AD-A140 722 RED RIVER OF THE NORTH RECONNAISSANCE REPORT: BOIS DE SIOUX-MUSTINKA RIVERS SUBBASIN(U) GULF SOUTH RESEARCH INST BATON ROUGE LA DEC 80 DACW37-80-C-0017 1/2

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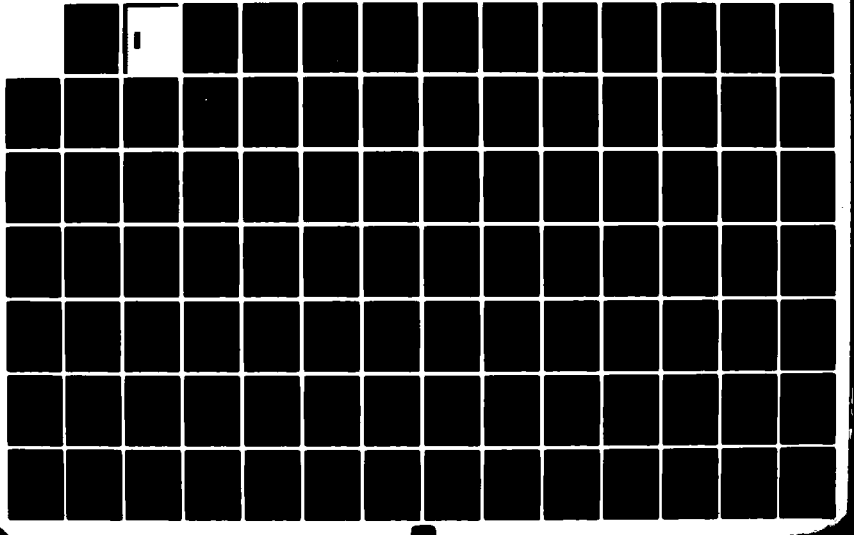

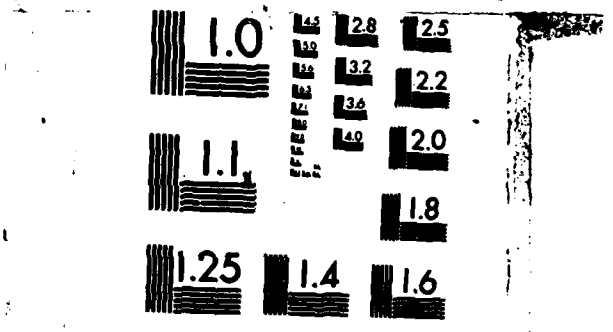

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SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

REPORT DOCUMENTATION PAGE	READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO. AD-A140 722 — 3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* RED RIVER OF THE NORTH, RECONNAISSANCE REPORT: BOIS DE SIOUX-MUSTINKA RIVERS SUBBASIN.	5. TYPE OF REPORT & PERIOD COVERED: Final Report
	6. PERFORMING ORG. REPORT NUMBER: GSRI Project No. 955
7. AUTHOR(s)	8. CONTRACT OR GRANT NUMBER(s): DACW37-80-C-0017
9. PERFORMING ORGANIZATION NAME AND ADDRESS: GSRI/Gulf South Research Institute, P.O. Box 14787, Baton Rouge, LA 70898	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS: U.S. Army Engineer District, St. Paul, 1135 USPO & Custom House, St. Paul, MN 55101	12. REPORT DATE: 1980 — 13. NUMBER OF PAGES: 105 p.
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)	15. SECURITY CLASS. (of this report): Unclassified — 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

18. SUPPLEMENTARY NOTES Bois de Sious-Mustinka Rivers; Buffalo River; Devils Lake; Elm River; Forest River; Goose River; Maple River; Middle River; Main Stem; Ottertail River; Park River; Pembina River; Red Lake; Roseau River; Sand Hill River; Sheyenne River; Rush River; Snake River; Tamarac River; Two Rivers; Turtle River; Wild Rice-Marsh Rivers, Wild Rice River (N.D.) & Summary Report.

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

FLOOD CONTROL
FLOODING
WATER RESOURCES
RED RIVER BASIN

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

This report is one of 23 subbasin reports produced by the St. Paul District Corps of Engineers in connection with a reconnaissance report for the whole of the Red River Basin. The reconnaissance report is itself part of the overall Red River of the North study, which was initiated by Congress in 1957 in order to develop solutions for flooding problems within the basin. The purpose of a reconnaissance study is to provide an overview of the water and related land resource problems and needs within a particular geographic area, to identify planning objectives, to assess potential solutions and

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problems, to determine priorities for immediate and longrange action, and to identify the capabilities of various governmental units for implementing the actions.

The information developed in this report has been combined with information developed in the other subbasin reports to produce a main report covering the basin as a whole. The various flood control measures discussed in this and in other subbasin reports are combined in the main report to develop the outline of an integrated flood control plan for the basin within the context of a comprehensive plan.

The Bois de Sioux-Mustinka Rivers Subbasin constitutes the southern limit of the Red River Basin, and is one of the largest of the subbasins. Most of the subbasin is located in the Minnesota counties of Traverse, Big Stone, Stevens Grant, Ottertail, and Wilkin. The North Dakota portion is constituted by the southeast corner of Richland County, and the South Dakota portion is constituted by the northeast corner of Roberts County. Most of the subbasin is devoid of vegetation, however, there are numerous small lakes, potholes, and swampy areas on the perimeters of the subbasin that form an excellent habitat for wildlife.

The dominant water features on the subbasin are Lake Traverse, the Bois de Sious River, the Mustinka River, and the Rabbit River. Lake Traverse and the associated smaller Mud Lake were constructed by the Corps of Engineers in 1941 for flood control and water conservation.

GULF SOUTH RESEARCH INSTITUTE
8000 GSRI Avenue Telephone Area Code 504 766 3300 Baton Rouge, Louisiana 70808

December 1980

Final Report

Contract No. DACW37-80-C-0017
GSRI Project No. 955

RECONNAISSANCE REPORT: RED RIVER OF THE NORTH BASIN, BOIS DE SIOUX-MUSTINKA RIVERS SUBBASIN

Prepared for:

U.S. Army Corps of Engineers
St. Paul District
St. Paul, Minnesota

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This report is one of 23 subbasin reports produced by the St. Paul District Corps of Engineers in connection with a reconnaissance report for the whole of the Red River Basin. The reconnaissance report is itself part of the overall Red River of the North Study, which was initiated by Congress in 1957 in order to develop solutions for flooding problems within the basin.

The purpose of a reconnaissance study is to provide an overview of the water and related land resource problems and needs within a particular geographic area, to identify planning objectives, to assess potential solutions and problems, to determine priorities for immediate and long-range action, and to identify the capabilities of various governmental units for implementing the actions.

The Bois de Sioux-Mustinka Rivers Subbasin is a water resource planning unit located at the southern end of the Red River Basin. This report describes the social, economic, and environmental resources of the subbasin, identifies the water-related problems, needs, and desires, and suggests measures for meeting the needs, particularly in the area of flood control.

The report was prepared almost entirely on the basis of secondary information. However, some telephone contacts were made to verify information and to acquire a more complete picture of local conditions. There are two comprehensive reports available on the subbasin. The first is a 1947 appendix to the Red River of the North basin survey report, which was published by the St. Paul District Corps of Engineers, and the second is a Type II Study, which was published by the Souris-Red-Rainy River Basins Commission in 1972. Other published sources on the subbasin include:

1. A Design for Tommorrow, which was published by the Souris-Red-Rainy River Basins Commission in 1973 and summarizes the results of the Type II Study for the subbasin.
2. West Tributary Bois de Sioux River Watershed, which was published in 1960 by the Richland County and Roberts County soil and water conservation districts through the Soil Conservation Service and is concerned with only a small portion of the subbasin.
3. Environmental Assessment of Lake Traverse, which was prepared by the Center for Environmental Studies at Tri College University (Fargo, North Dakota) and published by the St. Paul District Corps of Engineers in 1975. The report covers only the immediate project area.

4. Draft Master Plan for Public Use Development and Resource Management, Lake Traverse, Minnesota-South Dakota, which was published by the St. Paul District Corps of Engineers in 1978 and concerns the immediate project area.

5. Environmental Assessment, Lake Traverse Master Plan for Public Use Development and Resource Management, Lake Traverse, Minnesota-South Dakota, which was published by the St. Paul District Corps of Engineers in 1979. This report is an environmental assessment of the aforementioned master plan and incorporates information developed in the 1975 Tri College report.

The subbasin received partial coverage in the Souris-Red-Rainy River Basins Comprehensive Study, which was published by the Souris-Red-Rainy River Basins Commission in 1972, and in the Red River of the North Basin Plan of Study, which was published by the St. Paul District Corps of Engineers in 1977. In addition, applications for planning assistance were developed by local interests in the 1960s and submitted to the Soil Conservation Service. These applications contain valuable information on problems and needs for the Rabbit River and West Branch Mustinka River watersheds.

The information developed in this report has been combined with information developed in the other subbasin reports to produce a main report covering the basin as a whole. The various flood control measures discussed in this and in other subbasin reports are combined in the main report to develop the outline of an integrated flood control plan for the basin within the context of a comprehensive plan. The main report will consider the possibility of various water resource-oriented agencies serving as vehicles for implementing flood damage reduction actions and undertaking additional study needs.

II. DESCRIPTION OF STUDY AREA

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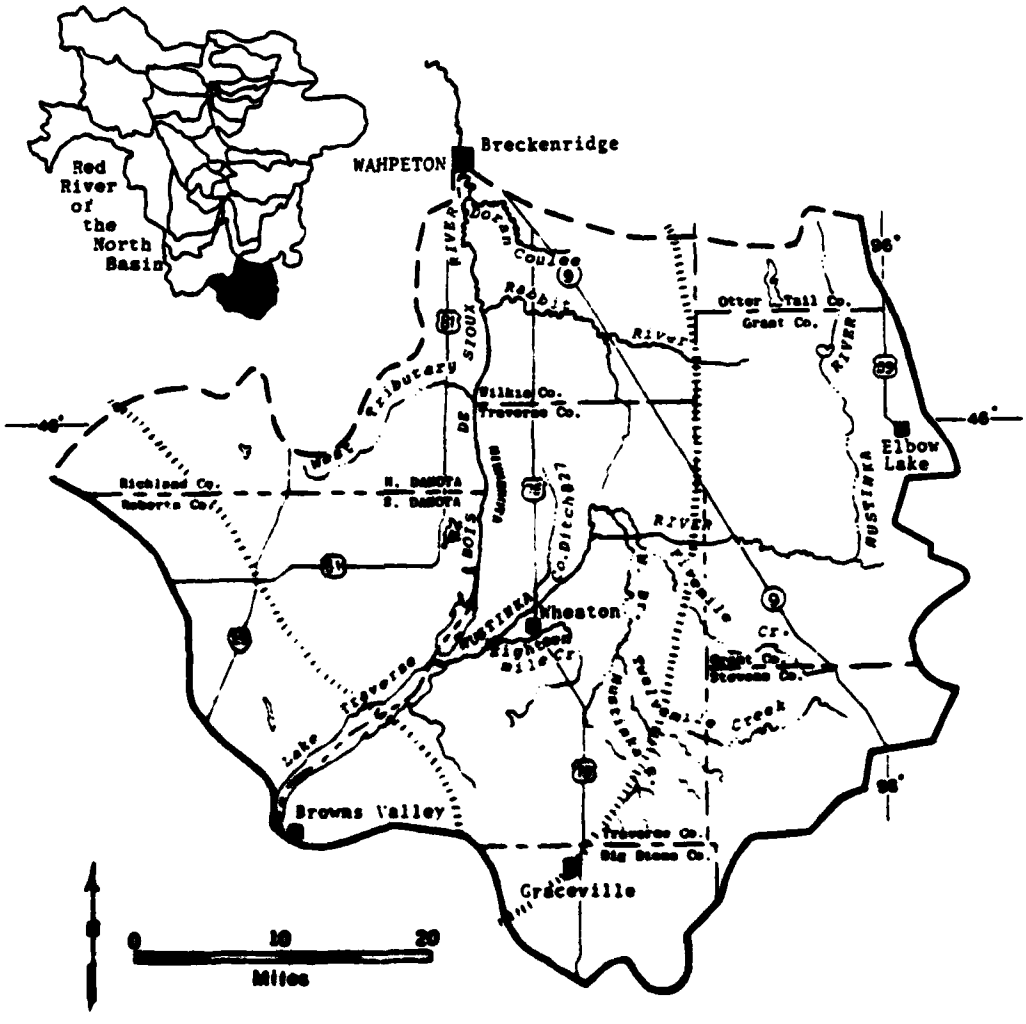
The Bois de Sioux-Mustinka Rivers Subbasin is roughly circular in shape and constitutes the southern limit of the Red River Basin (Figure I). The subbasin occupies portions of Minnesota, North Dakota, and South Dakota and constitutes a total land area of 2,340 square miles, which makes this one of the largest of the subbasins. Most of the subbasin is located in the Minnesota counties of Traverse, Big Stone, Stevens, Grant, Ottertail, and Wilkin. The North Dakota portion of the subbasin is constituted by the southeast corner of Richland County, and the South Dakota portion is constituted by the northeast corner of Roberts County. There are no watershed districts within the subbasin, and the subbasin does not have any legal status to complement its natural status as a hydrologic unit.

