem. The task force also was to determine what courses of action to take in securing funding to accomplish the recommended alternatives. Phase I of the Bad River Water Quality Project received EPA Section 205G funding in 1988 and 1989 for a study to determine the sources of sediment.
The Bad River Phase I project was initiated under the sponsorship of the North Central Resource Conservation & Development office and the Stanley County Conservation District to determine the sources of sediment entering the river. Sediment samples were taken during flow periods from nine sites along the reach of the Bad River.

Conclusions drawn from analysis of the sampling were:

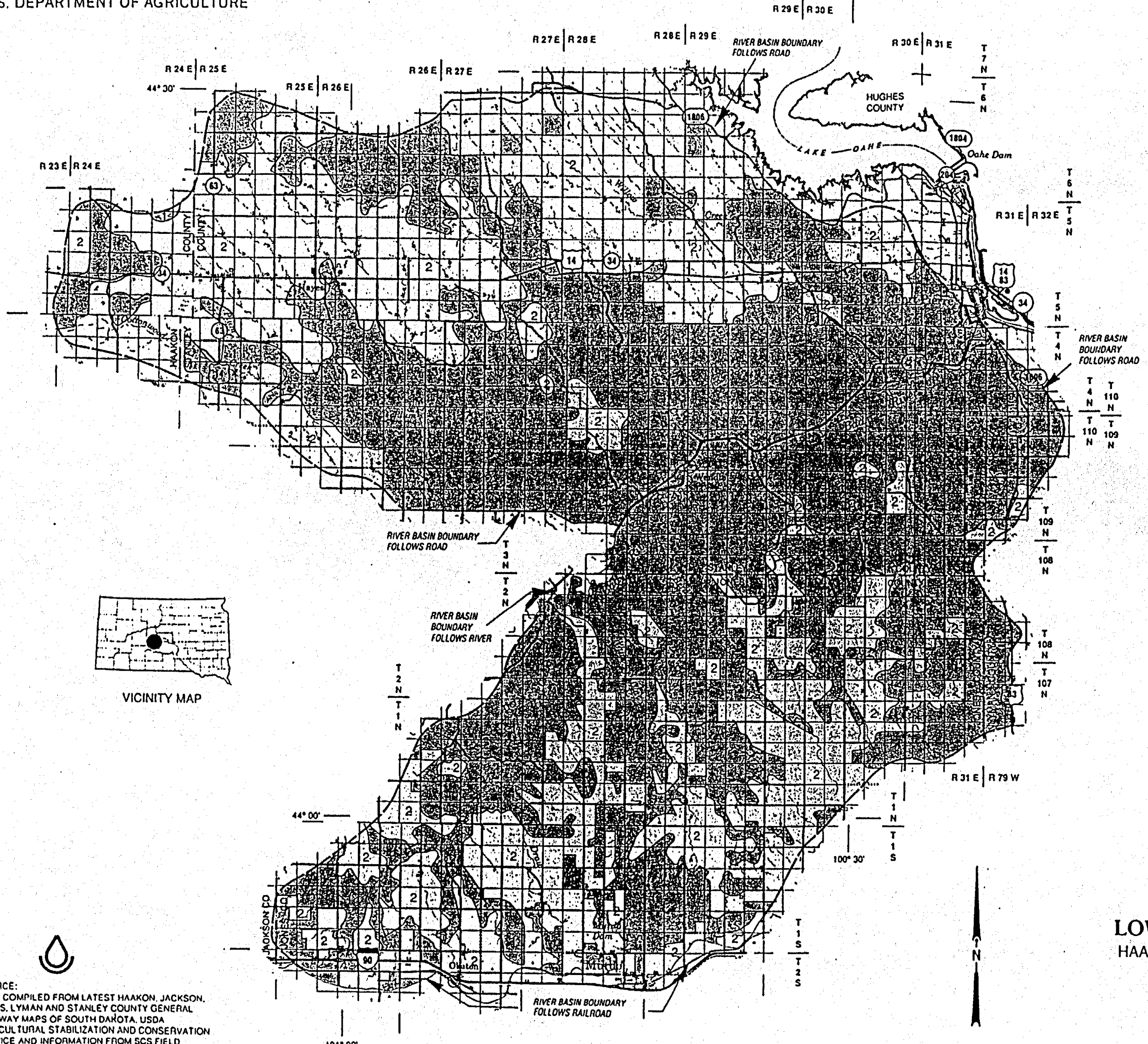
1. Cropland is not a major sediment source.

2. The upper reaches of the Bad River Watershed or Badlands is not a major sediment source.

3. The major sediment appears to be coming from the lower 1/3 of the Bad River Watershed (See Map 2, following page). The area is comprised of approximately 66% rangeland with various stages of incised channels and headcuts in the breaks. Cropland comprises approximately 34% of the watershed and is located mainly on the upper tablelands. Of the 3.25 million tons of sediment delivered annually by the Bad River, approximately 2.17 million tons comes from the lower one-third of the watershed.

U.S. DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE



LEGEND

▨ NATIVE GRAZING AND HAYLAND

2 CROPLAND (INCLUDES CRP AND TAME HAYLAND)

N

(Map 5)
LAND USE MAP
LOWER BAD RIVER - RIVER BASIN STUDY
HAAKON, JACKSON, JONES, LYMAN AND STANLEY COUNTIES
SOUTH DAKOTA

0 5 10 15
MILES

SOURCE:
BASE COMPILED FROM LATEST HAAKON, JACKSON, JONES, LYMAN AND STANLEY COUNTY GENERAL HIGHWAY MAPS OF SOUTH DAKOTA, USDA AGRICULTURAL STABILIZATION AND CONSERVATION SERVICE AND INFORMATION FROM SCS FIELD PERSONNEL
LAMBERT CONFORMAL CONIC PROJECTION.

MAY 1993 1027743-02

USDA, SCS, NATIONAL CARTOGRAPHY & GIS CENTER, FORT WORTH, TX, 1993

III. GOAL AND OBJECTIVES

GOAL 1.-- Determine principle sediment sources in the treatment area.

GOAL 2.-- Determine cost effective land treatments that provide long lasting erosion control and reduction in sediment load.

Objective 1 -- Determine which BMP's are most effective in reducing erosion and reduction of sediment load.

Objective 2 -- Determine what is needed for landowner acceptance such as incentives, information and education, and sedimentation.

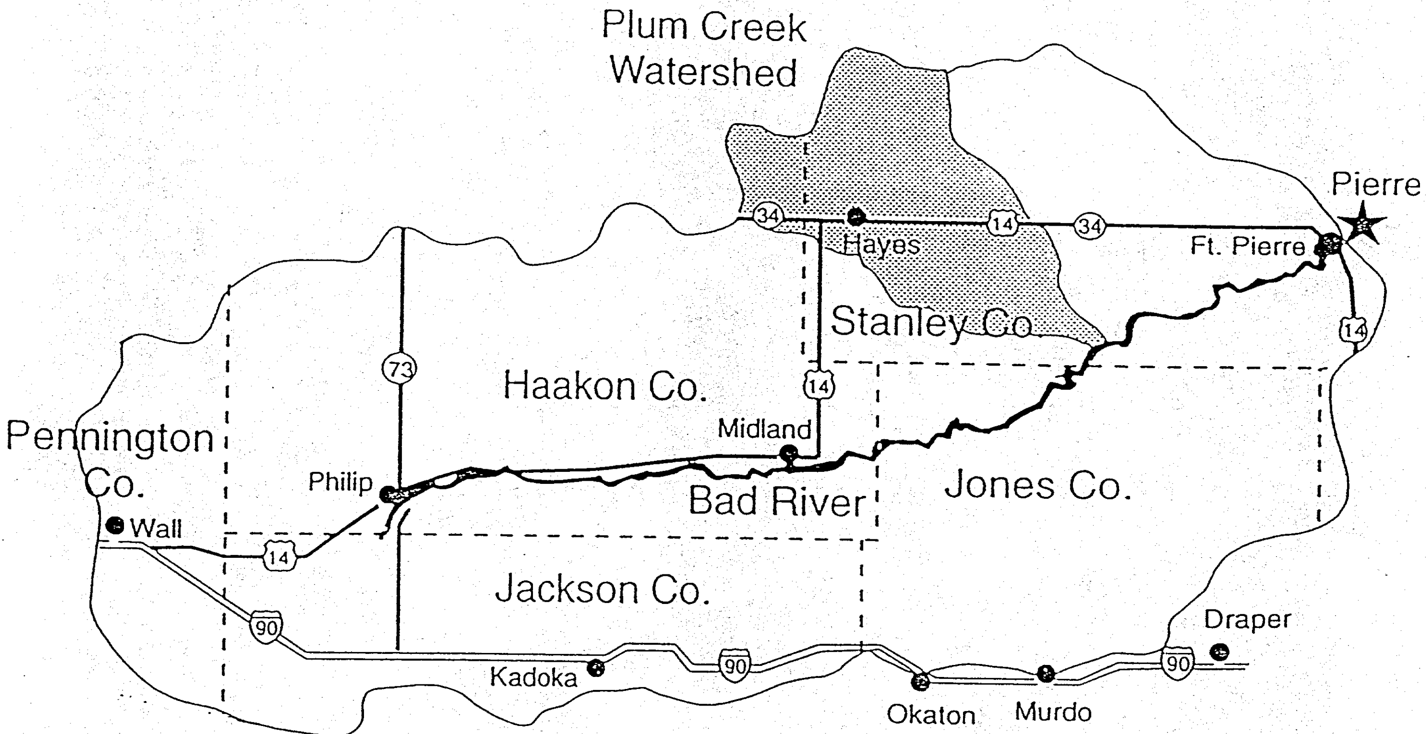
Project planned Best Management Practices that were proposed to be placed in the project treatment area were:

Planned Grazing Systems	80,000	Acres
Controlled Grazing Practices	50,000	Acres
Range Seedings	1,000	Acres
Riparian Revegetation Establishment	10	sites
Erosion Control Structures	10	each
Stockwater Ponds	10	each
Water Spreader Systems	2	each
Animal Waste Systems	3	each

IV. PROJECT ACTIVITIES

In 1989, an EPA 319 Non-Point Source Implementation Plan Grant application was developed by the Stanley County Conservation District and submitted to the State Non-Point Task Force for competitive grant funding. The District received final approval and EPA 319 funding for the Bad River Phase II Water Quality Implementation Project in 1990.

The approved plan called for implementation of numerous conservation practices in the Plum Creek watershed (see Map #3) over a 4 year time period. The primary goal was to determine which practices were economically feasible and socially acceptable to the landowners. The practices were to be of a type that would not jeopardize the economic stability of the ranch or farm enterprise. The project workplan targeted practices such as: planned grazing systems, proper grazing use, erosion control structures, riparian revegetation, range seedings, water spreader systems, stock water facilities and animal waste systems.



MAP #3

The Plum Creek Watershed is a 250 sq. mi. watershed located in southwest Stanley County with its mouth located 21.2 miles southwest of Ft. Pierre, SD. Elevation of the watershed ranges from 2300 ft. above sea level at its origin to 1612 ft. above sea level at its mouth.

General watershed data is as follows:

> The climate is semiarid and continental, characterized by wide temperature ranges, low relative humidity, frequent high winds, small amounts of precipitation, long winters and warm summers. Recurring periods of near-drought conditions are common.
>
> The average annual precipitation for this region is approximately 16 inches. Normally 80 percent of this total occurs during the months of April through September, which is the growing season for most of the crops raised in the watershed.
>
> It is estimated that more than 75 percent of the annual runoff occurs during the four month period of March through June. Runoff in March and April is usually snowmelt while the runoff in May and June if from rainfall. June normally has the highest amounts of precipitation and runoff. Heavy runoff during summer months may occur as a result of brief, intense thunderstorms. The bad River and its tributaries will experience period of no flow almost every year during the fall and winter months.
>
> Pierre Shale is the parent material for the erodible gray black silt and clayey soils present in most of the project area. The dominant soils within the area are residual clays on the upland and alluvial clays on the flood plains and low terraces. The cropland is generally limited to the upper tablelands with the rangeland comprising the steeper more fragile soils closer to the mouth of the creek and its tributaries. These soils are classified as highly erodible for wind and water erosion by NRCS.

The project was based on the voluntary efforts of the local landowners to implement various BMP's in the watershed to control erosion and sedimentation. Sources of special funding for the project dictated that funds not be limited to the Plum Creek watershed specifically, but to the entire Bad River Watershed in Stanley County. Project personnel placed emphasis on planning and implementation in the Plum Creek Watershed. The principal project partners who contributed financially and with technical expertise were:

1. Stanley County Conservation District (Primary Sponsor)

2. U.S. Fish & Wildlife Service
3. South Dakota Department of Environment & Natural Resources
4. South Dakota Game, Fish & Parks
5. South Dakota Department of Agriculture - Resource Conservation & Forestry
6. South Dakota Cooperative Extension Service
7. USDA - Farm Services Agency
8. USDA - Natural Resources Conservation Service
9. US Geological Survey
10. North Central Resource Conservation & Development
11. Pheasants Forever
12. South Dakota Wheat Commission

Federal, State and local programs utilized to provide financial funding for the project were.

USDA -- ASCS - Agriculture Conservation Program (ACP)
ASCS - Water Quality Special Projects (WQSP)
ASCS - Water Quality Incentive Program (WQIP)
NRCS - Great Plains Conservation Program (GPCP)
NRCS - Cooperative Agreements

USGS -- Cooperative Agreements

SD Game, Fish and Parks -- Wildlife Habitat Development

SD Department of Environment and Natural Resources --
Consolidated Water Facility Construction Fund

SD Resource Conservation and Forestry
Cooperative Agreements
Stewardship Incentive Program
Conservation Tillage Demonstration Grant

South Dakota Wheat Commission --
Conservation Tillage Demonstration Grant

Pheasants Forever -- New Tree Planter

The major accomplishments of the project are as follows:

Practice	Amount	No. of Oper.
Rangeland:		
1. Planned Grazing Systems	35,511 Ac.	8
2. Proper Grazing Use	72,794 Ac.	20
3. Deferred Grazing	7,397 Ac.	8
4. Cross Fencing	48,787 Ft.	15
5. Wells	8 Ea.	9
6. Pipelines	218,480 Ft.	14
7. Tanks	64 Ea.	20
8. Livestock Ponds	7 Ea.	5
9. Livestock Windbreak Shelters	15 Ea.	10
10. Range Seedings	210 Ac.	4
11. Riparian Revegetation	2 Ea.	1
12. Water Spreaders	3 Ea.	3
14. Erosion Control Structures	16 Ea.	4
15. Farmstead & Feedlot Windbreaks	1,589 RR.	4
16. Wildlife Habitat Development	10,191 Ac.	4
Cropland:		
1. Stripcropping	4,113 Ac.	2
2. Grassed Waterways	3 Ac.	1
3. Cropland Windstrips	400 Ac.	1
4. Conservation Tillage	16,878 Ac.	8
5. CRP	22,169 Ac.	29
6. Conservation Compliance	76,641 Ac.	