The Bois de Sioux-Mustinka Rivers Subbasin is bordered on the northwest by the Wild Rice Subbasin in North Dakota and on the northeast by the Ottertail River Subbasin in Minnesota. The southeast, southwest and southern borders are the limit of the Red River Basin study area. The northern point of the subbasin is constituted by the city limits of Wahpeton, North Dakota, and Breckenridge, Minnesota, which fall within the Main Stem Subbasin.

The total drainage area of the subbasin is about 1,497,000 acres. However, on the northwest and northeast perimeters, it is difficult to distinguish between the drainage areas of the Bois de Souis-Mustinka Rivers Subbasin on the one hand and the Wild Rice and Ottertail subbasins on the other. Generally, the topography of the subbasin is subdued. A near-level glacial lake plain covers most of the eastern portion, and the western portion is characterized by gently rolling glaciated uplands. Between the rolling hills and the flat plain is a transition zone composed of a series of ridges with moderate slopes that are former beach ridges of glacial Lake Agassiz. Most of the subbasin is devoid of vegetation, with the exception of the Lake Traverse and Cottonwood Slough areas. However, there are numerous small lakes, potholes, and swampy areas on the perimeters of the subbasin that form an excellent habitat for wildlife.



Source: Gu outh Research Institute.

Figure I. BOIS DE SIOUX-MUSTINKA RIVERS SUBBASIN

The dominant water features of the subbasin are Lake Traverse, the Bois de Sioux River, the Mustinka River, and the Rabbit River. Lake Traverse and the associated smaller Mud Lake were constructed by the Corps of Engineers in 1941 for flood control and water conservation. Lake Traverse is an open-water lake surrounded for the most part by farm fields and pastures. The northern and southern ends are bordered by marsh vegetation and willow and cottonwood stands. The lake is elongated, with an average width of 1.5 miles and tending in a southwest-northeast direction for about 16 miles. The average depth is 13.2 feet. Mud Lake is about 7.5 miles long, with water less than two feet deep and interspersed with dense stands of cattails and bulrushes.

Lake Traverse and Mud Lake are the source of the Bois de Sioux River, which forms the boundary between the Dakotas and Minnesota and travels northward to the Wahpeton-Breckenridge area, where it meets the Ottertail River to form the Red River of the North. The river drops about 30 feet from Lake Traverse to Wahpeton, or about 0.3 feet per mile of river channel. Before channel improvements, which were completed by the Corps in connection with the Lake Traverse project, the river was very shallow, with large areas of rushes and grasses. The channel has received better definition through straightening and clearing, which were completed in 1941.

The Mustinka River is the main tributary to the Bois de Sioux River. It begins in morainic hills in the northeast portion of the subbasin and flows southerly for about 28 miles, then generally westerly for 26 miles, and then southwesterly for 15 miles to Lake Traverse. The valley of the upstream portion of the river is well defined. However, at Norcross, Minnesota, the terrain becomes so level that drainage divides are not discernible, and the defined valley disappears for about 12 river miles, after which it becomes visible again.

The Rabbit River is another important tributary to the Bois de Sioux. It is located in Grant, Wilkin, Traverse, and Ottertail counties, has a drainage area of approximately 211,000 acres, and flows in a westerly direction before joining the Bois de Sioux about 12 miles south of Breckenridge. Important tributaries to the Mustinka River include Five Mile Creek, Twelve Mile Creek, and Eighteen Mile Creek. Five Mile Creek has been diverted into Twelve Mile Creek through County Ditch No. 42, so that it is actually a tributary to the Mustinka only during periods of high flow.

III. PROBLEMS, NEEDS, AND DESIRES

III. PROBLEMS, NEEDS, AND DESIRES

The primary water-related problems, needs, and desires in the Red River Basin are flood control, fish and wildlife conservation and enhancement, recreation, water supply, water quality, erosion control, irrigation, wastewater management, and hydropower. Various water-related problems, needs, and desires have been identified for the Bois de Sioux-Mustinka Rivers Subbasin in previous planning reports on the basis of analysis of conditions and public and agency comments. The list of problems, needs, and desires for the subbasin is the same as the list for the Red River Basin as a whole, with the exception of hydropower. Each problem is discussed separately below, with an emphasis on flooding problems.

Flooding Problems

Nature of the Problems

Floods occur nearly every year in the subbasin as the result of snowmelt in March or April and sometimes in early May. Frequently aggravated by rains of high intensity, these floods force delays in planting operations which are reflected in reduced crop yields. Given the short growing season, if water stays on the land too long, it may be impossible to engage in planting operations.

Besides spring snowmelt flooding, there is also a significant amount of flood damage from high-intensity summer rains. Although they occur less often, these summer floods are characterized by high peak flows and, unlike spring floods, can cause extensive damage to maturing crops and even render crop harvest impossible.

Two separate types of flooding occur: the most damaging type associated with riverbank overflow (overbank flooding) and another type caused by runoff from snowmelt or heavy rainfall impounded by plugged culverts and ditches within sections of land bounded by roadways on earthen fill (overland flooding). In overland flooding, the trapped water slowly accumulates until it overflows the roadways and inundates section after section of land as it moves overland in the direction of the regional slope until reaching river or stream channels.

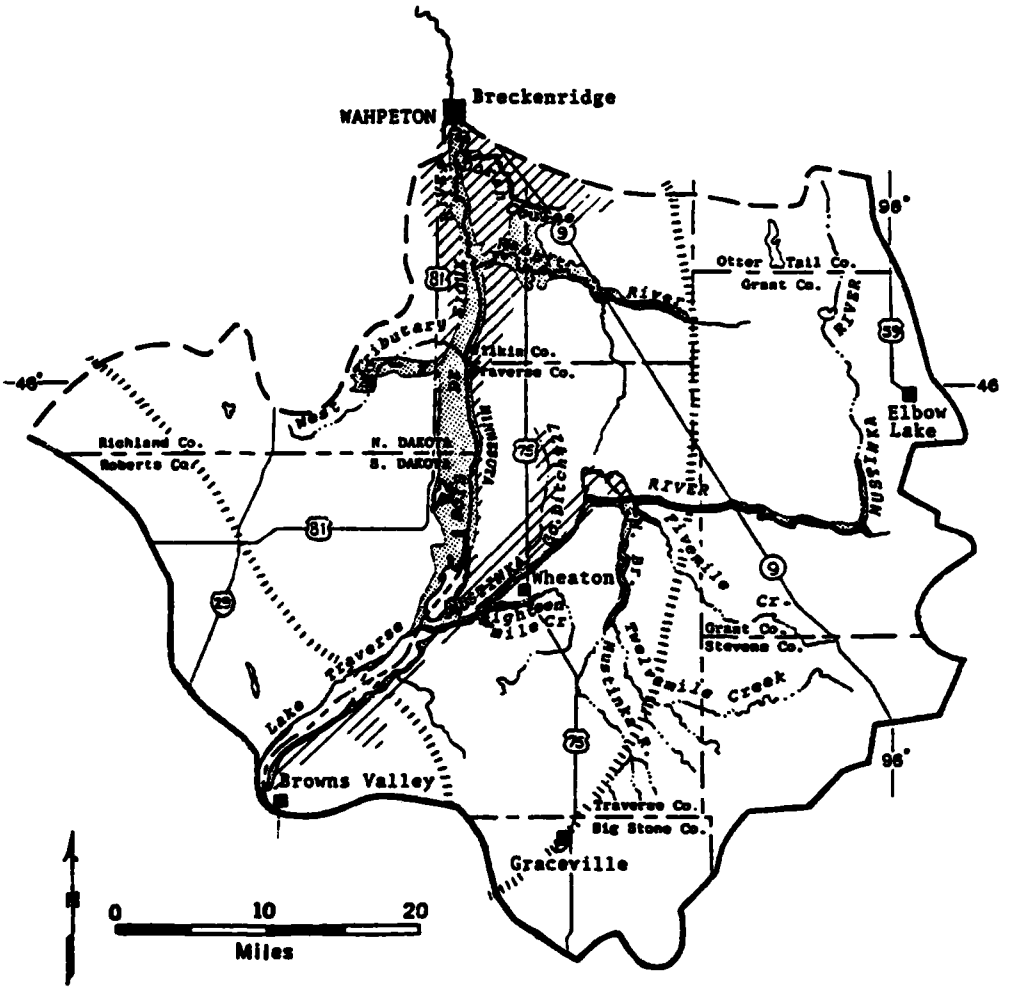
The topography of the subbasin, subdued as it is, nevertheless influences flooding problems. A near level glacial lake plain covers most of the eastern part of the subbasin. The western part is characterized by gently rolling glaciated uplands. This flat topography, together with inadequate channels, contributes to widespread flooding to shallow depths especially prevalent in the central portion of the subbasin.

Flooding conditions within the subbasin are seldom made worse because of peak flows correlated with main stem peak flows, since this area constitutes the headwaters of the Red River. Rather, the subbasin contributes more to floods on the main stem, particularly since snowmelt from this area often occurs when the lower reaches of the Red River are still jammed with ice. The subbasin's rivers contribute to flooding in the Wahpeton-Breckenridge area, but this will be covered in the Main Stem Subbasin report. The subbasin contains about 6.0 percent of the total drainage area of the Red River Basin, and runoff from the subbasin constitutes about 6.5 percent of the total Red River flow at the international boundary.

Location and Extent

Figure II depicts the 100-year floodplain for the Bois de Sioux-Mustinka Rivers Subbasin. Prior to this study, no attempt had been made to publish even a generalized delineation of the entire subbasin. A number of sources were investigated in order to produce the present delineation. Among these were: (1) U.S. Geological Survey (USGS) Flood Prone Area Maps at 1:24,000 scale; (2) Federal Insurance Administration flood maps (various scales); (3) published secondary sources describing flooded areas; and (4) USGS 7 ½ minute topographic maps. Because of the wide disparity of delineated and descriptive data, the latter is shown in an additional crosshatch pattern.

The map is thus a composite of available sources supplemented by inferences where necessary. Because the sources were incomplete and based on surveys differing in purpose and accuracy, it should be understood that Figure II does not constitute a scientific delineation and is useful only for general planning purposes. A more complete description of sources and limitations is given in Appendix A.



Source: Gulf South Research Institute.

Figure II. 100-YEAR FLOODPLAIN

According to this provisional delineation, the Bois de Sioux-Mustinka River floodplain is about 52,000 acres in size. Descriptive sources add another 75,000 acres, expanding the total to 127,000 acres. It is constituted by the following major components: a 2,000-acre area associated with the Mustinka River, a 10,000-acre area corresponding to Rabbit River drainage, and a 40,000-acre Bois de Sioux River floodplain. Consideration of descriptive accounts in the Souris-Red-Rainy River Basins Comprehensive Study would add 30,000 acres to the Mustinka portion and 45,000 acres to the Bois de Sioux floodplain.

Each of the component areas lies entirely within the confines of the Red River Valley glacial lake plain. The Mustinka floodplain area, delineated principally from flood insurance maps, depicts a narrow well-defined band along the length of the principal channel. The delineation from descriptive sources, although general as to location and shape, depicts a much larger area up to three miles in width (Figure II). The Rabbit River floodplain area, on the other hand, is essentially taken directly from flood insurance maps and includes a dominant central segment approximately two miles by six miles in size.

The Bois de Sioux 100-year floodplain (as delineated) varies from about one mile in width at either end to more than two miles in the central segment. The additional area described places the width of the floodplain from two miles near the South Dakota border to more than six miles near the junction with the Ottertail River. The extreme flatness of the area and the corresponding lack of well-defined channels accounts for the large disparity between delineated and descriptive identifications of the subbasin's floodplain.

Flood Damages

The primary areas affected by flooding throughout the subbasin's floodplain are urban, agricultural and environmental in nature. Several small urban areas such as Wheaton, Fairmont and Campbell lie adjacent to the floodplain. Most of the land in the floodplain has been under cultivation for many years. Only urban and rural damages are taken into consideration in the computation of average annual damages.