V.- FINANCIAL SUMMARY
BAD RIVER PHASE II WATER QUALITY PROJECT
(ALL FIGURES X 1000)

PROJECT ACTIVITY	TOTAL $ PLANNED	TOTAL $ ACTUAL	GPCP ACP PLANNED	GPCP ACP ACTUAL	OTHER FEDERAL PLANNED	OTHER FEDERAL ACTUAL	EPA 319 PLANNED	EPA 319 ACTUAL	STATE PLANNED	STATE ACTUAL	LOCAL CASH PLANNED	LOCAL CASH ACTUAL	IN KIND PLANNED	IN KIND ACTUAL
BMP -- SUMMARY TOTAL $	775	1411	396	605			65	33	17	73	140	247	157	453
PERSONNEL SERVICES TOTAL $	379	356			127	15	153	293	99	18			0	20
Project Coordinator	142	176					142	173		3				
SCS Technician	86	30					86						0	30
Water Quality Specialist	108	132				15	108	102	0	15				
Secretary (Part Time)	43	18					43	18						
WATER QUALITY MONITORING	100	86			50	34	50	52						
EQUIPMENT	20	40					20	8	0	25	0	7		
TRAVEL	16	44			0	40	16	4						
OFFICE RENT & INDIRECT OFF. EXP.	20	45			0	5	20	40						
INFO & EDUCATION	10	12			2	0	5	6	2	0	1	4	0	2
SUBTOTAL	1320	1994	396	605	179	94	329	436	118	116	141	258	157	475
INDIRECT (13.9% X Pers. Serv.)	53				18	0			14	0				
ADMINISTRATION (10% 319 activities)	35	35					35	35						
TOTAL	1408	2029	396	605	197	94	364	471	132	116	141	258	157	475

VI. PROJECT EVALUATION

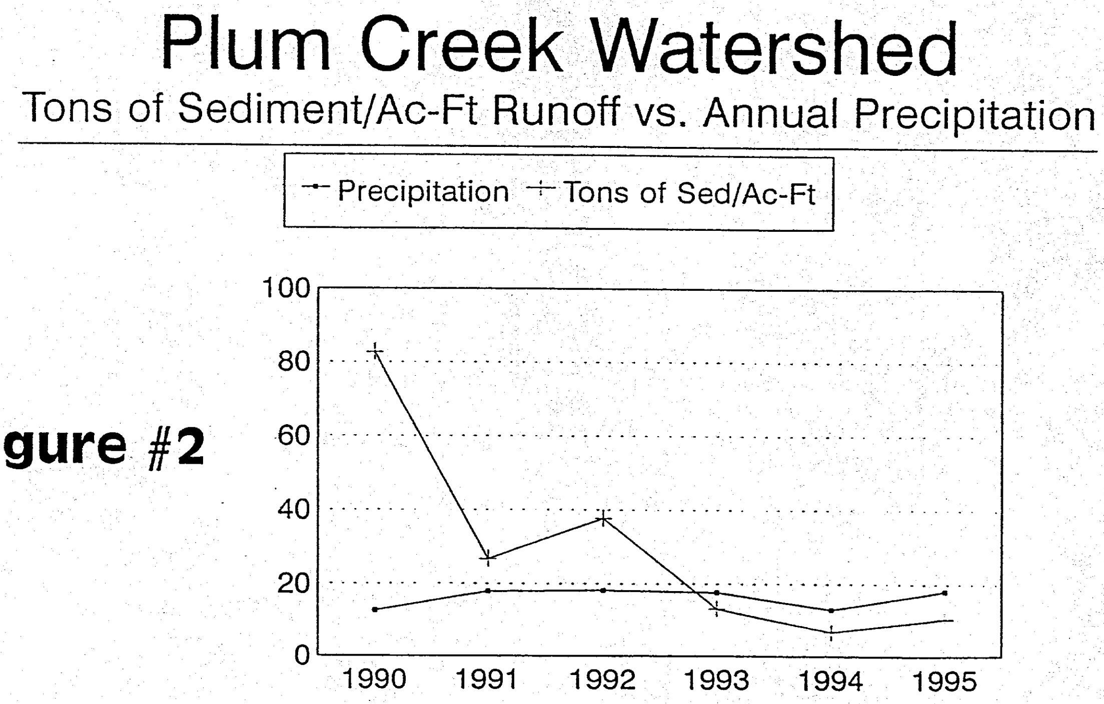
The project was assessed by three methods:

> Cooperator participation in applying Best Management Practices (BMP's).
>
> Monitoring of sediment delivery at the mouth of Plum Creek by the U.S. Geological Survey.
>
> Rangeland Hydrology Study conducted in 1992.

Based on assessments, this project has been very successful. Landowner participation in the Plum Creek Watershed was approximately 90%, with approximately 95% of all land under some type of more intense management.

In the 1990 Water Year, Plum Creek was delivering 82.7 tons of sediment per acre/foot of runoff. The average delivery for the years of 1993 through 1995 was 10.2 tons of sediment per acre/foot of runoff. Data was collected by U.S. Geological survey in cooperation with Stanley County Conservation District and is published in their annual USGS Water Resources Data for South Dakota, years 1990 through 1995. Years 1991 and beyond were unusually high precipitation years (See Figure 2). However, a significant reduction of sediment delivery was apparent. This is a result of increased vegetation to control water yield and improved land resource management by project cooperators.

Figure #2



	1990	1991	1992	1993	1994	1995
Precipitation	12.82	17.94	18.25	17.73	13.12	18.18
Tons of Sed/Ac-Ft	82.7	26.7	37.7	13.3	6.7	10.6

In 1992, Dr. K. Spaeth from the NRCS Technical Center in Lincoln, NE conducted a rangeland hydrology study (see Appendix A) in the Project watershed utilizing a small plot simulator. Based upon these trials, Dr. Spaeth drew the following conclusions:

1. Intensity of grazing affected runoff and sediment production.

2. Composition of grass species affects infiltration rates.

3. Critical erosion areas need continual, year around management.

4, The short grass species accentuate gully formation.

The original workplan called for 80,000 acres of rangeland under planned grazing systems with an average of 22,600 acres/year peaking at 80,000 acres in the fourth year of the project. In actuality, the Phase II Project peaked at 35,511 acres of planned grazing applied in the final year but averaged in excess of 30,000 acres/year in the final 4 years of the Project.

Controlled grazing practices were to be applied to 50,000 acres. This was to be accomplished by fencing, furrowing, wells, pipeline, tanks, etc. The Phase II Project applied controlled grazing practices to 78,794 acres. This was accomplished by application of proper grazing use (leaving 50% by weight of the key grass species by weight after grazing), installation of 8 deep wells, installation of 218,480 ft. of pipeline distribution system, installation of 64 livestock water tanks, construction of 7 multi-use dams, construction of 48,787 ft. of crossfence, construction of 15 livestock windbreak shelters and deferred grazing on 7,397 acres of over-utilized rangeland.

Range seeding was planned on 1000 acres. 210 acres were seeded.

Water spreaders were to be constructed at 2 sites. Three water spreader systems were constructed.

Erosion control structures were planned to be 10 large and 50 small structures. 2 large and 14 small structures were installed.

Riparian revegetation was planned on 10 sites. Two sites were established.

Not included as part of the original workplan, but applied to 10,191 acres, was upland wildlife habitat development.

One practice that is very capable of reducing runoff and erosion on rangeland is contour furrowing. It was applied to only 10 acres of hardpan clay rangeland. Due to the severe disturbance of the soil, ranchers were not at all receptive to this practice in spite of its benefits. It was therefore not vigorously pursued as an option.

The Project workplan also called for installation of three animal waste systems. Conclusions of the Bad River Phase I & IB Project indicated that concentrated livestock operations within the Project area were not of a size that was contributing significantly to water quality problems. No waste management systems were constructed.

Cropland BMP's that were addressed and applied by landowners in the Project were:

> Strip cropping applied to 4,113 acres with 3600 acres of this amount being applied voluntarily without the need for financial incentives to the landowner.
>
> Grasses waterways were minimal with application to only 3 acres.
>
> Crop windstrips were applied voluntarily without financial incentives on 400 acres.
>
> Conservation tillage (maintaining 30% minimum residue at all times) was applied to 16,878 acres of cropland with financial incentives supplied under the Water Quality Incentive Program (WQIP).
>
> CRP was applied to 22,169 acres of highly erodible cropland in the Project area during the Project.

Conservation Compliance provisions of the Food Security Act required all farmers who were cultivating highly erodible land to have a compliance plan on their farms. These plans specified maintaining certain levels of crop residue during critical erosion periods, based upon land classification and cropping systems applied by the farmer.

A Conservation Tillage/Crop Rotation Demonstration component was added to the original workplan. This component was funded through grants from the South Dakota Department of Agriculture and the South Dakota Wheat Commission. Four cropping systems that were being researched by South Dakota State University and were favorable to the area were put to large scale trials by the project. One hundred acres of cropland was leased from a cooperator for the trials. Rotations were abandoned in the fourth year. Weather conditions seriously injured the crops other than winter wheat to such degree that they were destroyed. Results achieved by the project in four years were such that we cannot recommend a change to anything but a winter wheat - summer fallow rotation. To do otherwise, the farmer must be able to afford some less than desirable economic returns until the rotations are fully established. The period of time could exceed four years.

VII. PROJECT INSIGHTS AND RECOMMENDATIONS

Cooperators who were involved with the project since it began and have had their LTA's expire were so impressed with their practices that they are requesting technical assistance in continuing the BMP's without additional financial assistance. These actions give the strongest indication of the success and acceptance of the project and its lessons.

Recommendations to other areas where similar problems exist are:

- approach potential cooperators with a request to conduct a resource inventory of their property to determine if your project has anything of benefit to offer them.
- stress to the cooperators that their involvement in the project is totally voluntary.
- work as closely as you can to encompass the desires of the cooperator while maintaining the integrity and technical correctness of the applied practices.
- develop a complete farm plan that embraces a holistic approach.
- develop agreements with a win-win outcome.
- employ personnel who have practical, applicable experience and are not idealistic to the point they alienate potential cooperators.
- develop a financial cost-share package that is creative and seeks involvement of non-traditional parties as project partners.

APPENDIX
"A"

USDA-Soil Conservation Service Technical Note
Rangeland Hydrology

Hydrologic Assessments within the Bad River Watershed of South Dakota

K. Spaeth, (SCS) NW Watershed Res. Ctr., Boise, ID.; F. Pierson (ARS) NW Watershed Res. Ctr., Boise, ID; D. Schmidt (SCS), Huron, SD; and W. Vander Vorste, (SCS) Pierre, SD.

Abstract:

Rainfall simulation studies can provide valuable information for SCS planning efforts (i.e., River Basin studies, Special projects, State Water Quality programs, PL-566 programs, etc). In the past, the Soil Conservation Service has relied almost entirely on the Universal Soil Loss Equation to estimate erosion. With increasing concern over quality of surface and ground water, erosion and sedimentation, it is imperative that the Soil Conservation Service utilize other existing technologies to better understand the hydrologic cycle and key factors that affect it.

This study provides an example of how small plot rainfall simulations can provide information on infiltration and erosion rates on rangeland, pastureland, forestland, or cropland. The primary advantage for using small plot rainfall simulations is to obtain field data which can be used to compare relative hydrologic differences for 1) vegetation types; 2) management (i.e., grazing intensity, range improvement practices, etc.); and 3) compositional and species changes in ecological sites.

Introduction:

By having knowledge of hydrologic principles and processes and how these processes are affected by vegetation, vegetation management practices, and structural practices (engineering activities), the conservationist or land manager can more easily conceptualize how various activities in a given area effect the water cycle.

Solutions to existing or potential problems involving the relationship between water and land uses can be physical, economic, or regulatory. Conservation strategies on grazingland watersheds can be classified as preventive or restorative. Usually, most situations are a combination of the two. Preventive strategies and sound management plans are equally as important as the more dramatic and sometimes more politically visible restorative actions. For every watershed and site within the watershed, there exists a critical point of deterioration due to surface erosion. Beyond this critical point, erosion continues at an accelerated rate which cannot be overcome by the natural vegetation and soil stabilizing forces until a new equilibrium is achieved. Areas that have deteriorated beyond this critical point continue to erode even when man-caused disturbance is removed (Satterlund 1972).

Preventing losses of soil, desirable vegetation, wildlife habitat, and losses of forage production are much less costly than achieving the same benefit from a degraded situation by restoration. Depending on the severity of resource and watershed degradation (which includes water, soil, plant, animal, air, and human resources), restoration may not be feasible from an ecological and/or economic perspective. The results of grazingland watershed degradation can be serious and irreversible.

Infiltration, one of the most important processes in the hydrologic cycle is regulated by the kind and amount of vegetation, edaphic, climatic, and topographic influences (Wood and Blackburn 1981, Spaeth 1990). The kind and amount of vegetation influences many hydrologic processes including: interception, infiltration, evaporation, transpiration, percolation, surface runoff, soil water storage, soil erosion, and deposition of sediment. Every plant-soil complex exhibits a characteristic infiltration pattern (Gifford 1989). Hydrologic processes are affected by more than plant cover: Many plant and soil factors affect infiltration, runoff, and interrill erosion.

The purpose of this study was to 1) study the effects of grazing levels, plant composition on hydrologic assessments (infiltration, runoff, and erosion); and 2) identify important vegetative and soil variables which could be used to predict erosion and infiltration on dominant range sites in the Bad River Basin.

Methods:

Study Area:

The Bad River basin has a drainage area of about 8,161 km^2 (3,151 mi^2). The headwaters of the Bad River begin in the badlands of western South Dakota and empties into Lake Sharpe, an impoundment on the Missouri River. About 75 percent of the watershed is rangeland and the remaining 25 percent is mostly cropland. Sediment produced from fragile clayey soils on rangeland has been identified as a major water quality problem in the state. The average annual Bad River sediment discharge (as measured by USGS, 1982-1991) was 1,816,082 Mg tonnes (2,002,295 tons). Previous studies within the river basin concluded that a substantial amount of sediment comes from gullies and sheet and rill erosion on rangelands.

Years of intense grazing pressure along these river breaks caused substantial deterioration of an already fragile ecosystem. Many of the desirable climax species such as big and little bluestem, sideoats grama, green needlegrass, and western wheatgrass were replaced by shortgrass species such as buffalograss and blue grama. Although adequate cover may exist in stands of buffalograss and blue grama, runoff may be excessive. Accelerated runoff from these sites exaccerbates erosion in rills and drainage ways within a field and ultimately on the watershed.

Rainfall Simulation:

Rainfall simulation studies were conducted on 16 sites representing Sansarc and Promise soils, Shallow Clay and Clayey range sites, respectively. These two soils are prominent range soils in the Bad River Drainage area. Two grazing levels were evaluated: light to moderate grazing and heavy grazing. Table 1 lists the variables that were measured on each plot.

Table 1. Summary of variables collected on each rainfall simulation plot.

Symbol	Dependent Variables	Units
TCI	Terminal cumulative infiltration	in/hr
5IN	5-minute infiltration	in/5 min
10IN	10-minute infiltration	in/5 min
15IN	15-minute infiltration	in/5 min
20IN	20-minute infiltration	in/5 min
5-10SED	5-10 minute sediment	lbs/ac
15-20SED	15-20 minute sediment	lbs/ac
TSED	Total sediment at 1 hr	lbs/ac
Ksat	Saturated Hydraulic Conductivity	in/hr

Table 1. cont.

Symbol	Independent Variables	Units
BIO	Biomass (standing green)	lbs/ac
PHY	Phytomass (BIO+LIT)	lbs/ac
GRASS	Total Grass Component	lbs/ac
LIT	Litter or Mulch	lbs/ac
ROOT	Root biomass (at 4 in depth)	lbs/ac
Pb1	Bulk Density (0 to 1.5 in depth)	Mg/m^3
Pb2	Bulk Density (1.5 to 3.0 in depth)	Mg/m^3
COV	Canopy Cover	%
SLOPE	Slope	%
HT	Average Height of Vegetation	in

Simulation plots were pre-wet by applying 100 l/m^2 (26 gal/10 ft^2) of water. Depth of wetting was approximately 15 cm (6 in). The pre-wetted area was covered with plastic and rainfall simulation commenced about 24 hours later. A portable single nozzle rainfall simulator was used on 0.5 m^2 (5.4 ft^2) plots in June 1991. Water was applied 2.0 m (6.5 ft) above the plot at 20 Kpa (3 psi) pressure which produces an average droplet size 2.4 mm in diameter.

Plot simulation was replicated 2-4 times on each treatment. Simulated rainfall was applied at the rate of 10 cm/hr (4 in/hr) for 60 minutes. Runoff was measured at 5-minute intervals and mean infiltrability was calculated by determining the difference between applied rainfall and the quantity of water running off the plot. Sediment samples were obtained at 5-10 and 15-20 minutes (depending on when runoff started). A cumulative sediment sample was also collected after the one hour run.

Each plot was clipped (grasses, forbs, half shrubs, and litter). Root samples were taken in each plot [26 cm (10.2 in) diameter x 10-cm (4.0 in) depth]. Cover measurements of each species and bare ground was made by ocular estimates to the nearest percent. Soil bulk density was determined by the core method at 0- to 4-cm and 1.5- to 8.0-cm depths. A 375 m^2 (0.1 ac) circular macroplot was established with the 0.5 m^2 plot in the center, and all plant species were recorded to the nearest percent. The macroplot was used to further verify (quantify and identify) that the 0.5 m^2 microplots were actual representations of the respective community types. The soil in each plot was verified by an SCS Soil Scientist.

Treatments:

Sansarc Shallow Clay Range site, heavily grazed, 5% slope
Sansarc Shallow Clay Range site, light to moderate grazing, 5% slope
Sansarc Shallow Clay Range site, heavily grazed, 25% slope
Sansarc Shallow Clay Range site, light to moderate grazing, 25% slope
Promise Clayey Range site, heavily grazed, 5 % slope
Promise Clayey Range site, light to moderate grazing, 5 % slope

Statistical Analysis:

Multiple regression analysis was used to determine the amount of variation in infiltration attributable to selected independent and dependent variables. Diagnostic procedures, and practical considerations of the equations were also considered: the magnitude of the regression coefficients and their signs with respect to realistic expectations; significance of the calculated F* value of the analysis of variance (ANOVA); significance of t* tests for individual variables; residual plots for independent variables and their respective error variances, and the coefficient of determination (R^2).

Results:

Infiltration Curves:

5-Minutes

Five minute infiltrability was approximately 30% higher on the light to moderate grazed (LMG) Sansarc (5% slope, Fig. 1) and Promise (5% slope, Fig. 2) sites. On the heavily grazed (HG) treatments of these soils, buffalograss was a predominant species. On the LMG treatment, western wheatgrass and green needlegrass were the major components.

There was no difference in 5-minute infiltration rates on the Sansarc (25% slope, Fig. 3) treatments. Both the LMG and HG treatments contained tall grass components, however difference in height of vegetation was significant: 9.9 cm (3.9 in) for (HG) and 54.9 cm (21.6 in) for (LMG).

15-Minutes:

At 15 minutes, infiltrability was about 2/3 higher on the LMG treatments for the Sansarc (5% slope), Promise (5% slope), and Sansarc (25% slope) sites (See Figs. 1,2, and 3).

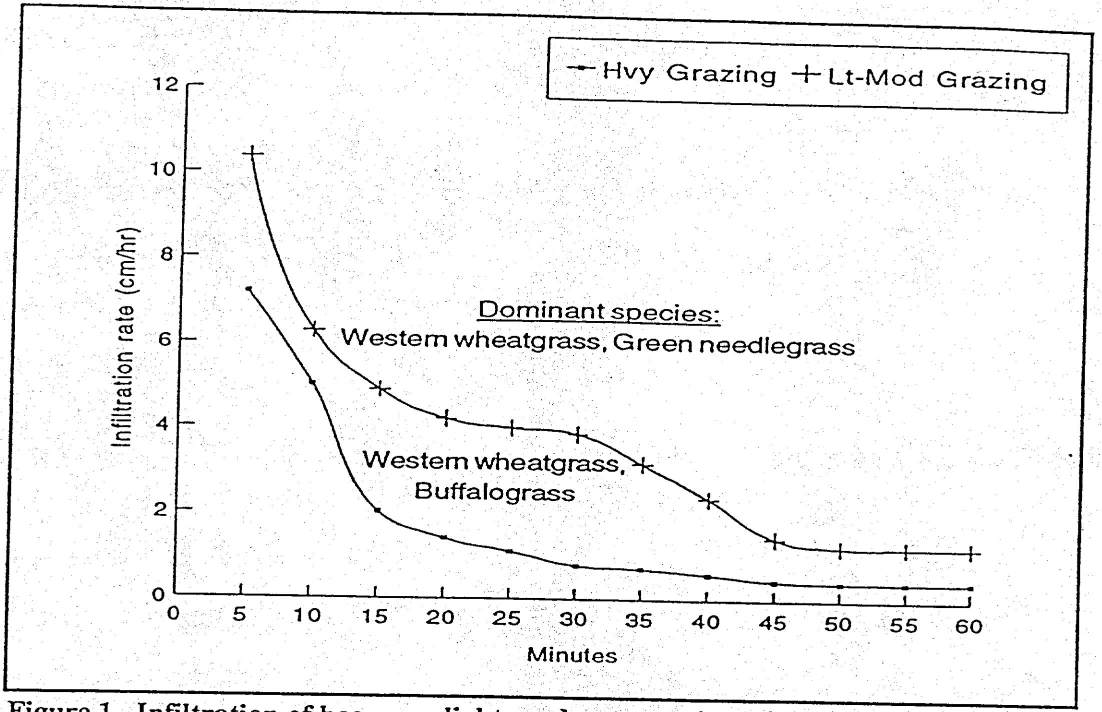


Figure 1. Infiltration of heavy vs. light-moderate grazing on a Sansarc, Shallow Clay range site (5% slope).

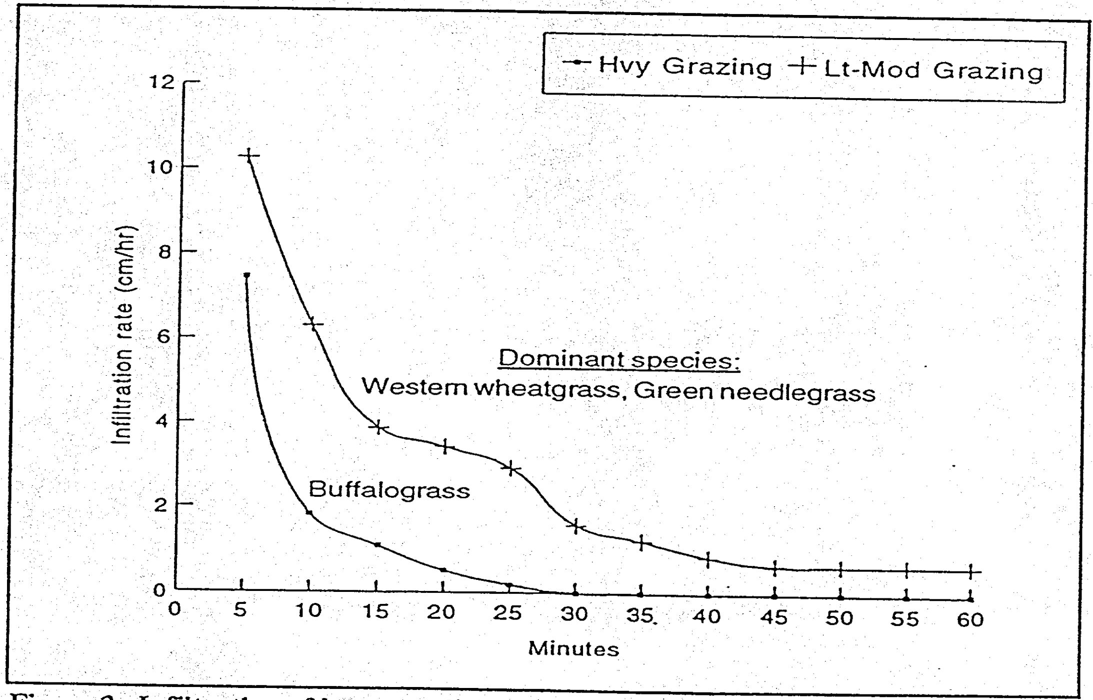


Figure 2. Infiltration of heavy vs. light-moderate grazing on a Promise, Clayey range site (5% slope).

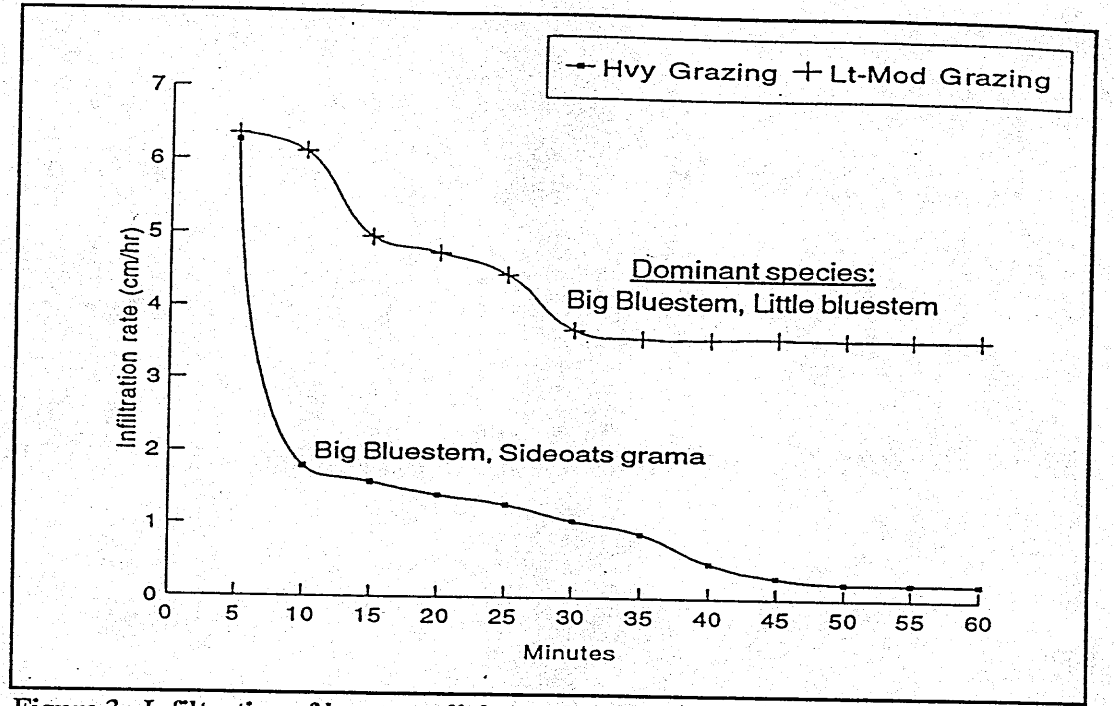


Figure 3. Infiltration of heavy vs. light-moderate grazing on a Sansarc, Shallow Clay range site (25% slope).

Steady State Infiltration:

On the Sansarc (5% slope) site, average steady state infiltration (SSI) was 0.41 cm/hr (0.16 in/hr) for the HG and 1.27 cm/hr (0.50 in/hr) for the LMG treatments. The comparative SSI on the Promise (5% slope) site was 0.13 cm/hr (0.05 in/hr) and 0.66 cm/hr (0.26 in/hr), an 82% difference between the HG and LMG treatments. The steeper Sansarc site (25% slope) SSI values were 0.03 cm/hr (0.01 in/hr) and 3.6 cm/hr (1.42 in/hr), a 94% difference between the HG and LMG treatments.