Present average annual damages in the subbasin are $611,000. In comparison to the other subbasins, this is a very small figure, accounting for less than one percent of the Red River of the North basinwide flood damage total. Average annual damages are divided into two basic classifications: urban and rural. Urban damages include damages to residences, businesses (commercial and industrial) and public facilities (streets, utilities, sewers, etc.). Rural damages include damages to crops, other agricultural assets (fences, machinery, farm buildings, etc.) and transportation facilities. Rural damages account for 98 percent of the total average annual damages in the subbasin, and urban damages account for the remaining two percent.

There were no urban damages in the subbasin as a result of the 1975 or 1979 flood events. Average annual urban flood damages are displayed in Table 1.

Table 1

BOIS DE SIOUX-MUSTINKA RIVERS SUBBASIN, ESTIMATED AVERAGE ANNUAL URBAN FLOOD DAMAGES
(In Thousands of 1979 Dollars)

Category	Flood Damages
Residential	$ 5.9
Business	4.7
Public	1.2
TOTAL	$11.8

Sources: Red River of the North Basin Plan of Study, April, 1977; and Gulf South Research Institute.

Total average annual urban flood damages in the subbasin are $11,800. Residential damages, at $5,900, were the largest single component of this total. Business damages were $4,700 and public damages were $1,200.

There were no rural flood damages in the subbasin resulting from the 1975 flood event. Rural damages (Table 2) incurred in the flood event of 1979 were about 3.5 times higher than the average annual damages. The 1979 flood event resulted in 1,440,000 in crop damages, $644,000 in other agricultural damages, and $143,000 in transportation damages.

Table 2

BOIS DE SIOUX-MUSTINKA RIVERS SUBBASIN, ESTIMATED 1979 AND AVERAGE ANNUAL RURAL FLOOD DAMAGES (Thousands of 1979 Dollars)

Category	1979	Average Annual
Crop	$1,440.0	$412.0
Other Agricultural	644.0	137.3
Transportation	143.0	49.5
Total	$2,227.0	$598.8

Sources: Red River of the North Basin Plan of Study, April, 1977; and Gulf South Research Institute.

Average annual rural flood damages are estimated at $412,000 in crop damages, $137,000 in other agricultural damages, and $49,000 in transportation damages. Total rural flood damages were $2.2 million in the 1979 flood event and $599,000 on an average annual basis.

Environmental Concerns

Much of the native prairie in the subbasin has been eliminated for agricultural production or altered by heavy grazing of livestock. Conversion of woodlands and woody and herbaceous cover in riparian communities to cropland has occurred. These actions have completely eliminated or reduced the quality of habitats available for wildlife resources. Wetland losses caused by draining, filling or leveling, burning, plowing, and siltation are a major problem for migratory birds and resident fauna (U.S. Army Corps of Engineers, 1979; North Central Forest Experiment Station and Minnesota State Planning Agency, no date; Souris-Red-Rainy River Basins Commission, 1972). The Souris-Red-Rainy River Basins Commission (1972) indicated an urgent need for preservation of wetlands and development of replacement habitats due to continued destruction of wetlands and unavoidable delays in authorized acquisition and protection programs.

Lake and stream environments for aquatic biota are being degraded through siltation resulting from wind erosion on nearly all lands and from wind and water erosion on slopes (Souris-Red-Rainy River Basins Commission, 1972). Water quality problems in Lake Traverse and Mud Lake, discussed

later under water quality, are adversely affecting aquatic habitats and biota. "Winterkills" occur periodically in these two lakes as a result of depressed oxygen levels, which has favored rough fish populations. Additionally, algal blooms and high turbidities have tended to limit habitat and spawning sites for game and pan fish. Minnesota and South Dakota are now trying to rectify this situation (Falk et al., 1975; U.S. Army Corps of Engineers, 1979a, b). Intermittent stream flows and low dissolved oxygen levels in the Bois de Sioux River, as indicated by the South Dakota Department of Natural Resources Development (1975), are undoubtedly affecting aquatic organism populations.

Recreation Problems

Recreational areas are concentrated in the eastern and western portions of the subbasin. Problems in the region relate primarily to water quality rather than to the quantity of resources. Lake Traverse and Mud Lake illustrate problems that are typical in the lake areas of the subbasin. These lakes have been declining in fishing and other water-related recreational activities during the past few years. Area lakes are basically shallow and are seriously affected by siltation and low water levels. The introduction of agricultural wastes through runoff encourages excessive growth rates for algae and nuisance aquatic plants and accelerates the eutrophic condition of many lakes. Domestic sewage disposal has adversely affected the recreational and aesthetic qualities of many lakes and streams. Several communities, such as Elbow Lake and Wheaton, are upgrading sewer facilities.

Unplanned resort and residential growth along lakeshores, particularly along Lake Traverse, has added to erosion and water quality problems. In a survey conducted in 1975 (Environmental Assessment of Lake Traverse), 44 percent of the respondents rated recreation as the primary benefit of the Lake Traverse reservoir. In view of the importance of the lake as a recreational resource, plans for correcting pollution problems and controlling erosion should be implemented.

Water Quality Problems

On the Minnesota side of the subbasin, recent water quality data for the Mustinka River (1958) and Bois de Sioux River (1962-1964) are lacking

In the Mustinka River watershed, problems in the past were associated with low dissolved oxygen concentrations, excessive turbidities, and moderately high nitrate and phosphorus levels (probably caused by sewage or agricultural wastes). Comparison of the old data with more recent data from other segments indicate that violations with turbidity are still likely to occur, as well as fairly high nitrate and phosphorus levels. Problems in the Bois de Sioux River watershed are related to high turbidities, in violation in 50 percent of the samples; fairly high phosphorus levels; and high fecal coliform concentrations, in violation in 17 percent of the samples (Minnesota Pollution Control Agency, 1975).

In North Dakota, in the area between the South Dakota line and the Wild Rice River, the problem parameter is phosphates originating from non-point sources that are impairing recreational usage of the Bois de Sioux River (North Dakota State Department of Health, 1979). In South Dakota problems in the Bois de Sioux River are related to low dissolved oxygen levels for fish life propagation. It was noted that the stream is essentially dry during part of most years and that extremely low streamflows have resulted in a small assimilative capacity (South Dakota Department of Natural Resources Development, 1975).

With regard to Lake Traverse and Mud Lake, eutrophication has advanced to the point where algal blooms occur in summer and early fall. Causative factors include (1) nutrients in runoff from surrounding farmlands; (2) runoff from adjacent cattle yards and direct access by livestock; (3) sewage wastes from Wheaton and private residences; and (4) cattle wastes from the Mustinka River. The shallowness of the two lakes creates a problem in relation to high turbidities generated by wind and wave action. Both lakes experience decreased oxygen levels during the winter months, when there is high fertility, shallowness, and restricted inflows in Lake Traverse and shallowness, combined with accumulated organic muds, thickness of the ice, and near absence of water conduction in Mud Lake (Falk et al., 1975; U.S. Army Corps of Engineers, 1979a, b).

Groundwater quality problems in the subbasin are related to undesirable levels of manganese, sulfate, iron, total dissolved solids, and fluoride (Souris-Red-Rainy River Basins Commission, 1972; South Dakota Department of Natural Resources Development, 1975).

Water Supply Problems

There are approximately 39,000 acres of surface water available in lakes in the subbasin; however, only about one-third of the acreage is in lakes over 40 acres in size. The lakes have inadequate storage potential that would be required to meet the needs of an adequate municipal water supply. Lake Traverse and Mud Lake are used primarily for flood control and are subject to limited flows and high evaporation rates. The major rivers of the area (i.e., Bois de Sioux, Mustinka, and Rabbit) experience periods of no-flow or low flow and are high in dissolved solids. Consequently, groundwater is used for water supply throughout the subbasin.

There are many glacial drift wells in the lake plain area; however, some of the wells yield less than 10 gallons per minute (gpm) and produce water that is high in dissolved solids and iron. Public officials in each of the three largest towns in the subbasin (Wheaton, Elbow Lake, and Brown's Valley) report water supply problems in recent years. Additional wells have been drilled in Wheaton and Elbow Lake into the aquifers currently supplying the towns; however, Brown's Valley is in the process of locating new aquifers because of possible contamination of the presently used aquifer by an overlying disposal area. The increase in the number of wells is attributed to a need for upgrading the municipal systems rather than aquifer depletion. Additional problems experienced by the major towns include high iron and manganese content at Wheaton and corrosion of water lines because of chemical properties of the soil at Brown's Valley. Elbow Lake has corrected supply problems with the addition of two wells in 1978. In Wheaton, water treatment plans are being formulated and implemented. All of the towns' reported supplies were adequate to meet anticipated demands because the populations have remained stable over the past few years, and growth is expected to be very gradual.

Erosion Problems

Erosion problems from wind and water are experienced in the subbasin. Wind erosion causes soil losses in the subbasin slightly in excess of the allowable loss per acre. Although loss of topsoil and fertility

are problems locally within the area, the major concern is air and water pollution caused by wind-borne sediment. Upland sandy soils and some bottomland soils with high slopes are particularly susceptible to severe wind erosion and require proper land treatment.

Water erosion accelerated by flooding affects agricultural lands, roadsides, and streambanks. Some areas of lake shoreline have been affected by wave-induced erosion, which results in increased sedimentation and water pollution. Loamy sands with high slopes in the eastern and western sections of the subbasin are subject to moderate to severe water erosion. Large areas of agricultural land are exposed to potential erosion during the summer and fall and should be protected by land treatment measures. Siltation caused by water and wind erosion on the slopes has resulted in the loss of some wetlands and has decreased the fishing value of lakes and streams.

Irrigation

The eastern portion of the subbasin is located in the West Central Region Planning District in Minnesota. Irrigation throughout this region has been on a constant increase since the 1930's. Although the initial investment for equipment is relatively large, many farmers who have proper soil and water conditions will invest in an irrigation system to reduce the climatic risk involved in agriculture. Between 1970 and 1974 the number of irrigated acres in the region increased from 9,400 to 32,600. Of the 1974 total regional acreage, more than 45 percent was in Ottertail County. The region's total irrigated acreage accounts for almost 30 percent of the state's total irrigated acreage.

The western portion of the subbasin has a negligible amount of irrigated acreage. There has been little interest by landowners in irrigation even though a sizeable portion of the land has been classified as suitable for irrigation. Because of lack of interest on the part of farmers, irrigation development will probably be slow. The availability of suitable water for irrigation purposes is unknown.

County agents in Minnesota predict that the trend toward increased irrigation will continue well into the future. Increasing the irrigated

acreage may lead to the development of specialty crop farming and encourage the location of additional agri-processing plants in west central Minnesota.

Wastewater Management

The Bois de Sioux and Mustinka rivers are described as Water Quality Limited because of the following conditions: (1) periodically the stream flows are not sufficient to provide enough dilution to maintain water quality standards after introduction of secondarily (or best practicably) treated effluents; (2) non-point sources are expected to cause violations of water quality standards (Minnesota Pollution Control Agency, 1975).

Thirteen point sources have been identified within the Minnesota portion of the subbasin: six municipalities, one industry, three municipal water treatment works, and three major feedlots. These dischargers are presented in Table 3 along with problems, treatment needs, and other planning considerations (Minnesota Pollution Control Agency, 1975). No point sources are indicated within North or South Dakota, where waste discharges are generally small and intermittent (North Dakota State Department of Health, no date; South Dakota Department of Natural Resources Development, 1975).

Hydropower

There are no hydropower facilities in the subbasin, and there are no plans to construct any plants. Development of hydroelectric power plants is limited by the flat terrain of the subbasin. Most of the future large-scale hydropower developments in Minnesota are expected to occur in the Minneapolis-St. Paul area, which is located southeast of the Red River Basin.

Public Perception of Problems and Solutions

The public's perception of problems and solutions in the subbasin is not adequately defined at this point because the Corps of Engineers has not held any public meetings in this area, and the subbasin has not been organized as a watershed district. However, several sources including informal meetings and discussions with local interests do reflect public perception of problems and solutions.