Interrill Erosion:

Average interrill erosion on the HG Sansarc, 5 and 25% slope phases, produced about 2.7 Mg/ha (1.2 t/ac) of sediment during a 10 cm/hr (4.0 in/hr) rainfall simulation (Table 2). Comparatively, the LMG treatments produced an average of 0.2 Mg/ha (0.1 t/ac). Sediment production on the HG treatment was considerably less on the Promise site because it was dominated by buffalograss, a sod-forming grazing resistant short grass species. The buffalograss sites were correlated with low sediment, low infiltration rates, and relatively high runoff. This phenomenon has been documented in other studies (Mazarak and Conrad 1959, Dee et al. 1966, and Spaeth 1990). Buffalograss is associated with a highly compacted fine root mass in the upper 10 cm (4.0 in) of soil.

Table 2. Summary of bulk density, infiltration, and sediment yields for a Promise Clayey site and Sansarc Shallow Clay site. A portable rainfall simulator was used with an application rate of 4.0 inches/hr.

	Promise Clayey Site (5% slope)			Sansarc Shallow Clay (5% slope)			Sansarc Shallow Clay (25% slope)		
Variable	Heavy Grazing Use	Light to Moderate Grazing Use	Percent Difference	Heavy Grazing Use	Light to Moderate Grazing Use	Percent Difference	Heavy Grazing Use	Light to Moderate Grazing Use	Percent Difference
Bulk Density 0-1.5' Depth Mg/M3	1.28	1.01	- 21%	1.37	1.13	- 18%	1.32	1.24	- 6%
Bulk Density 0-3" Depth Mg/M3	1.55	1.24	- 20%	1.38	1.34	- 3%	1.33	1.11	- 17%
Infiltration Rate In/hr	0.047	0.26	+ 82%	0.16	0.50	+ 63%	0.085	1.42	+ 94%
Cumulative Infiltration Rate In/hr	0.35	1.08	+ 68%	0.61	1.44	+ 58%	0.51	1.87	+ 73%
Erosion Rate lbs/ac	425	163	- 62%	2732	144	- 95%	2120	265	- 88%
Canopy Cover %	88	84	- 4%	28	87	+ 68%	21	94	+ 78%
Biomass lbs/ac	1401	2308	+ 39%	644	1362	+ 53%	514	1101	+ 53%
Litter lbs/ac	258	157	- 39%	1481	1792	+ 21%	109	130	+ 16%
Grass Production lbs/ac	1277	2112	+ 40%	326	1024	+ 68%	492	897	+ 45%
Root Biomass 0-4" Depth lbs/ac	7100	3824	- 46%	1779	1449	- 19%	8670	12,432	+ 30%
Avg. Plant Height inches	3.9	21.6	+ 82%	9.05	21.7	+ 58%	3.9	21.6	+ 82%
Range Condition %	29	77	+ 48%	24	43	+ 19%	59	78	+ 19%

Infiltration and Runoff Characteristics: Sansarc 5% slope

Thunderstorms occur on about 40 days each year, most of which occur during the summer. Average storm intensities are: 2-year, 24 hr, is about 5.3 cm (2.1 in); 5-year, 24 hr, is about 7.4 cm (2.9 in); and 25-year, 24 hr, is about 10.4 cm (4.1 in).

As an example, comparisons of infiltration and runoff on the Sansarc (5% slope) sites, HG and LMG treatments, showed that heavily grazed sites will produce considerable more runoff than light to moderately grazed sites. Under antecedent conditions, average runoff was about 2/3 higher on the HG treatment at 10 minutes with 1.68 cm (0.66 in) of water applied (Fig. 4). Average cumulative rainfall at 15 minutes (2.54 cm, 1.0 in of rain), produced 48% more runoff on the HG treatment. Average cumulative infiltration was 56% higher on the LMG treatment.

Infiltration Models:

The following infiltration models were developed from field data from the rainfall simulation plots. Terminal cumulative infiltration (TCI) rate at 1 hr was correlated with 3 variables: grazing level, average height of vegetation, and litter. The best single variable equation was

Model 1:

TCI = 1.18 - 0.715(Grazing Level)

$r^2 = 0.85$

where:

heavily grazed = 1
lightly to moderately grazed = 0

example TCI= 1.18 - 0.715(1) for heavy grazing, TCI = 0.465 in/hr. For light to moderate grazing, TCI = 1.18 in/hr.

This model accounted for 85% of the variation in terminal cumulative infiltration rate at 1 hour. At a 95% confidence level, heavy grazing tends to reduce cumulative infiltration on Promise Clayey and Sansarc Shallow range sites somewhere between 0.93 and 0.49 in/hr compared to light grazing.

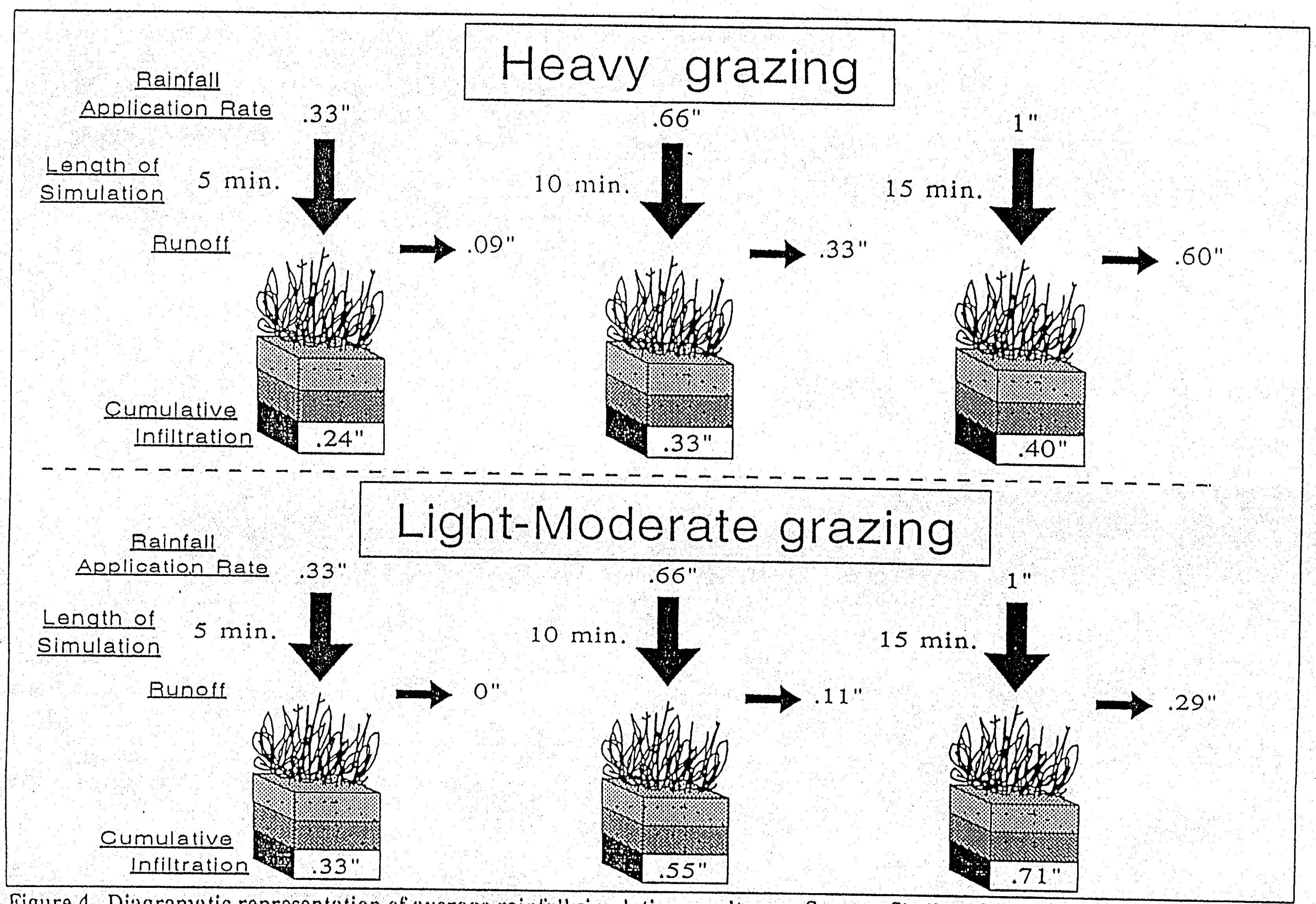


Figure 4. Diagramatic representation of average rainfall simulation results on a Sansarc Shallow Clay range site (5% slope), in the Bad River Basin, South Dakota. Rainfall application rates, length of simulation (5-15 minutes), runoff, and cumulative infiltration are represented for Heavily grazed and Light to Moderately grazed sites.

Model 2:

The best two variable model was

TCI = 1.0137 + 0.000253(litter,lbs/ac) - 0.615(Grazing Level)

$R^2 = 0.93$

where:

heavily grazed = 1, and lightly grazed = 0. This model accounted for 93% of the variation in terminal infiltration rate at 1 hour. The above equation indicates that cumulative infiltration rate at 1 hour is expected to increase 0.00025 in/hr when litter increases by 1.0 lb/ac, holding grazing influence constant. Cumulative infiltration rate at 1 hour is also expected to decrease by 0.615 in/hr under heavy grazing, holding litter constant.

Sediment Models:

Sediment was correlated with grass production, percent canopy cover, average height of vegetation, litter, and soil bulk density. The best predictive equation for sediment yield was

ln(TSED) = 4.33 - 0.0286(Cover) - 0.000389(Litter) + 3.3306(Bulk density of soil 0-3 inch depth), $R^2 = 0.92$

where:

ln(TSED) = natural log of Total Sediment Yield (lbs/ac) for a one hour simulation at 4 inches/hr application rate.

The above regression function indicates that mean ln(TSED) is expected to decrease by 0.028 units when percent canopy cover increases by 1 percent holding litter and bulk density constant. The lnTSED is also expected to decrease by 0.000389 units as litter increases by 1 lb/ac holding the other 2 variables constant. As bulk density increases by 1 Mg/m³, the lntsed increases by 3.306 units holding cover and litter constant.

Conclusions:

The following conclusions are specific to the Sansarc and Promise range sites in the Bad River Drainage.

Management Implications:

1. Grazing level, amount of litter or mulch, and height of vegetation had the greatest influence on infiltration rates.

2. Grass production, percent canopy cover, height of vegetation, and soil bulk density had the greatest effect on sediment production.

3. Controlling utilization levels is one of the most important management options to maximize plant canopy cover, continued optimum grass production, desired plant composition (mid grass species i.e., green needlegrass, western wheatgrass, and sideoats grama), and litter accumulation.

4. Season of use and degree of use are critical factors in reducing runoff and sediment production from upland range sites. In using actual climate data on a daily basis over a 5-year period, the Simulation, Production, and Utilization of Rangelands (SPUR-91, Carlson and Thurow 1992) model showed that sediment peaks begin in April, continue throughout the summer months and subside in October. Comparisons of sediment peaks for April and July (1990) were 5.9 and 8.3 times greater, respectively, for the poor condition site compared to the good condition rangeland site.

5. Grazing management strategies must maximize accumulation of litter, plant height, and promote growth of the taller non-sod forming species.

6. Critical erosion areas or pastures where gully erosion and headcuts are accelerating, require year round management to maintain adequate litter, plant height, grass residue, high mid grass composition levels, and lower soil compaction (lower soil bulk density). Excessive runoff from contiguous sites because of changes in species composition from midgrasses to shortgrasses accellerates existing gully erosion and new headcuts.

7. Grass composition greatly affects the hydrology of the site. Certain grasses such as green needlegrass, sideoats grama, little bluestem are associated with higher infiltration rates, lower runoff, and lower sediment yields.

8. The shorter sod-forming species such as buffalograss and blue grama are associated with high runoff and this accentuates gully formation and headcuts.

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APPENDIX
"B"

AVERAGE PER ACRE COST OF CONSTRUCTION PROJECTS ON LTA'S AND GPCP'S
BAD RIVER WATER QUALITY PHASE II IMPLEMENTATION PROJECT
NOTE: All contracts are not included, only a representative sample

23-Jan-97
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FARM #	CONSTRUCTION PRACTICES	RANGE ACRES	TOTAL $	FEDERAL COST-SHARE $ (GPCP & ACP)	PROJECT (319 & SD) + LANDOWNER $	FEDERAL/AC. COST-SHARE	TOTAL $/AC.
1 (LTA)	Windbreak Fencing	1017	$2,520	$1,260	$1,260	$1.24	$2.48
2 (LTA)	Windbreak Fencing	1526	$2,520	$1,260	$1,260	$0.83	$1.65
	Pipeline	1526	$1,395	$1,046	$349	$0.69	$0.91
	Tanks	1526	$1,437	$1,078	$359	$0.71	$0.94
3 (LTA)	Windbreak Fence	3112	$3,500	$1,750	$1,750	$0.56	$1.12
	Pipeline	3112	$8,947	$6,710	$2,237	$2.16	$2.88
	Tanks	3112	$1,469	$1,102	$367	$0.35	$0.47
	Feedlot Windbreak	3112	$1,611	$1,208	$403		
	Fencing	3112	$2,376	$1,782	$594	$0.57	$0.76
4 (LTA)	Watespreader (Diversion)	588	$22,710	$15,296	$7,414	$26.01	$38.62
5 (LTA)	Hayland planting	90	$9,268	$5,430	$3,838	$60.33	$102.98
	Range Renovation	600	$2,100	$2,100	$0	$3.50	$3.50
	Windbreak fences	870	$5,040	$2,520	$2,520	$2.90	$5.79
6 (LTA)	Pipeline	102	$3,601	$2,701	$900	$26.48	$35.30
	Tanks	102	$2,000	$1,500	$500	$14.71	$19.61
	Cattle Crossings	2358	$3,000	$1,500	$1,500	$0.64	$1.27
	Fencing	1143	$1,067	$800	$267	$0.70	$0.93
	Dams	790	$14,123	$10,592	$3,531	$13.41	$17.88
7 (LTA & GPCP)	Well	3652	$16,074	$10,000	$6,074	$2.74	$4.40
	Pipeline	5056	$19,410	$13,658	$5,752	$2.70	$3.84
	Tanks	5056	$3,446	$2,702	$744	$0.53	$0.68
	Farmstead windbreak	2	$341	$257	$84		
	Waterspreader (Diversion)	415	$21,100	$13,202	$7,898	$31.81	$50.84
8 (LTA & GPCP)	Well	6160	$27,234	$10,000	$17,234	$1.62	$4.42
	Pipeline	6160	$34,992	$17,496	$17,496	$2.84	$5.68
	Tanks	6160	$14,680	$7,340	$7,340	$1.19	$2.38
	Farmstead windbreak	1	$2,182	$1,205	$977		
	Windbreak fence	1085	$6,750	$5,250	$1,500	$4.84	$6.22
9 (LTA & GPCP)	Well	5980	$25,000	$10,000	$15,000	$1.67	$4.18
	Pipeline	5980	$14,400	$7,200	$7,200	$1.20	$2.41
	Tanks	5980	$2,936	$1,468	$1,468	$0.25	$0.49

	Fencing	2680	$5,346	$2,673	$2,673	$1.00	$1.99
10	Well	1973	$25,000	$10,000	$15,000	$5.07	$12.67
(LTA & GPCP)	Pipeline	1973	$17,350	$8,675	$8,675	$4.40	$8.79
	Tanks	1973	$2,292	$1,146	$1,146	$0.58	$1.16
	Fencing	1973	$2,600	$1,300	$1,300	$0.66	$1.32
	Feedlot Windbreak	465	$2,124	$1,186	$938	$2.55	$4.57
	Windbreak fence	465	$2,550	$1,750	$800	$3.76	$5.48
TOTAL			$334,491	$186,143	$148,348		

AVERAGE ANNUAL COSTS per acre

Interest Rate 8.00%

24-Jan-97
11:11 AM

FARM #	CONSTRUCTION PRACTICES	Practice Life	Installation Costs per Acre	Amortized Inst. Costs per Acre	Annual Percent OM&R	Annual OM&R ($/ac/yr)	Total Avg. Annual Cost ($/ac/yr)
1 (LTA)	Windbreak Fencing	10	$2.48	$0.37	2%	$0.05	$0.42
2 (LTA)	Windbreak Fencing	10	$1.65	$0.25	2%	$0.03	$0.28
	Pipeline	25	$0.91	$0.09	1%	$0.01	$0.09
	Tanks	10	$0.94	$0.14	1%	$0.01	$0.15
3 (LTA)	Windbreak Fence	10	$1.12	$0.17	2%	$0.02	$0.19
	Pipeline	25	$2.88	$0.27	1%	$0.03	$0.30
	Tanks	10	$0.47	$0.07	1%	$0.00	$0.08
	Feedlot Windbreak	50	$1,611.00	$131.69	1%	$16.11	$147.80
	Fencing	20	$0.76	$0.08	2%	$0.02	$0.09
4 (LTA)	Watespreader (Diversion)	30	$38.62	$3.43	3%	$1.16	$4.59
5 (LTA)	Hayland planting	25	$102.98	$9.65	0%	$0.00	$9.65
	Range Renovation	10	$3.50	$0.52	0%	$0.00	$0.52
	Windbreak fences	10	$5.79	$0.86	2%	$0.12	$0.98
6 (LTA)	Pipeline	20	$35.30	$3.60	1%	$0.35	$3.95
	Tanks	10	$19.61	$2.92	1%	$0.20	$3.12
	Cattle Crossings	5	$1.27	$0.32	3%	$0.04	$0.36
	Fencing	20	$0.93	$0.10	2%	$0.02	$0.11
	Dams	15	$17.88	$2.09	1%	$0.18	$2.27
7 (LTA & GPCP)	Well	20	$4.40	$0.45	1%	$0.04	$0.49
	Pipeline	25	$3.84	$0.36	1%	$0.04	$0.40
	Tanks	10	$0.68	$0.10	1%	$0.01	$0.11
	Farmstead windbreak	50	$341.00	$27.87	1%	$3.41	$31.28
	Waterspreader (Diversion)	30	$50.84	$4.52	3%	$1.53	$6.04
8 (LTA & GPCP)	Well	20	$4.42	$0.45	1%	$0.04	$0.49
	Pipeline	25	$5.68	$0.53	1%	$0.06	$0.59
	Tanks	10	$2.38	$0.36	1%	$0.02	$0.38
	Farmstead windbreak	50	$2,182.00	$178.36	1%	$21.82	$200.18
	Windbreak fence	30	$6.22	$0.55	2%	$0.12	$0.68

9 (LTA & GPCP)	Well	20	$4.18	$0.43	1%	$0.04	$0.47
	Pipeline	25	$2.41	$0.23	1%	$0.02	$0.25
	Tanks	10	$0.49	$0.07	1%	$0.00	$0.08
	Fencing	20	$1.99	$0.20	2%	$0.04	$0.24
10 (LTA & GPCP)	Well	20	$12.67	$1.29	1%	$0.13	$1.42
	Pipeline	25	$8.79	$0.82	1%	$0.09	$0.91
	Tanks	10	$1.16	$0.17	1%	$0.01	$0.18
	Fencing	20	$1.32	$0.13	2%	$0.03	$0.16
	Feedlot Windbreak	50	$2,124.00	$173.62	1%	$21.24	$194.86
	Windbreak fence	10	$5.48	$0.82	2%	$0.11	$0.93
Notes:	Feedlot Windbreaks are on a per unit basis						

AVERAGE ANNUAL COSTS PER PRACTICE PER RANCH

Interest Rate
8.00%

24-Jan-97
11:11 AM

FARM #	CONSTRUCTION PRACTICES	Practice Life	Total Installation Costs Per Acre	Amortized Inst. Costs	Annual Percent OM&R	Annual OM&R	Total Avg. Annual Cost ($/yr)
1 (LTA)	Windbreak Fencing	10	$2,520	$376	2%	$50	$426
2 (LTA)	Windbreak Fencing	10	$2,520	$376	2%	$50	$426
	Pipeline	25	$1,395	$131	1%	$14	$145
	Tanks	10	$1,437	$214	1%	$14	$229
3 (LTA)	Windbreak Fence	10	$3,500	$522	2%	$70	$592
	Pipeline	25	$8,947	$838	1%	$89	$928
	Tanks	10	$1,469	$219	1%	$15	$234
	Feedlot Windbreak	50	$1,611	$132	1%	$16	$148
	Fencing	20	$2,376	$242	2%	$48	$290
4 (LTA)	Watespreader (Diversion)	30	$22,710	$2,017	3%	$681	$2,699
5 (LTA)	Hayland planting	25	$9,268	$868	0%	$0	$868
	Range Renovation	10	$2,100	$313	0%	$0	$313
	Windbreak fences	10	$5,040	$751	2%	$101	$852
6 (LTA)	Pipeline	20	$3,601	$367	1%	$36	$403
	Tanks	10	$2,000	$298	1%	$20	$318
	Cattle Crossings	5	$3,000	$751	3%	$90	$841
	Fencing	20	$1,067	$109	2%	$21	$130
	Dams	15	$14,123	$1,650	1%	$141	$1,791
7 (LTA & GPCP)	Well	20	$16,074	$1,637	1%	$161	$1,798
	Pipeline	25	$19,410	$1,818	1%	$194	$2,012
	Tanks	10	$3,446	$514	1%	$34	$548
	Farmstead windbreak	50	$341	$28	1%	$3	$31
	Waterspreader	30	$21,100	$1,874	3%	$633	$2,507
	(Diversion)		$0				

8 (LTA & GPCP)	Well	20	$27,234	$2,774	1%	$272	$3,046
	Pipeline	25	$34,992	$3,278	1%	$350	$3,628
	Tanks	10	$14,680	$2,188	1%	$147	$2,335
	Farmstead windbreak	50	$2,182	$178	1%	$22	$200
	Windbreak fence	30	$6,750	$600	2%	$135	$735
9 (LTA & GPCP)	Well	20	$25,000	$2,546	1%	$250	$2,796
	Pipeline	25	$14,400	$1,349	1%	$144	$1,493
	Tanks	10	$2,936	$438	1%	$29	$467
	Fencing	20	$5,346	$545	2%	$107	$651
10 (LTA & GPCP)	Well	20	$25,000	$2,546	1%	$250	$2,796
	Pipeline	25	$17,350	$1,625	1%	$174	$1,799
	Tanks	10	$2,292	$342	1%	$23	$364
	Fencing	20	$2,600	$265	2%	$52	$317
	Feedlot Windbreak	50	$2,124	$174	1%	$21	$195
	Windbreak fence	10	$2,550	$380	2%	$51	$431

BAD RIVER WATER QUALITY PHASE II IMPLEMENTATION PROJECT
TOTAL INSTALLATION COSTS PER RANCH

Interest Rate
8.00%

24-Jan-97
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FARM #	TOTAL COSTS	RANGE ACRES	FEDERAL COST-SHARE (GPCP/ACP)	PROJECT (319 & SD) LANDOWNER	TOTAL COST PER ACRE	FEDERAL COST-SHARE PER ACRE	PROJECT & LANDOWNER $ PER ACRE
1 (LTA)	$2,520	1,017	$1,260	$1,260	$2.48	$1.00	$1.24
2 (LTA)	$5,352	1,526	$3,384	$1,968	$3.51	$1.00	$2.22
3 (LTA)	$17,903	3,112	$12,552	$5,351	$5.75	$1.00	$4.03
4 (LTA)	$22,710	588	$15,296	$7,414	$38.62	$1.00	$26.01
5 (LTA)	$16,408	870	$10,050	$6,358	$18.86	$1.00	$11.55
6 (LTA)	$23,791	2,358	$17,093	$6,698	$10.09	$1.00	$7.25
7 (LTA&GPCP)	$60,371	5,056	$39,819	$20,552	$11.94	$1.00	$7.88
8 (LTA&GPCP)	$85,838	6,160	$41,291	$44,547	$13.93	$1.00	$6.70
9 (LTA&GPCP)	$47,682	5,980	$21,341	$26,341	$7.97	$1.00	$3.57
10 (LTA&GPCP)	$51,916	1,973	$24,057	$27,859	$26.31	$1.00	$12.19
TOTALS	$334,491	28,640	$186,143	$148,348			
AVERAGES	$33,449.10	2,864	$18,614.30	$14,834.80	$13.95	$1.00	$8.26

AVERAGE COSTS PER PRACTICE

Interest Rate 0.00%

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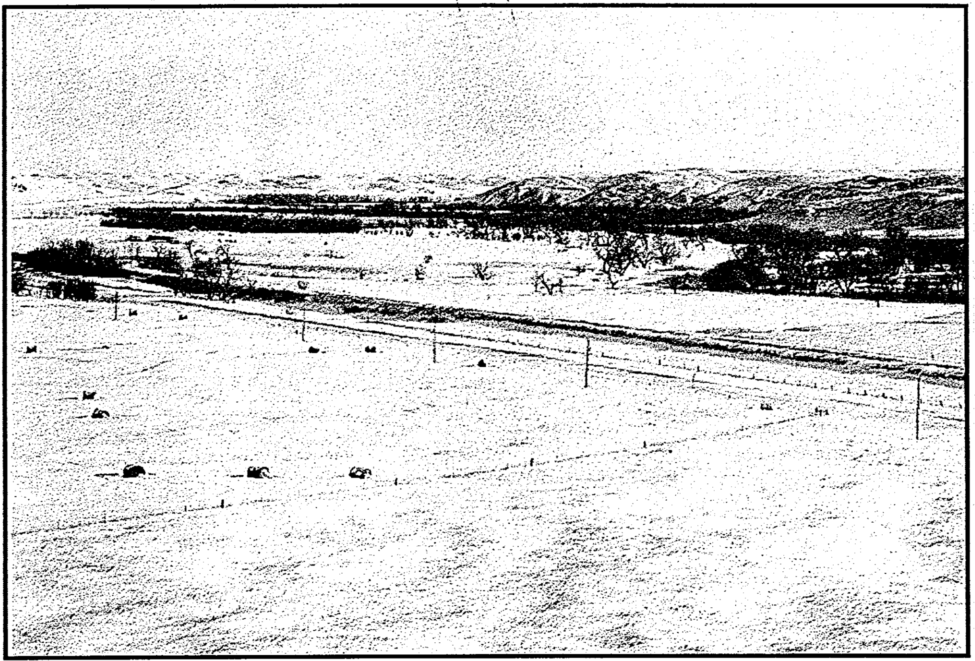
	PRACTICE	FEDERAL per ACRE COST-SHARE	TOTAL COST per ACRE	Amortized Inst. Costs per Acre	Annual OM&R ($/ac/yr)	Total Avg. Annual Cost ($/ac/yr)	
	Windbreak Fence	$2.35	$3.79	$0.50	$0.08	$0.58	
	Pipeline	$5.78	$8.54	$0.84	$0.09	$0.93	
	Tanks	$2.62	$3.68	$0.55	$0.04	$0.58	
	Feedlot Cost/Windbreak	$964	$1,565	$128	$16	$144	
	Fencing	$1.21	$2.06	$43.50	$5.33	$48.83	
	Watespreader (Diversion)	$28.91	$44.73	$3.97	$1.34	$5.32	
	Hayland planting	$60.33	$102.98	$9.65	$0.00	$9.65	
	Range Renovation	$3.50	$3.50	$0.52	$0.00	$0.52	
	Cattle Crossings	$0.64	$1.27	$0.32	$0.04	$0.36	
	Dams	$13.41	$17.88	$2.09	$0.18	$2.27	
	Wells	$2.78	$6.42	$0.65	$0.06	$0.72	
Notes:	Feedlot Windbreaks are on a per unit basis						

APPENDIX
"C"

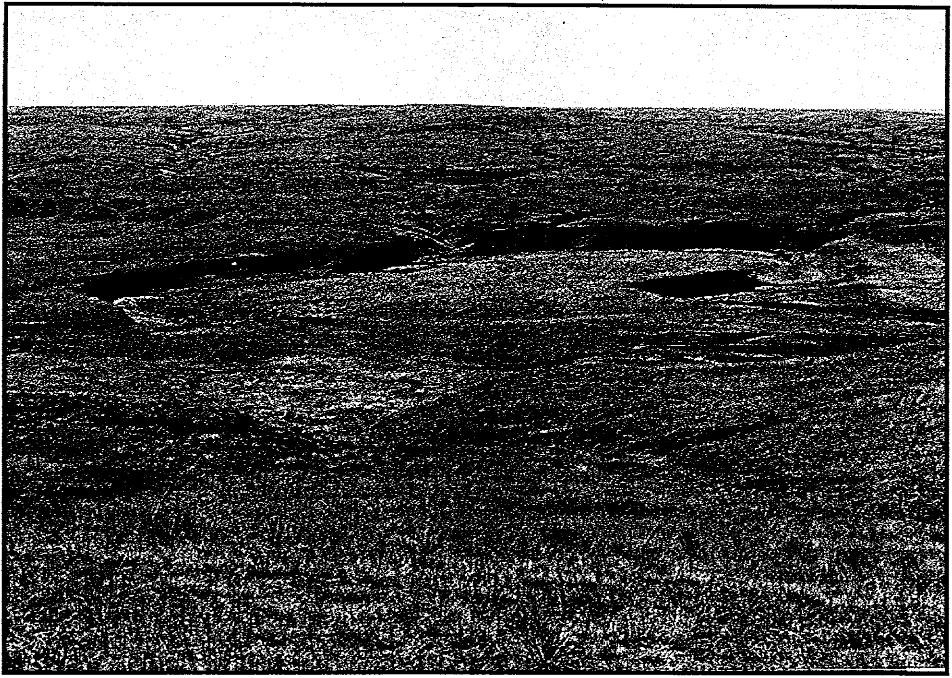
Bad River Phase II Water Quality Project

Pictorial Summary



The Bad River is a meandering river that flows through west-central South Dakota for more than 190 miles, draining a watershed that covers 3,172 square miles. The river does not flow continually in most years. It is subject to high runoff events as a result of heavy spring snowmelt and severe summer thunderstorms in its watershed. It is a timbered river bottom that rises quickly from its floodplain to the upper tablelands. The main river channel is not severely eroded. The main erosion occurs in the side tributaries that contribute runoff to the main channel.