Table 3

PROBLEMS AND TREATMENT NEEDS OF POINT SOURCE DISCHARGERS IN THE BOIS DE SIOUX-MUSTINKA RIVERS SUBBASIN

Receiving Water	Discharger Description	Discussion of Problems	Treatment Needs	Other Planning Considerations
Mustinka River	Wendell	Inadequate treatment	New facility	Low on MNL - will not be considered for funds in the near future must apply for permit 180 days before discharge
Mustinka River	Marius Martineau Feedlot	No apparent problems if facility is maintained properly	None if present pond is maintained properly	----
Worm Lake	Elbow Lake Water Treatment Works	No treatment	Treat wastes or connect to municipal system	Contract for connection option executed by 6/30/75 connection by 6/30/76 draft permit
Worm Lake	Elbow Lake	Treatment is inadequate for all measured parameters: Phosphorus removal needed	New facility or advanced treatment	Interim effluent limits in permit: low on MNL
Pullman Lake	Herman	Treatment is adequate	*Treatment should be* adequate	*Population projected to decline*
West Branch Mustinka River	Anthony Arens Feedlot	No apparent problems if facility is maintained properly	None if present pond is maintained properly	----
West Branch Mustinka River via Ditch C-4	Graceville	Treatment appears adequate	Uncertain but ponds should be adequate	----
West Branch Mustinka River	Zobach's Locker	No Treatment	----	----
Twelve Mile Creek via a lake	Donnelly	Inadequate Treatment	New facility	Population decreasing rapidly low on MNL - must apply for permit 180 days before discharge
Joe Pederson's Slough	Donnelly Water Treatment Works	No Treatment	Treat Wastes	Draft permit
Twelve Mile Creek	Kenneth Baldry Feedlot	No apparent problems if facility is maintained properly	None if present pond is maintained properly	----
Mustinka River	Wheaton	Poor maintenance: plant is not designed to meet standards & is inadequate	New facility or advanced treatment	Low on needs list draft permit interim standards
Worm Lake	Culligan Elbow Lake, Inc.	Need treatment	Provide adequate Treatment	----
South Fork Rabbit River	Campbell	No apparent problems	----	----

Source: Minnesota Pollution Control Agency, 1975.

The primary documents for determining public perceptions of problems and solutions are the West Tributary Bois-de-Sioux River Watershed Work Plan and separate applications for assistance for West Branch Mustinka and Rabbit River watersheds under the Watershed Protection and Flood Prevention Act (Public Law 566). The former was published in 1960 by the North Dakota Soil Conservation Service with the assistance of the South Richland County Soil Conservation District, the Richland County Water Conservation and Flood Control District, and the U.S. Soil Conservation Service. At that time, the primary water-related needs identified for the subbasin were conservation of fish and wildlife, water quality, erosion control, and flood control.

The application for assistance for improvements in the Rabbit River watershed made in 1962 is similar to the application for improvements in the West Branch of the Mustinka watershed submitted in 1968. Both cited water and sediment damage to crops, roads, bridges, culverts, and farm buildings and loss of livestock. Objectives centered on structural improvements for flood control and emphasis on land conservation measures to reduce pollution and sediment damage and assist in fish and wildlife management. Specific technical, educational, and financial assistance is indicated as a need for meeting the problems of the respective watersheds.

Additional evidence for interest in flood control measures is contained in public hearings held in East Grand Forks in 1978 and 1979 before subcommittees of the committee on Public Works and Transportation of the U.S. House of Representatives. From these documents, it is evident that residents of the Red River Basin consider flood control to be the primary water related need for the area and that they are interested in whatever solutions may be proposed by Federal, state, or local agencies.

IV. DESCRIPTION OF SUBBASIN RESOURCES

IV. DESCRIPTION OF SUBBASIN RESOURCES

This section of the report discusses the primary resource conditions within the subbasin that are water-related and that would be affected by a comprehensive water and related land resources plan centering on flood control measures.

Social Characteristics

The population of the subbasin remained fairly stable between 1920 and 1940 and declined steadily from 1940 to 1970. The decline in population resulted from the consolidation of smaller farms, mechanization, and the lack of industrial opportunities. Between 1970 and 1977, however, the subbasin's population experienced a slight increase of 0.5 percent (from 21,208 to 21,320), so that the present density is about nine persons per square mile. Although some of the counties within the subbasin had a net out-migration rate as high as -7.3 percent, (notably Traverse County) three of the counties experienced in-migration. Richland County, North Dakota, and the counties of Grant and Ottertail in Minnesota had in-migration rates ranging from 2.5 percent to 6.4 percent between 1970 and 1977. Preliminary figures for 1978 for Grant and Ottertail indicate that these counties are still experiencing inmigration.

There are 20 towns in the subbasin, 16 of which are located in Minnesota. The largest towns are Wheaton (2,008), Elbow Lake (1,404), Brown's Valley (977) and Graceville (749), all of which are located in Minnesota. Counties experiencing inmigration show increases in the smaller towns and rural areas. Of the four largest towns, Brown's Valley is the only one that is increasing in population. Telephone contacts with local public officials indicate that the increase in rural population and decrease in the population of larger towns reflects the local preference for a rural way of life. Increasing rural population appears to be a result of a decline in the farm consolidation rate and an increased turnover of farms to sons and daughters. Outmigration was reported to occur because the current expense of establishing a farm precludes many young people from buying land and operating their own farm. Since there is little industry in the larger

towns to attract young people, the trend is to migrate to industrial centers outside the subbasin to find employment.

The population of the subbasin is close-knit because of common ethnic backgrounds and other features such as home ownership, length of residence, and place of employment. Most of the people living in the area are of German and Norwegian background. The minority population is too small to be identified, but it should be noted that there are approximately 3,500 American Indians living on the Sisseton Reservation, a portion of which lies within Richland (North Dakota) and Roberts (South Dakota) counties.

Sections of eight counties are included in the study area. Home ownership data (1970) for these counties show ranges from 71.3 percent in Stevens County to 82.5 percent in Grant County. The number of people living in the same residence since 1965 varied from 59 percent in Stevens County tc 69 percent in Traverse County. Those residing within the same county ranged from a low of 76 percent in Stevens County to a high of 97 percent in Roberts County. Percentages of those who reside and work in the same county range from 75.8 percent in Wilkin County to 85.8 percent in Traverse County.

Economic Characteristics

Employment

Between 1940 and 1973 there was a shift from agriculture-related to nonagriculture-related employment in the subbasin. This decrease was largely the result of consolidation of farms and mechanization. Employment in other sectors, particularly trade and services, increased. This resulted in a total employment increase from 7,635 in 1970 to 9,168 in 1977. Agricultural employment is expected to continue to decline in the future, but at a lesser rate. An increase in agricultural processing plants and relatively higher prices for farm products would act as a stimulus to the industry and would increase employment in this sector.

Unemployment in the subbasin averaged about five percent during the 1970's. During the months of February, March and April, unemployment reaches its highest level. Employment in agriculture and construction

drops sharply because of cold weather. In addition, the service and retail trade industries experience decreases in employment because the tourist season has passed. Unemployment rates reach their lowest levels during the spring, summer, and fall months because this is the height of the tourist season, and agriculture and construction employment are at their peak.

Income

Total personal income for the subbasin increased from $98 million to $189 million between 1969 and 1977 (as expressed in 1979 dollars). Farm income accounts for more than 70 percent of the total personal income, and cash grain sales amount to more than half of the farm income. Average per capita income during the same years increased from $4,606 to $8,878, which was slightly above the 1979 state average of $8,314. This is one of the highest per capita income figures in the Red River Basin. Although there has been an upward trend in both total personal and per capita income, fluctuating farm prices are the primary determinants of income changes from year-to-year. In addition, severe flooding can cause sharp declines in income.

Business and Industrial Activity

Agriculture

Agriculture is the predominant sector in the subbasin's economy, and the production of grain and livestock are the most important agricultural components. Cattle are the single most important agricultural product raised in the western half of the subbasin, primarily in North and South Dakota. In 1969, cattle production accounted for approximately one-half of the farm income in this portion of the subbasin. In the eastern part of the subbasin, grain production is more important. Approximately 91 percent (or 1,363,000 acres) of the subbasin's land area is under cultivation, and another four percent is devoted to pasture.

The major crops grown in the subbasin are identified in Table 4. Wheat and corn are the leading crops, accounting for approximately 57 percent of the harvested acreage. These crops are followed by sunflowers, barley, and soybeans, which amount collectively to 40 percent of the

harvested acreage. Very minor acreages of flax, hay, rye, and sugarbeets are also grown. It is significant that the production of sunflowers during recent years has increased to the point that it is a major crop.

Table 4

1978 CROP STATISTICS, BOIS DE SIOUX-MUSTINKA RIVERS SUBBASIN

Crop	Harvested Acres	Yield Per Acre	Total Production
Wheat	272,700	25.1 bushels	6,844,770
Corn	246,000	78.2 bushels	19,237,200
Sunflowers	165,600	1,409 pounds	233,330,400
Barley	109,300	40.3 bushels	4,404,790
Soybeans	92,200	25.1 bushels	2,314,220

Source: Gulf South Research Institute.

Manufacturing

There are a few small manufacturing establishments located throughout the subbasin. These establishments are primarily involved in manufacturing agricultural products, mainly livestock feed and fertilizer. Of the 21 manufacturers in the subbasin, 12 produce feed and fertilizers. Table 5 groups the manufacturers according to their Standard Industrial Code (SIC) numbers. None of these establishments has more than 25 employees (Table 5).

Table 5

MANUFACTURING ESTABLISHMENTS, BOIS DE SIOUX-MUSTINKA RIVERS SUBBASIN

SIC	Description	Estimated Employment
20	Food and Kindred Products	40
27	Printing and Publishing	35
28	Chemicals and Allied Products	20
32	Stone, Clay, Glass and Concrete Products	10
35	Machinery, except Electrical	8
42	Motor Freight Transportation	10
51	Wholesale Trade-Nondurable Goods	20
76	Miscellaneous Repair Services	10
TOTAL		153

Sources: 1979-1980 Minnesota Directory of Manufacturers; 1978-1979 Directory of North Dakota Manufacturing; 1980 South Dakota Manufacturers and Processors Directory.

Trade

In 1977, total trade receipts for the subbasin exceeded $165 million (expressed in 1979 dollars). More than 60 percent (or $100.9 million) of the receipts were wholesale trade. Retail trade and selected service receipts were $64.5 million and $5.2 million, respectively, in 1977.

Transportation Network

The entire area is rural in nature, and a good transportation network is necessary to move farm produce to market and receive services from the metropolitan areas. In Minnesota the subbasin is crossed from north to south by Federal Highway 75, which passes through the towns of Doran, Wheaton, Dumont, and Graceville. It is also crossed by State Highway 9, which passes through the towns of Campbell, Tintah, Norcross, Herman, and Donnelly. State highways 27 (through Browns Valley, Wheaton, Herman), 28 (through Graceville), and 55 (through Elbow Lake, Nashua, Tenney, Wendell) cross the subbasin in an east-west direction.

Each of these major highways in Minnesota connect with Interstate 94, which provides direct access to Minneapolis-St. Paul and serves as a connection to Interstate 35, which leads north to the Port of Duluth. In the extreme western portion of the subbasin, the major highway that crosses from north to south is Interstate 29. This highway provides access to Sioux Falls, South Dakota (south of the subbasin) and to Fargo-Moorhead and Grand Forks (north of the subbasin).

One petroleum product pipeline crosses the subbasin near the towns of White Rock and Rosholt, South Dakota, and near Wheaton, Minnesota. There are five small airports located in the subbasin, each of which provides a landing strip and facilities mainly for local use. The subbasin is traversed by the Burlington Northern Railroad, the Soo Line, and the Chicago, Milwaukee, St. Paul and Pacific.

Land Use

Approximately 91 percent of the subbasin is under cultivation, 3.6 percent is pasture, and 2.8 percent is water, and the remainder is urban. Less than one percent of the subbasin is in forest or woodland. Most

of the woodland consists of windbreaks and farm woodlots that have been planted. There are also some small stands of natural woods along the bluffs around Lake Traverse. Urban development is minimal.

Land use in the floodplain does not differ significantly from land use in the subbasin. The floodplain is an important agricultural area that is used primarily to grow corn and small grains.

Recently there has been an upward trend in the amount of cropland converted to pasture and grazing, especially in the western portion of the subbasin. It is thought that the government feed grain programs have been the most significant factor in this trend.

Environmental Characteristics

Climate

Climatological data is available from the U.S. Weather Bureau Stations in Campbell, Brown's Valley, Elbow Lake, Fergus Falls, and Wheaton. The area is characterized by an annual mean temperature of 40.8°F. Extreme temperatures range from 114°F to 45° below zero. There is a frost-free period of 133 days from mid-May to late September, which severely restricts the growing season. Average annual precipitation is 23 inches, varying from 21 inches in the western area to 24 inches in the eastern section of the subbasin. Fifty to 60 percent of annual precipitation occurs from May to August (during the growing season). Snowmelt runoff in spring and rainstorms during spring, summer, and early fall contribute to flooding problems within the subbasin.

Geology

The subbasin lies within the Central Lowlands Province of the Interior Plains Division. Bedrock geology consists of precambrian and cretaceous deposits. The cretaceous sediments are primarily sandstone with interbedded shale. There is some thin shaley limestone and clay in the western portion of the area. Almost two-thirds of the subbasin is underlain by cretaceous deposits of the Colorado group. Glacial deposits include areas of till, outwash, lakeshore, and lake sediments. The western portion of the subbasin is characterized by till, which is a heterogeneous mixture of clay, silt, sand, and gravel. This area includes the ground and end moraine. There

are scattered ice-contact and glacial lakeshore deposits in this portion, banded by small outwash areas of sand and gravel. The eastern portion of the subbasin is underlain by till and glacial lakeshore deposits of delta sand and gravel. There are also areas of clay and silt glacial lake deposits and some beach sands in North Dakota and South Dakota.

Biology

Very little forest vegetation exists in the Minnesota portion of the subbasin, with the exception of some small stands of the elm-ash-cottonwood type along the eastern shore of Lake Traverse (1977 forest type map developed by the North Central Forest Experiment Station and Minnesota State Planning Agency, no date). There are limited stands of woods along the rivers and various tributaries located in the subbasin. Falk et al. (1975) in a study of the flora in the Lake Traverse-Mud Lake area found little true aquatic vegetation in Lake Traverse but defined 11 community types in the area:

1. Cattail-common reed-bulrush community: located in the shallow water areas
2. Willow-cottonwood community: found in small clumps around lake shores, reaching maximum development at the mouth of the Mustinka River
3. Cottonwood community: around lake edges
4. Elm-basswood community: found on slopes and up ravines
5. Green ash-boxelder-bur oak community: located on steeper and lower slopes and in draws
6. Bur oak savannah community: occupies the xeric zone near tops of valley slopes and ravines
7. Reed canarygrass-prairie cordgrass community: situated in small areas around seepages and wet springs
8. Big bluestem-switchgrass-Indian grass community: in mesic zone above wet meadows, used as hayland and for grazing
9. Little bluestem-big bluestem-needlegrass community: more xeric grassland, most of it in intensive cultivation and grazing
10. Little bluestem-stonyhills muhly-sideoats grama community: in the more xeric areas of steep slopes and hills
11. Tame grassland community: occupies minor areas, most of it under heavy cultivation

Mann (1979) defined the wetland zones of the subbasin on the Minnesota side: Red River Valley Lake Plain, Minnesota River Valley and Wet Prairie Till Plain, and Border-Pairie Transition. The lake plain zone includes the Wilkin County, western Grant County, and most of Traverse County portions of the subbasin. The tillplain zone includes the eastern Big Stone and the southwestern tip of Traverse County portions. The transition zone encompasses the remaining part of the subbasin. The majority of the wetlands are located in the morainic hills of the eastern and western reaches of the subbasin and are composed mainly of Type 3-5 wetlands (Souris-Red-Rainy River Basins Commission, 1971, 1972).

Habitats of major importance to wildlife consist of grasslands or prairie, woodlands, or wetlands. Intensive grazing and farming have reduced much of the areal extent of prairie and forests in the subbasin. These two environs can be very important to wildlife resources by providing feeding, resting, breeding, and nesting habitats for migratory and resident wildlife species. As indicated above, the majority of wetlands are found in the western and eastern portions of the subbasin. Breeding and spawning sites for aquatic biota are provided when wetlands are associated with aquatic systems such as lakes and streams. In upland areas they afford important breeding, nesting, feeding, and/or resting areas for fauna such as waterfowl, big and small game, furbearers, and other wildlife.

The principal big-game animal in the subbasin is the white-tailed deer, which is found in the vicinity of large lakes and sloughs and along stream bottoms. Moose and black bear are accidental species occurring in the area. Upland game birds consist of the pheasant (5-90/section) and gray partridge. Common game mammals include the fox squirrel, jack rabbit, and cottontails. Typical furbearers are the muskrat, beaver, mink, raccoon, and red fox (Falk et al., 1975; Mann, 1979; Souris-Red-Rainy Rivers Basin Commission, 1972; U.S. Fish and Wildlife Service, 1979 and 1980).

Waterfowl commonly breeding in the wetlands of the subbasin consist of the mallard, blue-winged teal, redhead, and coot. Waterfowl production is substantial in wet years. Some 103 species of breeding birds have

been reported from the Minnesota portion of the subbasin: non-native pest birds--three species; non-native game birds--two species; native game birds--15 species; and native non-game birds--83 species. Typical nongame breeding birds in the subbasin include the western meadowlark, horned lark, bobolink, and vesper sparrow. A colonial bird nesting site for the western grebe is located at Lake Traverse (Henderson 1978a, b).

About 17 species of herpetofauna possibly occur in the subbasin. The more common species include the northern prairie skink, western plains garter snake, and northern leopard frog. Approximately 23 species of nongame mammals inhabit the subbasin, with typical animals consisting of the short-tailed shrew, striped skunk, meadow vole, and northern grasshopper mouse (Henderson, 1979a and b; Henderson and Reitter, 1979).

As discussed under "Flooding Problems", the Bois de Sioux River joins with the Ottertail River to form the headwaters of the Red River of the North. The Mustinka River, one of two major tributaries, flows into Lake Traverse, which is a flood control impoundment on the southern most reaches of the Bois de Sioux. The combined waters flow into another smaller reservoir, Mud Lake, and then into the main stem of Bois de Sioux River. The other major tributary, Rabbit River, flows into the Bois de Sioux River approximately 20 miles downstream from Mud Lake.

The Bois de Sioux River experiences periodic flooding in the spring and occasional no-flow stages during periods of drought. Because of the high nutrient content from municipalities, feedlots, agricultural runoff, etc., the water quality has been degraded. This is especially true in Lake Traverse and Mud Lake, where eutrophication has proceeded into advanced stages. In spite of these conditions, the Bois de Sioux River is classified as a Class II (high priority fishery resource) stream due to the highly valued sport fishery for channel catfish, walleye, northern pike, and sauger that occur on the river (U.S. Fish and Wildlife Service; and North Dakota Game and Fish Department, 1978). Other common game and sport fishes include smallmouth bass, rock bass, and yellow perch. Small and rough species such as Johnny darters, common shiners, spotfin shiners, white sucker, red horse, and carp are also present (Peterson, 1975).

The fisheries resources of Lake Traverse vary seasonally. During the summer months, algal blooms are present due to the increased temperatures and light penetration. "Winter kills" occur during the winter months when optimum conditions arise such as large amounts of decomposing algae, extended periods of snowfall, and increased organic matter. Common species in Lake Traverse include sheepshead, emerald shiner, northern pike, crappie, and white bass. Along the littoral zone, several types of crustaceans such as crayfish, copepods, amphipods, and rotifers are present. Some insect larvae, bryozoans, and leeches inhabit this same zone. These variations in populations are brought about by the narrow but diverse band of emerged and submerged plants along the rocky shorelines. Where the shoreline is composed of mud and muck, the flora and fauna is more limited. Here the most abundant animal species is the chironomids and occasionally some oligochaetes and amphipods (Falk, et al., 1975).

Table 6 lists the fish and game lake resources, by lake type, in the counties that comprise the subbasin. Traverse County contains most of the drainage area, with Grant and Wilkin counties comprising most of the remaining area.

Water Supply

Groundwater is used for water supply throughout the subbasin. Groundwater moves from the morainal area in the eastern portion of the subbasin to the lake plain and Bois de Sioux River. Most of the wells in the lake plain that supply many of the towns and most of the farms yield less than 10 gallons per minute (gpm). However, supplies are considered adequate to meet future demands.

The three largest towns pumped a total of 227,106,000 gallons of water from aquifers in 1979. Based on 1979 figures, Wheaton uses 250,000 gpd, Brown's Valley uses 204,989 gpd, and Elbow Lake uses 167,219 gpd (personal communication with public officials). Wheaton and Elbow Lake supply significant amounts of water to agricultural processing plants.

Shortages of water during summer months in the largest towns have been corrected by the addition of new wells. Supplies are considered adequate in the subbasin for livestock, rural farms, and municipalities,

Table 6

FISH AND GAME LAKE RESOURCES, BY LAKE TYPE, IN THE COUNTIES INCLUDED IN THE BOIS DE SIOUX RIVER SUBBASIN

	County											
	Traverse		Wilkin		Grant		Ottertail		Stevens		Big Stone	
Lake	Number	Acres	Number	Acres	Number	Acres	Number	Acres	Number	Acres	Number	Acres
Dry Lake Basins[1]	5	304	-0-	-0-	52	1,869	27	1,110	84	5,207	22	2,490
Game Lakes[2]	58	2,125	24	523	215	9,795	605	31,184	212	10,741	164	17,834
Marginal Lakes[3]	3	7,514	-0-	-0-	34	6,335	267	26,633	12	3,009	6	1,346
Fish and Game Lakes[4]	-0-	-0-	-0-	-0-	-0-	-0-	4	515	-0-	-0-	-0-	-0-
Fish Lakes[5]	-0-	-0-	1	--	5	--	131	--	2	--	1	--
Unclassified Lakes[6]	-0-	-0-	1	150	1	93	72	28,110	2	204	-0-	-0-
Centrarchid Lakes[7]	-0-	-0-	-0-	-0-	1	4,368	20	12,695	-0-	-0-	-0-	-0-
Walleye Lakes[8]	-0-	-0-	-0-	-0-	1	1,794	13	72,140	-0-	-0-	1	11,135
Trout Lakes[9]	-0-	-0-	-0-	-0-	-0-	-0-	1	31	-0-	-0-	-0-	-0-

[1] Dry lakes as reported here include those basins that do not have standing water throughout the year. This includes drained lake basins, dry basins with emergent vegetation such as cattails, and shrub swamps.

[2] Game lakes are those lakes shallower than six feet which ordinarily contain water throughout the years. They are ordinarily designated as being Type III or Type IV marshes.

[3] Marginal lakes are those that range from six to 20 feet deep, winterkill, and frequently have rough fish populations. Lakes with inlets are most likely to have rough fish populations.

[4] Fish and game lakes are defined as lakes in which both the game and fish resources are of major importance. These are lakes with several distinct connected basins, some river lakes, impoundments (especially the navigation pools on the Mississippi River), and the northern pike--wild rice--waterfowl lakes.

[5] Fish lakes are those that do not winterkill and have maximum depths that are ordinarily more than 20 feet and average depths that are 10 feet or more. Some soft water lakes, however, have average depths less than 10 feet and do not winterkill, and some fertile shallow lakes have inflows of water that add sufficient oxygen to prevent winterkills.

[6] Unclassified fish lakes are those where sufficient information is available to determine that they do not winterkill and are definitely fish lakes, but data available does not justify further classification. This category also includes a few lakes that do not readily fall into the remaining categories. For example, rough fish lakes that do not winterkill.

[7] Centrarchid lakes are those having fish populations that are primarily composed of bluegills, pumpkinseed, crappies, rock bass, largemouth bass, and/or smallmouth bass. These lakes frequently have good populations of northern pike. Some of these lakes contain populations of walleye that are either artifically maintained or are a natural population that is a small fraction of the total fish population. In the northeastern part of the state smallmouth bass and rock bass tend to be the most important segments of a centrarchid population in a lake. Crappies and green sunfish are the centrarchids that occur most commonly in very eutrophic southern lakes.

[8] Walleye lakes are those having walleyes, yellow perch, common suckers, northern pike, and frequently tullibee as the main constituents of the fish population. Sometime these lakes have fair sized populations of centrarchids, but they tend to be restricted to protected areas such as shallower weedy bays.

[9] Trout lakes are those containing known populations of trout, either naturally or maintained by stocking.

Source: Peterson (1971).

but insufficient to permit irrigation on a large scale. There is a naturally high mineral content in both surface and groundwater supplies, which presents water quality problems.

Water Quality

As indicated earlier in the Problems and Needs section, surface water quality problems in the subbasin are related to low dissolved oxygen, excessive turbidities, moderately high nitrate and phosphorus levels, high bacterial concentrations, and low flows in the streams. In Lake Traverse and Mud Lake, eutrophication, high turbidities, and low dissolved oxygen levels (mainly in winter months) are problems. Known or suspected sources for most of the parameters were also included in the discussion.

Table 7 gives water quality data for the Mustinka River at Wheaton in 1958 and the Bois de Sioux River from 1962 to 1964. Table 8 presents 1963-1966 data for the Bois de Sioux River near White Rock. These data are probably not indicative of present conditions. Falk et al. (1975) conducted water quality analyses for certain parameters from Lake Traverse and Mud Lake in 1974. The parameters investigated included temperature; total, suspended, and dissolved solids; conductivity; hardness; alkalinity; pH; COD; DO; chlorides; sulfate; phosphate; ammonia; and nitrate. These data are not incorporated in this report, but may be found in the cited reference.

Some improvements in surface water quality have likely occurred since the time of the above-mentioned data in regard to point sources of pollution. However, the lack of recent monitoring stations or intensive surveys for the subbasin make it very difficult to describe existing conditions. It is expected that nutrient and bacterial inputs from Wheaton and private residences above Lake Traverse may have improved to some degree, but nonpoint sources such as farming operations and cattle yards have probably not been controlled. In the Mustinka River watershed, the Minnesota Pollution Control Agency (1975) indicated that high turbidity was the major problem and that existing data (1958) was not sufficient to identify the cause(s). It was assumed that water quality would improve, but it was not known whether it would eventually satisfy the standards. Nonpoint sources may continue to cause violations until they are controlled.