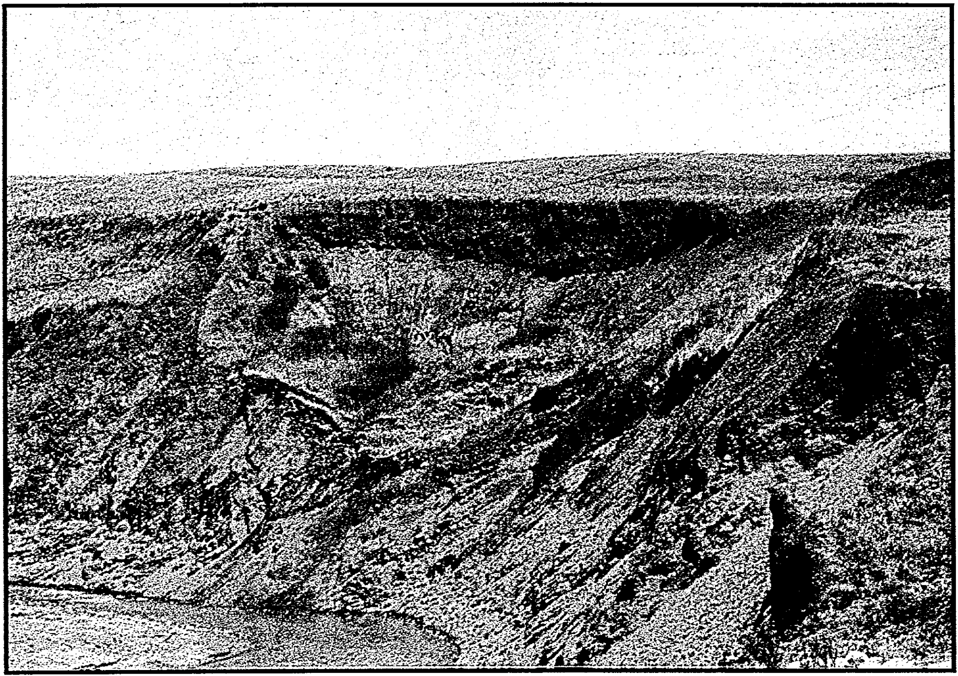
The following pictorial summary will visualize some of the problems associated with the Bad River Watershed and examples of some of the Best Management Practices that were applied during the Phase II Project and were readily accepted by the landowners.



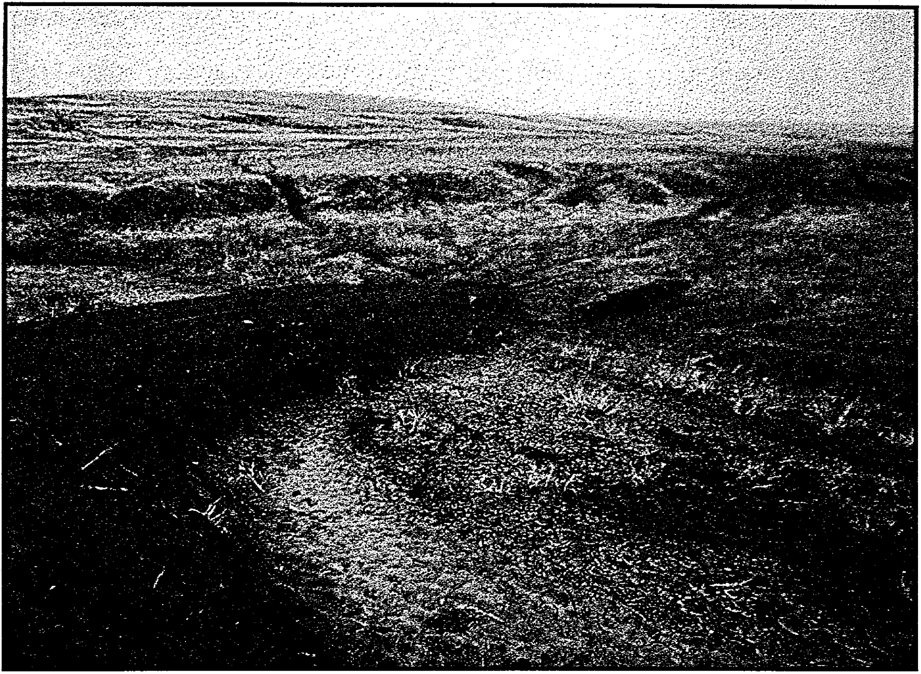
A view of the range landscape shows that the Bad River side tributaries are barren of woody species and consist of many incised channels.

The landscape also shows the barren shale outcrops that are typical in the watershed. These outcrops do not support vegetation in any period of the growing season and are subject to developing a layer of highly erodible soil as a result of the freeze-thaw action on the soil.

Gully erosion and channel scouring have been identified as major sources of erosion in the project area. This is apparent in the above photo taken after a recent severe summer storm.

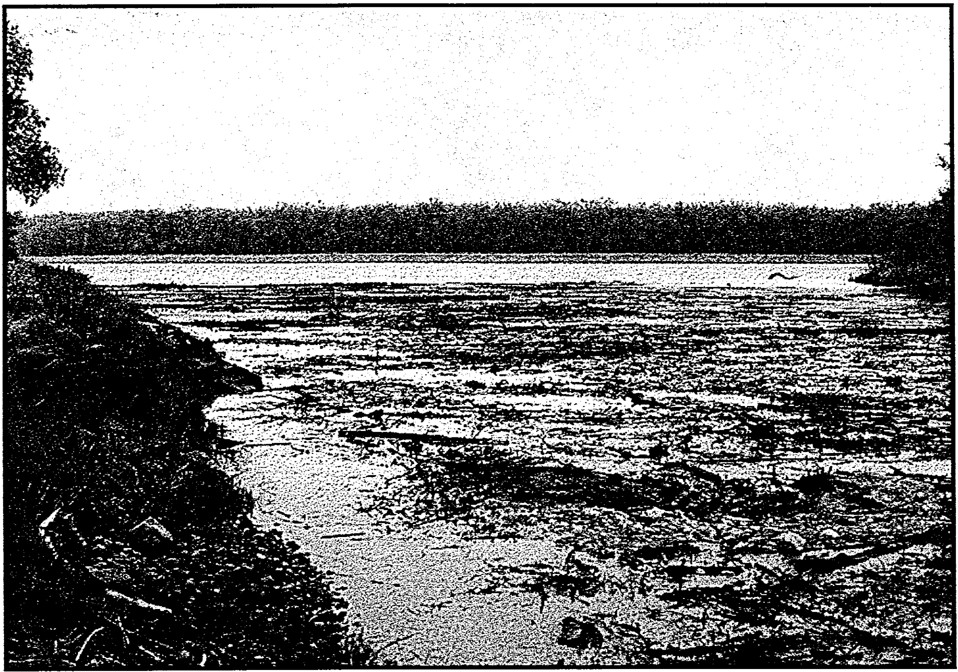


The topsoil in the watershed is underlain with a layer of shale at varying depths from the surface throughout the watershed. In wet years, this creates many slides that contribute greatly to the sediment problem along the tributaries of the Bad River.

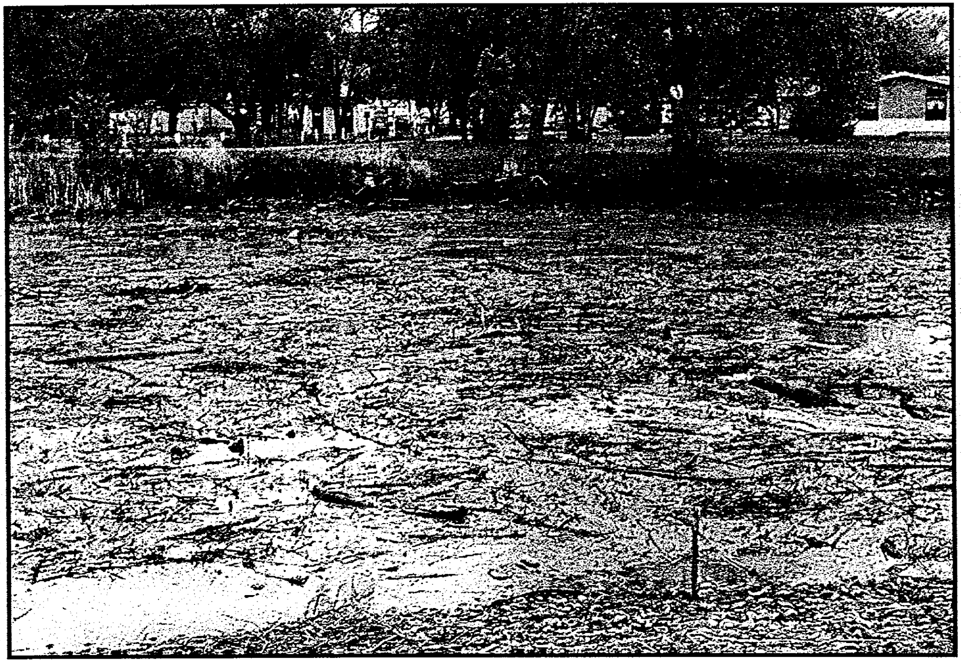


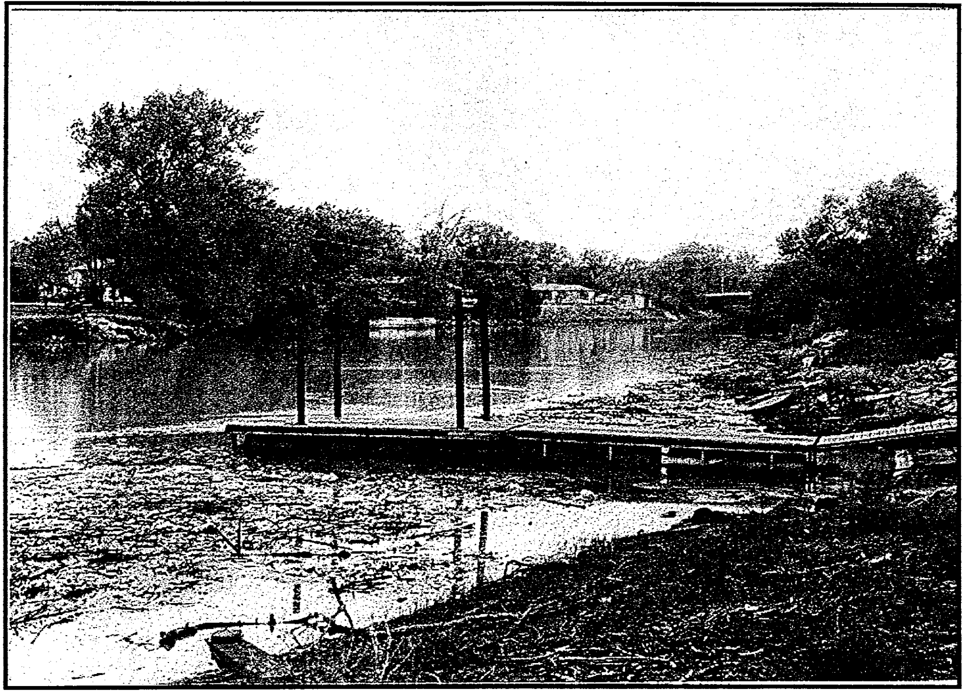
An example of typical creek crossings that ranchers install to facilitate livestock and vehicle crossing of creeks.

Several times during the summer months, depending on storm events, the crossings are destroyed by heavy runoff and need to be repaired. The sediment washed away increases the sedimentation problems.



The sediment created by erosion eventually reaches the mouth of the Bad River. When the Bad River is flowing and the Oahe Dam is discharging water, a situation arises where the outflow of the Bad River into Lake Sharpe is stalled as shown in these pictures. The sediment and trash coming down the Bad River are held at the mouth.