Table 8

WATER QUALITY DATA FOR THE BOIS DE SIOUX RIVER FROM 1963-1966

Parameter	Unit	Bois de Sioux River		
		Maximum	Average	Minimum
Discharge	c.f.s.	872		0.6
Silica (SiO_2)	mg/l	34	18.2	7.7
Iron (Fe)	mg/l	0.95	0.12	0.03
Calcium (Ca)	mg/l	300	126	68
Magnesium (Mg)	mg/l	212	86	47
Sodium (Na)	mg/l	135	64	25
Potassium (K)	mg/l	21	14	7.9
Bicarbonate (HCO_3)	mg/l	478	328	223
Sulfate (SO_4)	mg/l	1,400	507	203
Chloride (Cl)	mg/l	35	17	6.8
Fluoride (F)	mg/l	0.6	0.3	0.2
Nitrate (NO_3)	mg/l	5.8	2.9	1.0
Boron (B)	mg/l	0.32	0.22	0.09
Dissolved Solids	mg/l	2,370	1,024	529
Hardness as $CaCO_3$ (CaMg)	mg/l	1.620	666	351
Hardness as $CaCO_3$ Non Carb.	mg/l	521	176	18
Specific Condition	al ohms/25°C	2,860	1,360	754
pH		8.4	7.7	7.4
S.A.R		1.6	1.0	0.6
Manganese	mg/l	0.31	0.10	0.01
Color		35	28	22
Temperature	F	80.0	60.3	33 0
Turbidity	JU	130	87.5	8.0
Dissolved Oxygen	mg/l	10.8	7.2	2.6
BOD	mg/l	15.0	6.6	2.0
Total Coliform	100 ml	3,300	802	200
Fecal Coliform	100 ml	400	202	20
Ammonia (NH_3-N)	mg/l	1.3	0.29	0.05
Phosphate (P-Wet)	mg/l	0.55	0.33	0.15

Source: U.S. Geological Survey, 1963-1966 (after South Dakota Department of Natural Resources Development, 1975).

Groundwater quality data for 10 communities in the Minnesota portion of the subbasin are found in Table 9; Table 10 gives data for four South Dakota communities. The data in Table 9 show that iron values are high at nearly all of the communities and that hardness is high at some of the towns such as Donnelly and Barry. Maclay et al. (1968) indicated that excessive levels of sulfate and dissolved solids are found in the waters of the glacial drift in the morainal areas, while more acceptable concentrations occur in the lake plain. The South Dakota Department of Natural Resources Development (1972) pointed out that the data in Table 10 showed high total dissolved solids and sulfate in Britton and that fluoride had to be reduced by heating. The Roberts County sample, Peterson Farm, contained a highly mineralized water which was probably unsuitable even for livestock usage.

Cultural Elements

One of the earliest remains of prehistoric man in Minnesota was found in glacial deposits at Browns Valley. "Browns Valley Man" is estimated to date around 6,000-7,000 B.C. (Johnson 1962:160). Early man sites are rare, but the subbasin is undeniably rich in archeological resources, since 49 sites have been recorded to date. Thirty-five of these have Woodland components (mounds), which probably reflects the greater surface visibility of mound sites. At least one late prehistoric site in the subbasin is associated with the intrusive Mississippian culture of the southeastern United States. Similarities in culture traits raise interesting questions about prehistoric culture contacts (Wedel 1961:223; Howard 1953).

Historically, the subbasin was dominated by related members of the Siouan language group, most notably the Dakota and Teton Sioux. By 1750, the Tetons forged westward, leaving the Big Stone and Traverse lakes country to their Sisseton and Santee kinsmen (Wedel 1961:211). Land treaties with the Sioux and Chippewa in 1837 initiated settlement by whites. Americans, and others of German and Scandinavian descent, poured westward into Indian territory. By a treaty of 1851, the Sioux relinquished their claims to most of Minnesota, including land east of the Red River

Table 9

GROUNDWATER QUALITY DATA FOR 1963 FROM TEN MINNESOTA COMMUNITIES IN THE BOIS DE SIOUX-MUSTINKA RIVERS SUBBASIN

Community	Well Depth (Ft)	Operating Rate (gpm)	Daily Pumpage (gal)	Quality				
				Fe (ppm)	Cl (ppm)	Hardness as $CaCO_3$ (ppm)	Fluoride (ppm)	pH
Wheaton	149	185	146,000	0.73	68	243	0.4	7.7
	146	200-300						
Graceville	212	250	80,000	1.4	25	236	0.5	7.7
	213	250						
Elbow Lake	215	350	160,000					
	213	350		0.7	2.6	492	0.2	7.7
	215	400						
Herman	182	--						
	123	45	45,000	2.2	28	591	0.3	7.5
	132	45						
Donnelly	210	100		4.8	8.5	1,100	0.24	7.2
	210	150	25,000	11.0	7.2	1,080	0.2	7.4
Campbell	265			1.0	53	110	0.97	7.8
	280	300	20,000	0.28	51	131	0.9	7.8
Wendell	288	100	15,000	1.9	21	395[1]	0.4	7.5
Norcross	162	120	15,000					
Dumont	130	60	5,000	1.2	97	346	0.3	7.6
Barry	110	5	1,000	0.3	21	798	0.2	7.2

Source: Maclay et al., 1968.

Table 10

GROUNDWATER QUALITY FOR FOUR SOUTH DAKOTA COMMUNITIES
IN THE BOIS DE SIOUX-MUSTINKA SUBBASIN

Source of Information		1.	2.	3.	4.
Well Number or Name		Rosholt #3	F. Bauer	Britton #3	Peterson Farm
Well Location	T-R-S		127-57-7cc	127-58-23	127-51-10a
Date Sampled		4/65	1965	10/60	12/27/54
Depth of Well	Feet	120°		1,000'	660'
Geologic Formation		Glacial Outwash	Sand Lens	Dakota Sandstone	Dakota Sandstone
Iron (Fe)	mg/l (ppm)*	0.4	2.2	0.3	1.2
Calcium (Ca)	mg/l	65	522	20	86
Manganese (M)	mg/l	02		0.0	0.0
Magnesinm (Mg)	mg/l	15		5.0	5.2
Sodium (Na)	mg/l	145		842	2,469
Potassium (K)	mg/l	10.3		16.0	
Bicarbonate (HCO_3)	mg/l	410		317	
Sulfate (SO_4)	mg/l	179	682	1,207	1,033
Chloride (Cl)	mg/l	23	24	318	1,257
Flouride (F)	mg/l	0.3		6.7	1
Nitrate (NO_3)	mg/l	0.7		1.5	
Boron (B)	mg/l				
Dissolved Solids	mg/l	696	1,762	2,547	7,001
Hardness $CaCO_3$	mg/l	225	820	69	428
pH		7.5		7.9	

*Parts per million (ppm) approximately equal milligrams per liter (mg/l).

1. Division of Sanitary Engineering, South Dakota Department of Health, Public Water Supply Data, 1971.
2. State Geological Survey Special Report #7, Water Supply for the City of Rosholt.
3. State Geological Survey Report of Investigations #104, Geology and Hydrology of the Dakota Formation in South Dakota.

Source: South Dakota Department of Natural Resources Development, 1975.

and Lake Traverse (Blegen 1963:167-168). The treaty established a Sioux Reservation from Lake Traverse, south along the Minnesota River to the Yellow Medicine River. Violations of this treaty by the U.S. Government and its citizens provoked the well-known Sioux Wars of 1862 (Blegen 1963:264-266). Although most of the battles of the Sioux Uprising were waged outside the subbasin boundaries, it is nevertheless important to the area history. The Sioux reservation was abolished and opened to white settlers as the defeated Indians were relocated in North Dakota.

The tempo of the American settlement in the subbasin increased after the Indian war and at the close of the Civil War. The American impact on the landscape is reflected in the 31 historic sites recorded in the subbasin. Of these, none are listed on the National Register of Historic Places, but two have been nominated. There are currently no prehistoric archeological sites listed on, or nominated for inclusion in, the National Register of Historic Places.

Aesthetics

There are no state parks or state forests located within the subbasin. However, the abundant lakes and forest tracts in the morainic hills offer contrasts to the nearly level terrain and broad expanses of agricultural lands. Because of the scarcity of aesthetically appealing areas, it is important that existing scenic areas (including the major lakes, forest areas, and wetlands) be protected from pollution and erosion problems and maintained as a valuable resource in the subbasin.

Recreational Resources

The eastern portion of the subbasin lies within the Minnesota lake region, which provides intensive recreational use. There are approximately 9,393 acres of land with recreational opportunities such as fishing, hunting, swimming, picnicking and other water-based and water-related activities. There are no state parks within the subbasin; however, Lake Carlos, Glacial Lakes, and Big Stone Lake state parks are located in counties adjoining the study area.

Most of the recreational land within the subbasin is associated with the 23 wildlife management areas in Minnesota and the seven game

production areas in South Dakota, which together comprise about 8,553 acres. The locations of these and other recreational areas over 15 acres in size (99 percent of the subbasin's resources) is illustrated in Figure III. A description of each unit and an inventory of facilities is included in Appendix B of this report.

Hunting is popular in all parts of the subbasin. However, most of the wildlife areas are concentrated in the eastern and western portions. Upland game species include pheasant, gray partridge, cottontails, fox, and squirrels. In addition, there are numerous waterfowl production areas within the subbasin that are open to the public for hunting.

The region's many lakes comprise approximately 29,000 surface acres and are prime recreational areas. Private resorts, totalling approximately 560 acres, have been developed, mostly along Lake Traverse. There are many smaller resorts and extensive residential developments along the lake. In addition, the state of South Dakota has designated six lakes in Robert's County, including Lake Traverse and Mud Lake, as "meandered lakes," which are held in trust for the population and administered by the state's Game, Fish, and Parks Department. These lakes afford 5,350 acres of surface waters for recreational use. Walleye, northern pike, and rough fish are common species taken from these lakes. The Bois de Sioux and Rabbit rivers are also utilized by fishermen; however, low flow conditions result in a high percentage of winterkill.

The completion of Interstate 29 has made the western section of the subbasin, particularly the Lake Traverse area, much more accessible to residents outside the Red River of the North Basin. Increased recreational demands are anticipated for this area of the subbasin.

Significant Environmental Elements

Social

There are four population centers in the subbasin, including Wheaton, Elbow Lake, Brown's Valley, and Graceville, which account for 23 percent of the population. Spring flooding results in damages to residences, roads, and sewer systems. The towns have implemented plans to improve municipal sewage facilities because of problems caused by flooding.