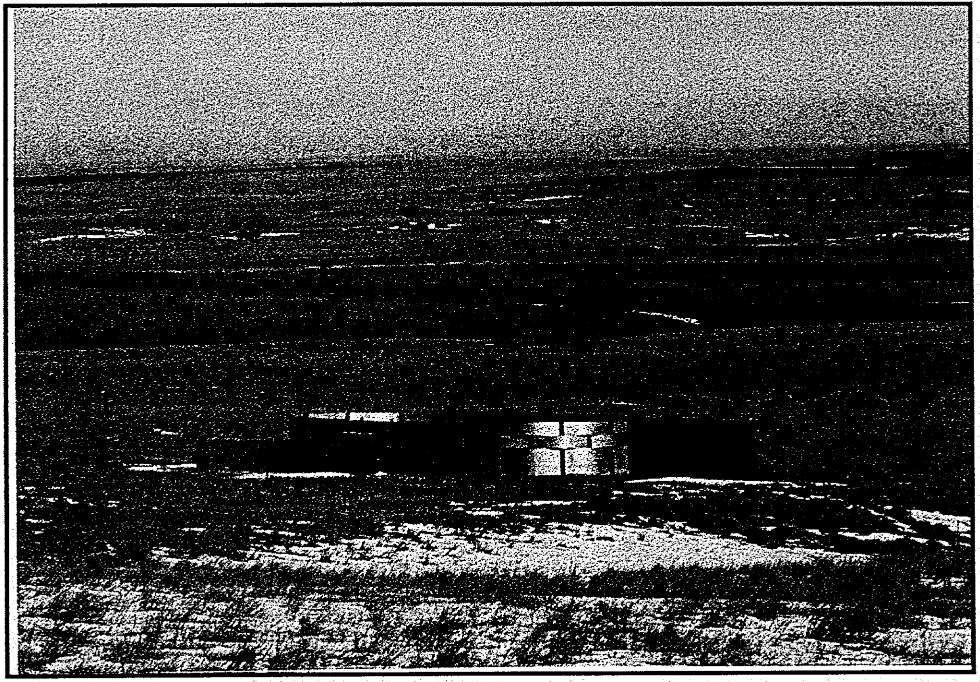


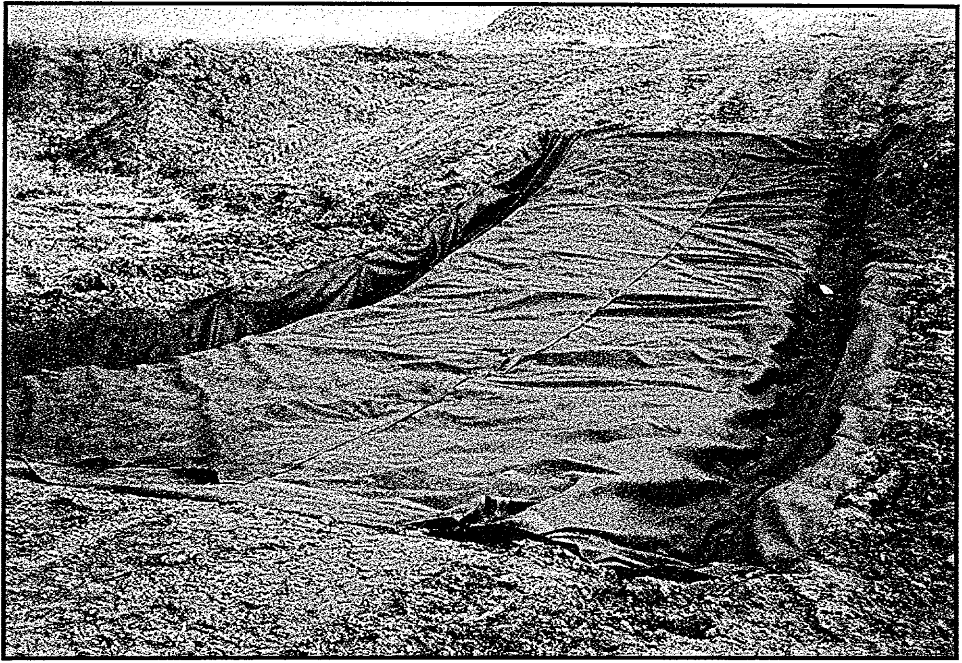


Recreation is severely affected by the stalling action at the mouth of the Bad River when heavily sediment laden. The boat ramp located near the mouth of the Bad River is rendered virtually unusable to conventional rear wheel, 2-wheel drive vehicles.

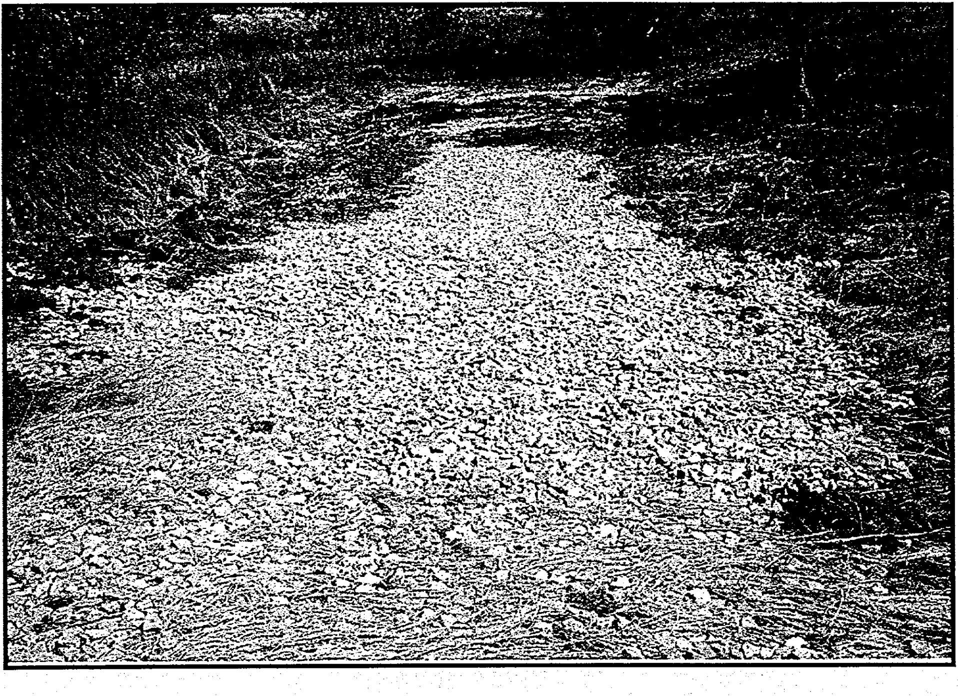
In periods of inclement weather and during calving season, ranchers of the region generally keep their cattle in the riparian areas of the watershed for protection.

A special practice that was used in the project was the construction of fabricated livestock windbreaks. These are located away from traditional riparian areas and as close as possible to a reliable water source. They are rangeland structures and were not constructed at the ranch headquarters. They are of a size that will hold 100 adult cows. Ranchers added small calf shelters around the perimeter of the windbreak for protection of the young calves away from their mothers.

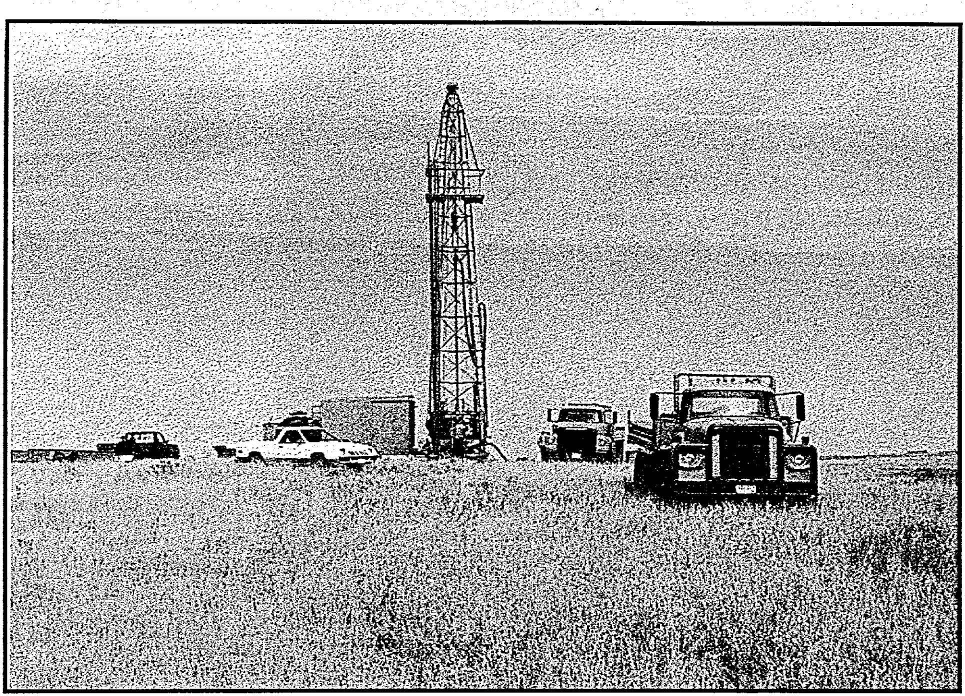




The project assisted the ranchers in installing creek crossings that would allow crossing of the creeks and reduced the sediment problems that are present with the typical crossings.



A finished crossing is installed at channel grade level using angular crushed rock. With the filter fabric underlay, it allows for livestock and vehicle usage during times of low stream flow.

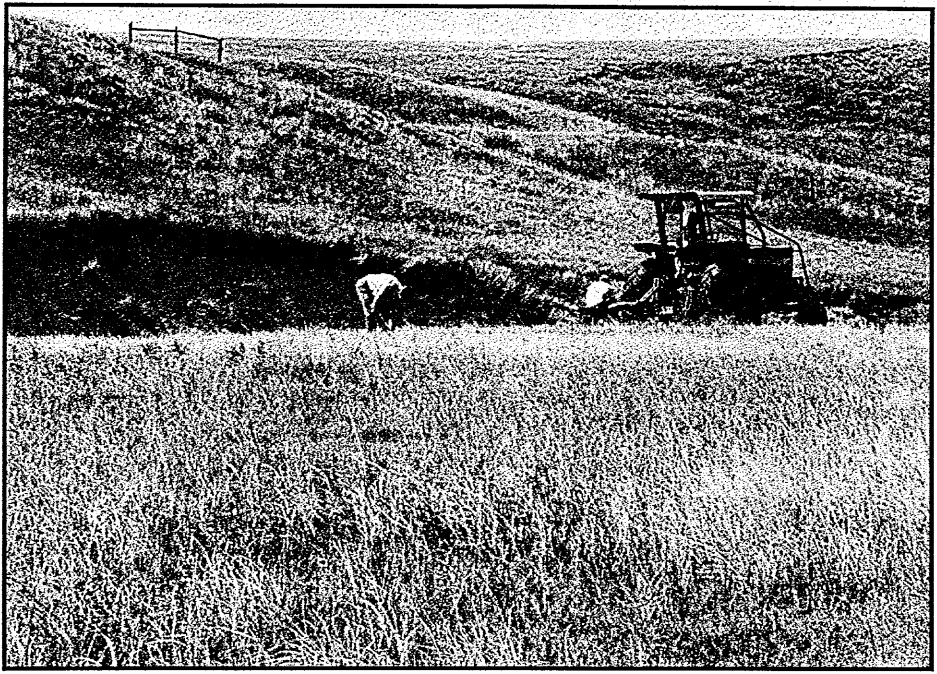


The drought of the late 1980's created a shortage of water for proper grazing of rangeland. Water development was of major concern when the project began. New wells were favored as a reliable source of water.

Pipelines and tanks were installed to provide for proper distribution of water. Where possible, tanks were placed close to existing dams to provide additional water and storage from the overflow produced by the flowing wells.

A water spreader system collects runoff that is heavily laden with suspended sediment. It also provides moisture for increased forage production.

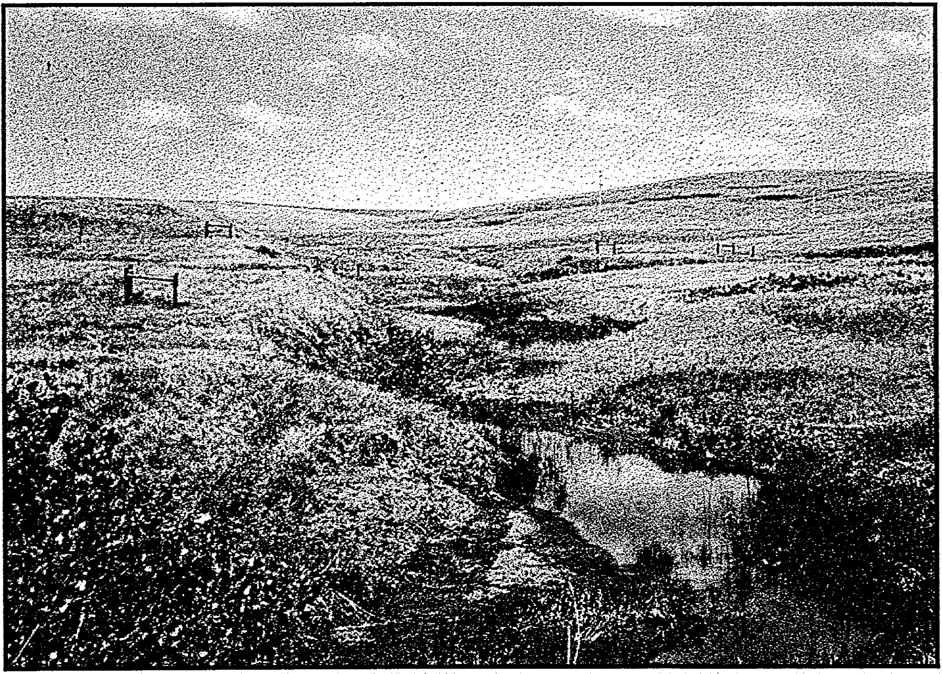
After 7-10 days within the dikes of the spreader system, the water is released through a gated valve to a lower dike. The sediment has had time to settle out and is released much cleaner than when it entered the spreader.