△ EXISTING RECREATION AREAS

1 Herman Municipal Camping Fairgrounds
2 White Rock Dam Recreation Area
3 Rainbow Island Resort
4 Traverse County Park
5 Toqua Lake Public Access

△ MEANDERED LAKES

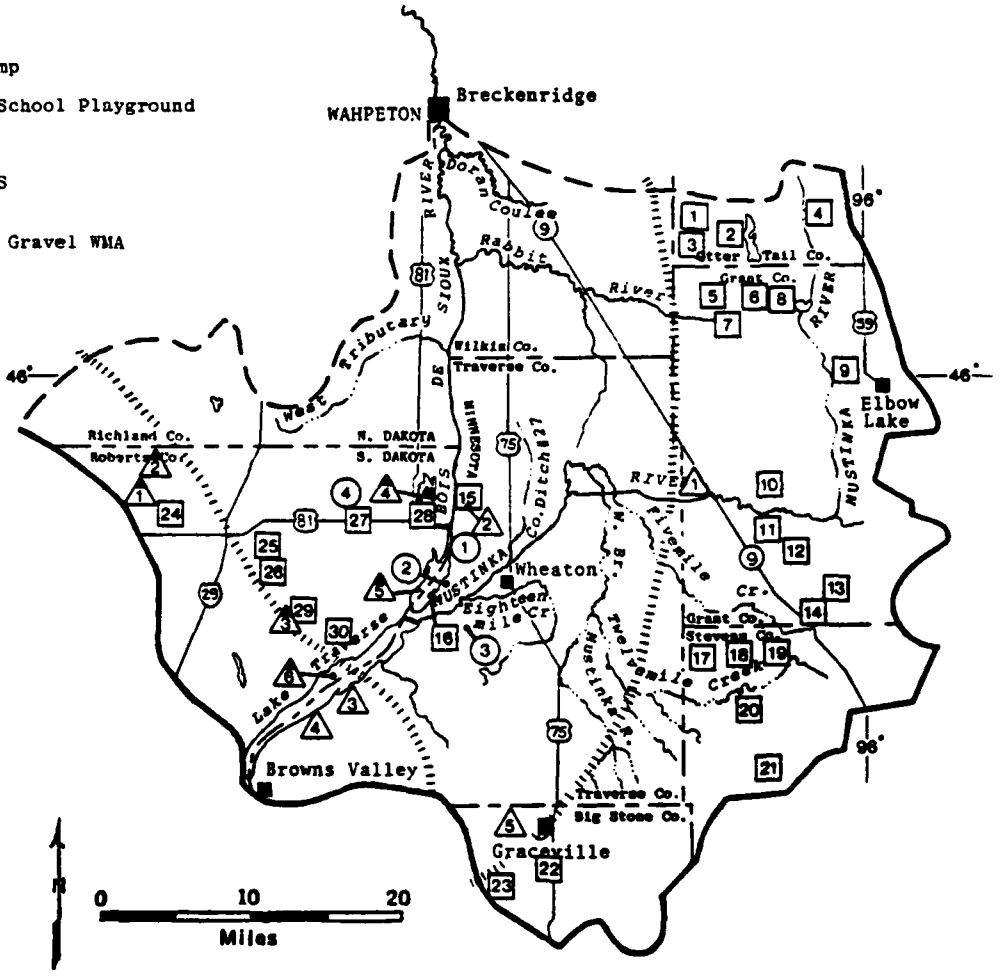
1 Hammer Lake
2 North Hammer Lake
3 Bde-Sake Lake
4 Club House Lake
5 Mud Lake
6 Lake Traverse

○ OTHER RECREATION AREAS

1 Larson Hunting Camp
2 Johnson's Hunting Camp
3 Wheaton Country Club
4 Rosholt Independent School Playground

□ EXISTING WILDLIFE AREAS

1 Doran WMA
2 Western Township Co. Gravel WMA
3 Copeland WMA
4 Aastad WMA
5 Kube-Swift WMA
6 Shuck WMA
7 Marple WMA
8 Bergurud
9 Mustinka WMA
10 Helsene WMA
11 Blakesley WMA
12 Wilis WMA
13 Macsville WMA
14 Towner WMA
15 White Rock Dam WMA
16 Reservation Dam WMA
17 Horning Pit WMA
18 Boekholt Grove WMA
19 Thedin WMA
20 Everglade WMA
21 Cin WMA
22 West Toqua WMA
23 Skoog WMA
24 Dobberstein GPA*
25 Bratten GPA*
26 Crawford Area
27 Victor GPA*
28 White Rock GPA*
29 Upper Dry Run GPA*
30 Diamond Area GPA*
* Game Production Area



Source: Gulf South Research Institute.

Figure III. RECREATIONAL RESOURCES

Commercial and service industries may be affected by flooding because of reduced income for residents of rural areas using the towns as service centers.

In agricultural areas, flooding accelerates loss of topsoil and decreases soil fertility. However, damages to crops, equipment, and homes and delays in planting are the most serious problems affecting agricultural production.

Road erosion and clogged watercourses increase county and municipal maintenance costs. Agricultural run-off, which is increased by flooding, has an adverse impact on lakes and streams of the subbasin and affects recreational and aesthetic resources.

Cultural

The subbasin is rich in archeological resources, and 49 have been recorded to date. One of the earliest known prehistoric sites in Minnesota has been found near Browns Valley. In addition, 31 historic sites have been recorded, all of which are standing structures.

Soils

The quality of soils in the subbasin contributes to the types of crops that can be grown and to the distribution of natural vegetation and determines, to some degree, the suitability of certain areas for construction or recreation purposes. The eastern and western areas are characterized by loamy fine sands such as the Hecla, Bearden, Glydon, McIntosh, Barnes, and Aastad series. The central portion of the subbasin is predominantly clays of the Fargo, Grimstad, and Rocksbury series. Large areas are exposed to wind and water erosion through summer fallowing and fall plowing.

Water

Besides Lake Traverse and Mud Lake, there are many thousands of small lakes on the eastern, western, and southern perimeters of the subbasin that account for about 29,000 surface acres of water. These water areas are important for recreation and for fish and wildlife. In addition, the many streams of the subbasin are important as a fishery resource.

Woodlands

The limited woodlands or forested areas of the subbasin are significant habitats for wildlife resources because of areas they afford for breeding, nesting, feeding, and resting, or as migratory or travel corridors. The Souris-Red-Rainy River Basins Commission (1972) reported that 10,600 acres of forest land are found within the subbasin; approximately 1,850 acres of this total are located in Minnesota (data supplied by Minnesota Land Management Information Service). Table 11 presents a comparison of subbasin county percentages of woodland vegetation between 1969 and 1977 for the Minnesota portion. The percentages for Ottertail County are considered high, since the part of the subbasin within this county is not forested to any significant degree. The increases in woodland acreages noted in every county are probably the result of increased numbers of planted shelterbelts and windbreaks and the reestablishment of vegetation along some streams (U.S. Fish and Wildlife Service, 1980).

Table 11

COMPARISON OF COUNTY PERCENTAGES OF WOODLAND VEGETATION IN MINNESOTA BETWEEN 1969 AND 1977

County	Percentage of County Containing Woodland Vegetation		Change in Percent Composition
	1969	1977	
Wilkin	0.6	0.7	+0.1
Ottertail	16.4	19.9	+3.5
Traverse	0.3	0.4	+0.1
Grant	0.6	1.1	+0.5
Big Stone	0.6	0.9	+0.3
Stevens	0.1	0.4	+0.3

Source: Minnesota Land Management Information Service (in U.S. Fish and Wildlife Service, 1980).

Wetlands

Wetlands are important because of the natural functions they serve such as habitats for flora and fauna, waterfowl production, nutrient entrapment, recharge areas for groundwater, and flood control. Data

supplied by the Minnesota Land Management Information Service indicate that 8,760 acres occur in Minnesota's portion of the subbasin. Wetland data for Type 1, 3, 4, and 5 wetlands in the six counties within the Minnesota portion of the subbasin are presented in Table 12. The figures were obtained during a 1964 inventory based on a 25 percent sampling of the wetlands within these counties. The number and acreage of all Type 3, 4, and 5 wetlands were multiplied by four to expand the 25 percent sample to 100 percent. Type 1 and 2 wetlands were not measured in the 1964 survey. The number and acreage of Type 1 wetlands, however, were estimated based on previous studies which indicated that they comprise about 60 percent of the total wetland numbers and 10-15 percent of the total wetland acres in the Prairie Pothole Region.

Table 13 shows wetland data obtained during a 1974 inventory based on a 100 percent sampling of Type 3 through 8 wetlands and stock ponds within the subbasin's six Minnesota counties. Table 14 shows a comparison of the 1964 and 1974 wetland inventory data for Type 3 through 5. These data are comparable, since methods used in the 1974 survey allowed direct comparison of the same sampling locations at the 25 percent level. These data show that the wetland numbers and acreages have been reduced by 7,638 and 4,591 acres, respectively, in the counties included wholly or in part within the subbasin during this 10-year period.

Data were available for Richland County in the North Dakota portion of the subbasin from the 1964 inventory. However, information is not presently available for later years that can be used as a comparison. Table 15 gives the number and acreage values for each wetland type in Richland County. Methodologies used to expand the 25 percent sample were the same as these described previously. The U.S. Fish and Wildlife Service (1979) indicates that the majority of wetlands have been drained in eastern North Dakota, with current annual wetland drainage estimates believed to be less than two percent of the remaining wetland base.

Waterfowl Production Areas

Numerous Federal Waterfowl Production Areas (WPA's) are located within the subbasin. These are wetland areas that the U.S. Fish and

Table 12

1964 WETLAND INVENTORY DATA FOR THE MINNESOTA COUNTIES IN THE BOIS DE SIOUX-MUSTINKA SUBBASIN

	Wetland Types[a]									
	1		3		4		5		Total	
County	Number[b]	Acres[c]	Number	Acres	Number	Acres	Number	Acres	Number	Acres
Wilkin	166	506	241	1,187	32	2,058	4	125	443	3,876
Ottertail	7,025	6,656	9,218	18,710	1,434	12,193	1,057	13,469	18,734	51,028
Grant	694	1,269	866	3,359	250	4,418	40	682	1,850	9,728
Traverse	305	615	472	1,899	32	1,570	4	630	813	4,714
Stevens	145	2,212	2,140	7,584	248	4,052	32	3,111	2,565	16,959
Big Stone	1,867	3,425	2,576	9,034	440	9,406	96	4,393	4,979	26,258
Total	10,202	14,683	15,513	41,773	2,436	33,697	1,233	22,410	29,384	112,563

[a]Type 1: Seasonally flooded basins or flats
Type 3: Shallow fresh marshes
Type 4: Deep fresh marshes
Type 5: Open fresh water

[b]Calculated at 60 percent of total wetland numbers.

[c]Calculated at 15 percent of total wetland acres.

Source: U.S. Fish and Wildlife Service, 1980.

Table 13

1974 WETLAND INVENTORY DATA FOR THE MINNESOTA COUNTIES IN THE BOIS DE SIOUX-MUSTINKA RIVERS SUBBASIN

	Wetland Type												Ottertail is only County with Type 8			
	3		4		5		6		7		8		Stock Ponds		Total	
County	Number	Acres	Number	Acres	Number	Acres	Number	Acres	Number	Acres	Acres	Acres	Number	Acres	Number	Acres
Wilkin	108	3,614	15	218	3	177	9	28	--	--	--	--	32	5	167	4,042
Ottertail	4,127	16,217	2,110	2,275	1,251	31,128	1,877	11,986	23	408	9	153	288	33	9,685	8[illegible],00
Grant	792	5,172	222	7,298	153	10,766	21	82	--	--	--	--	27	3	1,215	23,32[illegible]
Traverse	147	918	216	4,321	2	33	--	--	--	--	--	--	79	27	444	5,299
Stevens	700	3,040	399	7,127	78	8,316	7	17	1	1	--	--	128	2	1,313	18,503
Big Stone	403	1,553	898	14,965	87	6,392	--	--	--	--	--	--	242	72	1,630	22,982
Total	6,277	30,515	3,860	56,204	1,574	56,812	1,914	12,113	24	409	9	153	796	142	14,454	154,348

Source: U.S. Fish and Wildlife Service, 1980.

Table 14

COMPARISON OF 1964[a] AND 1974 WETLAND INVENTORY SHOWING NUMBER, ACREAGE, AND PERCENT CHANGES FOR MINNESOTA COUNTIES IN THE BOIS DE SIOUX-MUSTINKA RIVERS SUBBASIN

	Wetland Types															
	3				4				5				Total			
County	Number	Percent	Acres	Percent	Number	Percent	Acres	Percent	Number	Percent	Acres	Percent	Number	Percent	Acres	Percent
Wilkin	-147	-61.0	-337	-28.3	-5	-15.6	+516	+25.0	--	--	-61	-48.8	-152	-54.9	+118	+3.4
Ottertail	-5,094	-55.3	-3,676	-19.6	+801	+55.9	+1,264	+10.3	-12	-1.1	+270	+2.0	-4,305	-36.8	-2,142	-4.8
Grant	-226	-26.1	+662	-19.7	-47	-18.8	-46	-0.01	+32	+80.0	+861	+12.6	-24.1	-20.8	+1,477	+17.4
Traverse	-344	-72.9	-1,511	-79.5	+220	+678.5	+2,302	+146.7	-4	-100.0	-630	-100.0	-128	-25.2	+161	+3.9
Stevens	-1,492	-69.7	-5,138	-67.7	+80	+32.3	+2,351	+58.0	No Change		-2,056	-66.1	-1,412	-58.3	-4,843	-32.8
Big Stone	-2,092	-81.2	-7,891	-87.4	+648	+147.3	+7,227	+76.8	+44	+45.8	+1,302	+29.6	-1,400	-49.0	+638	+2.8
Total	-9,395		-17,891		+1,697		+13,614		+60		-314		-7,638		-4,591	

[a]Represents values multiplied to 100 percent from a 25 percent sample.

Source: U.S. Fish and Wildlife Service, 1980.

Table 15

1964 WETLAND INVENTORY DATA FOR RICHLAND COUNTY, NORTH DAKOTA, BOIS DE SIOUX-MUSTINKA RIVERS SUBBASIN

Wetland Type	Number	Acres
1	1,087[a]	2,949[b]
3	1,464	4,465
4	316	10,592
5	32	4,600
10	-0-	-0-
11	-0-	-0-
TOTAL	2,899	22,606

[a]Calculated at 60 percent of total wetland numbers.