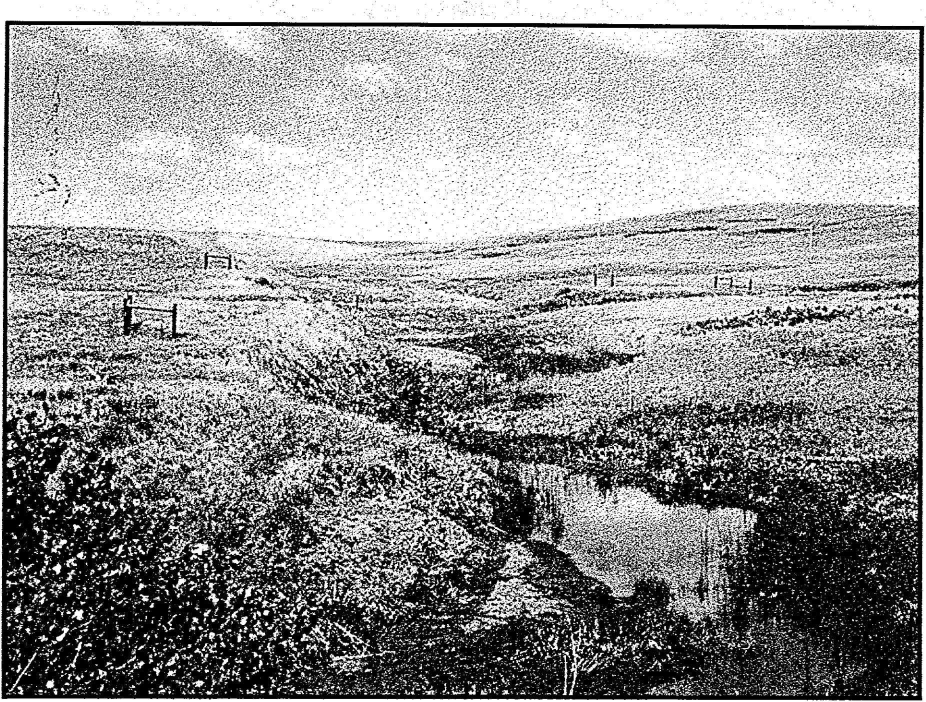
Riparian vegetation re-establishment was accomplished by machine planting of woody species on the floodplains and

hand planting of willows and cottonwoods closer to the stream channel.

Directly above the treated riparian area, cut banks and barren channels are evident.

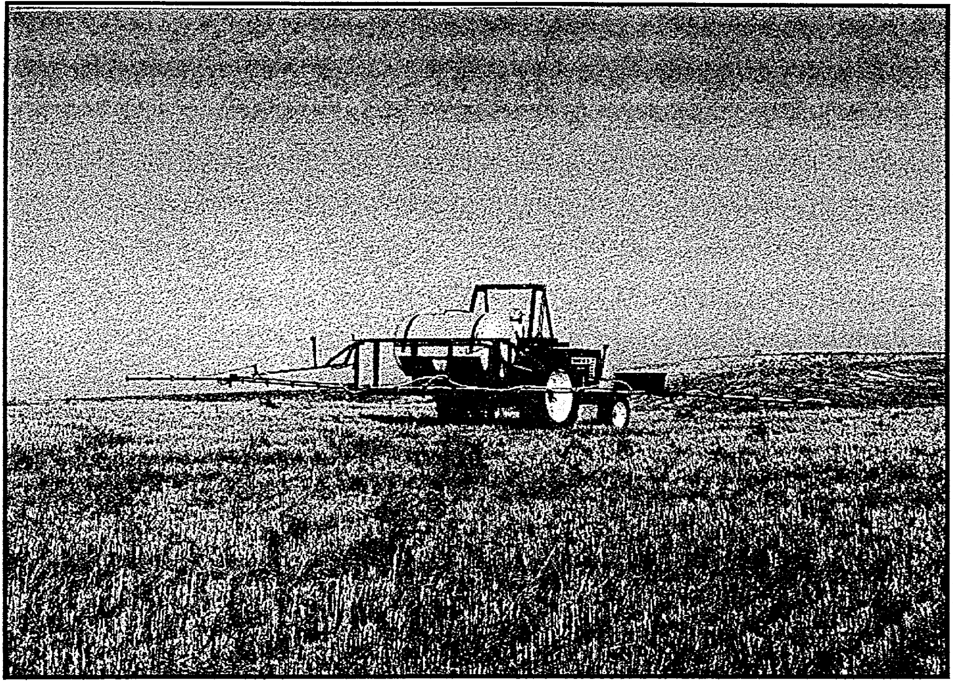


Tremendous vegetative response is exhibited in the treated riparian area after only three years of livestock exclusion. Managed livestock use may be possible after re-establishment of desired vegetation.

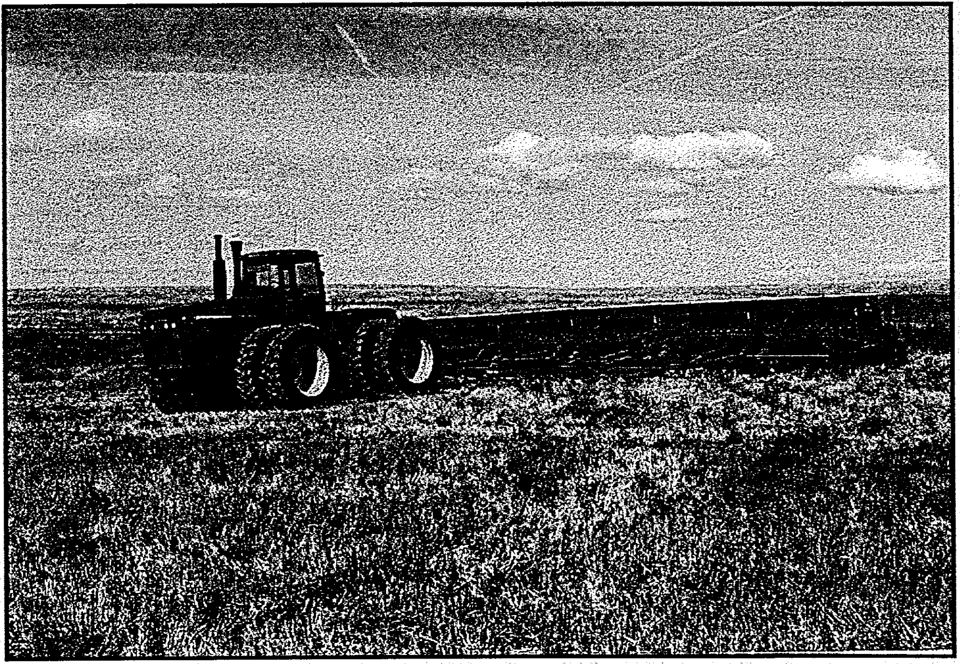


The riffle-pool effect and stabilizing channel that is typical of healthy riparian areas is evident in the treated riparian area as a result of increased vegetation and trapped sediment.

A healthy riparian area exhibits good growth of both woody and grassy species along with stable bank slopes adjacent to the flood plain.



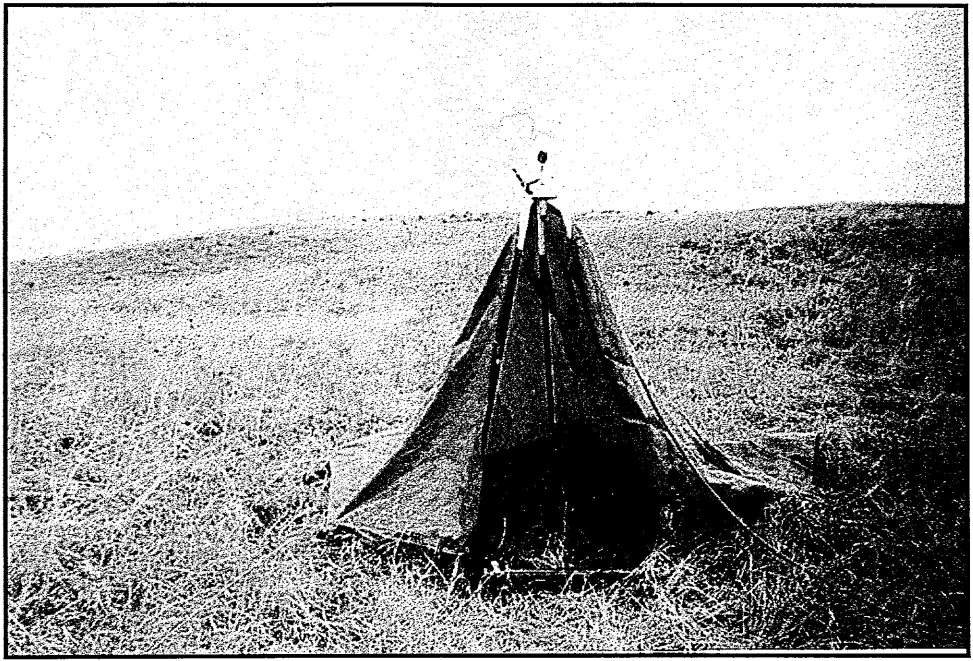
Conservation tillage or minimum tillage practices were applied to cropland in an effort to reduce erosion by wind as well as runoff. Conservation tillage requires increased use of chemicals for control of undesired weeds and seeding of crops into fields containing as much crop residue as possible. Increased management and cropping rotations are also necessary to reduce disease.



Sites in small drainage areas were selected on both cropland and rangeland to conduct water quality sediment sampling. The rangeland sites were fenced to exclude livestock. Water sample collectors and intensity measuring rain gauges were installed at each site.

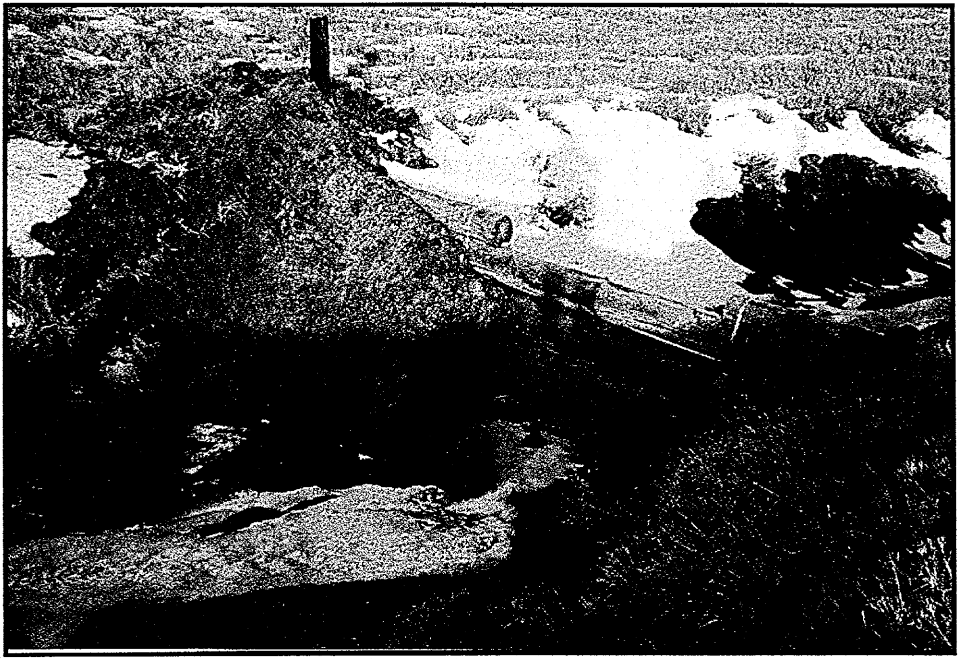
Numerous problems arose in the monitoring program. They included: varying intensity of storm events from site to site, activation switches corroding, and rodents eating through the insulation and the wire core of the activation switches.

Because of the project's inability to collect water samples as planned from the monitoring sites that were established, rainfall simulation was utilized. A small portable simulator was constructed. Dr. Kenneth Spaeth, NRCS Range Specialist, conducted rainfall simulation trials on rangeland with varying soil types, slopes, and vegetative species in the watershed.

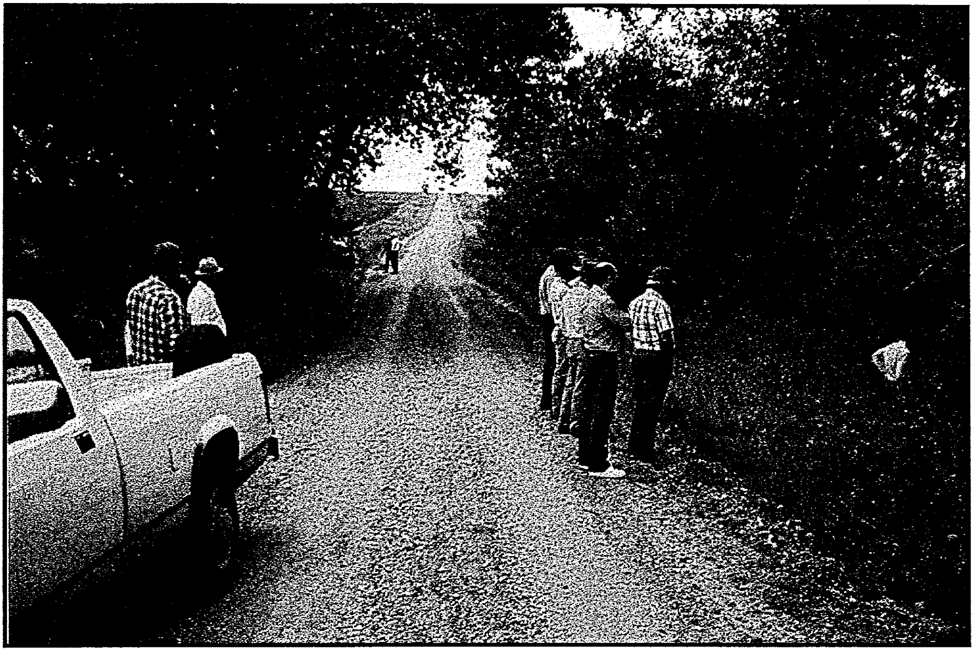


Not all practices were successful. Pole structures that were constructed to be used as small check dams were thought to have promise. Failure of these, as shown in the lower picture, resulted from improper compation of the backfill placed above the structure. Attempts continue to correct the problem for future use.

Another problem arose in the stream crossings. As a result of record high stream flows, the angular rock was removed from the fabric. An attempt to correct this problem by placing the rock in wire structures is being tested.



The information and education component of the project consisted of tours of the general watershed and the treatment areas plus annual field days held in conjunction with South Dakota State University at their crops field trials and the projects Conservation Tillage Demonstration Project. Annual Task Force meetings were also part of the program.



The project has been considered successful. In the target watershed, 90% of the landowners voluntarily participated in the project and treatment was applied to approximately 95% of the land. This is apparent with the colored areas of the treated watershed being those with plans applied. The sediment in this 160,000 acre watershed has been reduced from 82.7 tons of sediment per acre/foot of runoff during 1990, the base year of sampling, to an average of 10.2 tons of sediment per acre/foot of runoff for the years of 1993 through 1995.