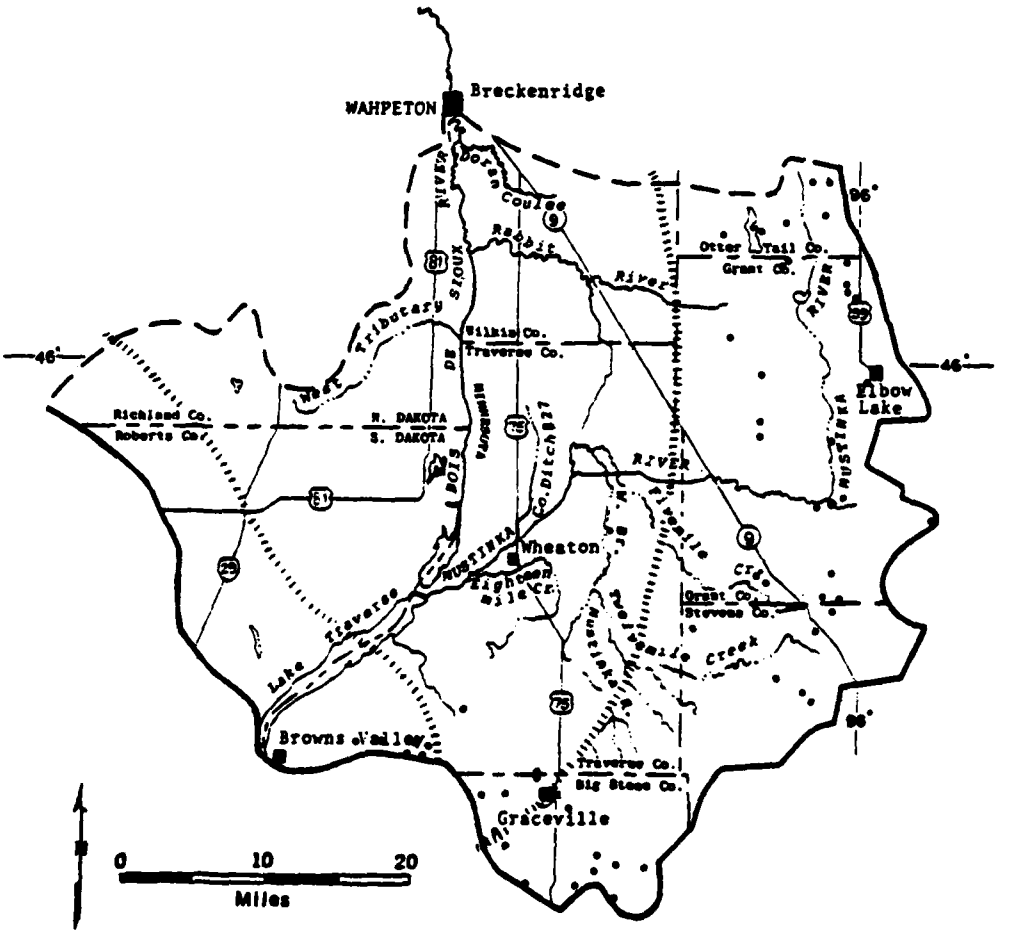
[b]Calculated at 15 percent of total wetland numbers.

Source: U.S. Fish and Wildlife Service, 1980.

Wildlife Service (USFWS) has either acquired through fee title or obtained an easement interest on to preserve valuable breeding, nesting, and feeding habitat for migratory waterfowl. These wetland areas are purchased, or an easement interest obtained, with funds received from the sale of Migratory Bird Hunting and Conservation Stamps ("Duck Stamps"). These WPA's are significant because they provide the public with a great variety of wildlife oriented recreational opportunities as well as provide valuable habitat for migratory waterfowl and many other forms of wildlife. The USFWS is responsible for the compatibility determinations (uses) and the issuance or denial of permits involving these lands. The approximate locations of these WPA's (fee tracts) within the subbasin arc shown in Figure IV. Total acreage of these WPA's (fee and easement) within Big Stone, Grant, Stevens, Wilkin, and Ottertail Counties are given in Table 16. No figures are given for Traverse County.

Wildlife Management Areas

A total of 30 wildlife management areas or game production areas are found in the subbasin. A list of these areas and their acreages and location were presented in the existing conditions section for recreation.



Sources: U.S. Fish & Wildlife Service (1979; 1980); Gulf South Research Institute.

Figure IV. WATERFOWL PRODUCTION AREAS

Table 16

ACRES OF FEDERAL WATERFOWL PRODUCTION AREAS (FEE AND EASEMENT) WITHIN THE BOIS DE SIOUX-MUSTINKA RIVERS SUBBASIN

County	Fee (Acres)	Easement (Acres)	Total Acres
Big Stone	8,661	4,429	13,090
Grant	7,816	1,212	9,028
Ottertail	15,265	5,365	20,630
Stevens	6,816	823	7,639
Wilkin	1,247	167	1,414
Traverse	2,655	903	3,558

Source: Annual Report of Lands Under Control of the U.S. Fish and Wildlife Service as of September 30, 1978. U.S. Department of the Interior, Division of Realty, Washington, D.C.

These areas are considered significant because of the opportunities provided for outdoor recreation and the protection and management given to biological resources.

Threatened or Endangered Species

Threatened or endangered species possibly occurring in the subbasin include the Arctic peregrine falcon and bald eagle. The falcon is not known to breed in the area, but its wintering range encompasses the subbasin boundaries. The nesting range of the bald eagle includes Ottertail County (U.S. Fish and Wildlife Service, 1979).

Other Important Species

The Minnesota Department of Natural Resources identified certain animals in need of special consideration, those of special interest, and priority species.

The animals in need of special consideration include the following: greater sandhill crane and greater prairie chicken--threatened; northern bald eagle, marsh hawk, and western grebe--changing or uncertain status;

bobcat and pileated woodpecker--special interest (Moyle, 1974). The sandhill crane is known to migrate through the subbasin during the spring, and the greater prairie chicken may occur along the Lake Agassiz beachlines. The eagle was discussed above under threatened or endangered species. The marsh hawk and pileated woodpecker are known to breed in the Minnesota region that includes the subbasin. A colonial bird nesting site is known for the western grebe at Lake Traverse. The bobcat may possibly occur, since they have been harvested from Ottertail County (Henderson 1978a and b, 1979; Mann, Souris-Red-Rainy River Basins Commission, 1972; U.S. Fish and Wildlife Service, 1980).

Reptiles and amphibian species of special interest known to exist within the counties of the subbasin consist of the western smooth green snake, Canadian toad, and Great Plains toad. The reptile is restricted to habitats of moist grassy areas of plains and meadows (Conant, 1975). The two amphibians are western species occurring on the eastern limits of their range. The state presently needs more information about the Great Plains toad (Henderson, 1979).

Non-game mammals indicated as priority species include the Arctic shrew (Ottertail County), northern grasshopper mouse (Ottertail, Grant, Traverse, and Stevens counties), and spotted skunk (Ottertail, Grant, and Stevens counties). Reports are needed for all of these species. The shrew is a northern species found at the southern limits of its range, and the mouse is a western species occurring on the eastern edge of its range (Henderson, 1979; Henderson and Reitter, 1979).

The North Dakota Chapter of the Wildlife Society (1978) and McKenna and Seabloom (1979) list the following proposed species for North Dakota that possibly occur in the subbasin: endangered--bald eagle; threatened--greater prairie chicken; and peripheral--pileated woodpecker. McKenna and Seabloom (1979) list peripheral mammals that may occur: eastern mole and plains pocket mouse. The bald eagle was discussed earlier. The greater prairie chicken is known from Richland County. The pileated woodpecker occurs in the extreme eastern counties of the state along rivers, including the Red. The eastern mole possibly occurs in the Red River Valley, and the pocket mouse is found in the southeastern corner of the state.

V. FUTURE CONDITIONS

V. FUTURE CONDITIONS

The subbasin's "most probable" and "without" project future conditions and resources are presented below and focus primarily on economic trends, population forecasts, and generalized statements of environmental conditions and resources.

Most Probable Economic Conditions

Projections of general economic and demographic indicators for the non-SMSA portion of the Fargo-Moorhead area appear to underestimate growth trends that have been noticeable in this vicinity since the early 1970s. OBERS Series E and E' projections have in fact predicted study decreases in these indicators during the course of the study period. It was thus judged that state, regional, and Gulf South Research Institute (GSRI) developed figures be adopted as the most probable. The Principles and Standards allow for such a deviation if conditions unique to the study area indictate that OBERS may not be totally satisfactory.

Table 17 presents population, employment, and per capita income (in 1979 dollars) figures for the subbasin for the 1980-2030 study period.

Table 17

BOIS DE SIOUX-MUSTINKA RIVERS SUBBASIN, POPULATION, EMPLOYMENT AND PER CAPITA INCOME PROJECTIONS, 1980-2030

	Year							
Parameter	1970	1977	1980	1990	2000	2010	2020	2030
Population	21,208	21,320	21,400	22,700	23,500	24,100	24,700	25,300
Employment	7,635	9,168	9,250	9,900	10,300	10,600	10,900	11,400
Per Capita Income (1979 Dollars)	$ 4,606	$ 8,878	$10,700	$14,500	$19,900	$26,900	$36,300	$48,600

Sources: U.S. Water Resources Council, 1972 OBERS Projections, Series E; West Central (Minnesota) Regional Development Commission; and Gulf South Research Institute.

These figures indicate a stabilization and slow reversal of the population and employment declines that preceded the 1970's, which were a result of mechanization and increased efficiencies of farm processes and the accompanying losses of relatively small farmsteads and the associated employment. Out-migration and natural population decreases in the rural portions of Grant, Traverse and Wilkin counties have been offset by in-migration in Richland, Stevens and Ottertail counties. Other counties with areas in the subbasin will continue to contribute population totals.

A predominantly agriculture-based economy is predicted to continue. The larger communities in the subbasin (i.e. Wheaton, Elbow Lake, Browns Valley and Graceville) will experience small gains in population as their importance to the area's services and trade sectors increases. Area residents will continue to commute to Wahpeton-Breckenridge for employment. The West Central Development Commission anticipates little growth in the counties and cities of this subbasin and notes that the recurring flooding that affects some 140,000 acres of rural floodplain will remain as the single most important subject of concern to the planners and leaders involved with subbasin activities.

Most Probable Agricultural Conditions

Roughly 1,363,000 acres within the subbasin are currently under cultivation, and wheat, corn, sunflowers and barley are the principal crops. The estimated value of production in 1980 of these principal crops, using October 1979 Current Normalized Prices for Minnesota is $78.4 million. Projections of total production through 2030 for the principal crops grown in the subbasin are presented in Table 18. The projected total production for 2030 represents a value of $160.5 million using October 1979 Current Normalized Prices for Minnesota.

Evaluation of Flood Damages—Future Conditions

A summary of present and future average annual flood damages is presented in Table 19. Assuming a discount rate of 7 1/8 percent, average annual damages throughout the projection period are expected to be $707,100, of which 91 percent is agricultural damages.

Table 18

BOIS DE SIOUX-MUSTINKA RIVERS SUBBASIN, PRINCIPAL CROPS AND PROJECTED PRODUCTION, 1980-2030
(Production in Thousands)

	Crop			
Year	Wheat (Bushels)	Corn (Bushels)	Sunflowers (Pounds)	Barley (Bushels)
1980	7,050	19,814	240,330	4,536
1990	8,178	22,985	278,783	5,263
2000	9,306	26,155	317,236	5,989
2010	10,011	28,136	341,269	6,442
2020	10,716	30,118	365,302	6,896
2030	11,844	33,288	403,754	7,622

Sources: OBERS Series E'; and Gulf South Research Institute.

Table 19

BOIS DE SOUIX-MUSTINKA RIVERS SUBBASIN, SUMMARY OF PRESENT AND FUTURE AVERAGE ANNUAL DAMAGES, URBAN, AGRICULTURAL, AND TRANSPORTATION
(October, 1979 Prices, 7 1/8 Percent Interest)

	Flood Damages									
Category	1980	1990	2000	2010	2020	2030	Increase 1980-2030	Average Annual Equivalency Factor	Average Annual Equivalent Increase	Equivalent Average Annual Damages
Urban	11,700	12,900	14,000	15,200	16,400	17,600	5,900	0.2903	1,700	13,400
Agricultural										
Crop	412,000	477,900	543,800	585,000	626,200	692,200	280,200	0.2903	81,300	493,300
Other Agricultural	137,300	148,300	159,300	166,100	173,000	184,000	46,700	0.2903	13,600	150,900
Transportation	49,500	49,500	49,500	49,500	49,500	49,500	--	--	--	49,500
TOTAL	610,500	688,600	766,600	815,800	876,100	943,300	332,800	0.2903	96,600	707,100

Source: Gulf South Research Institute.

Flood damages to residences, businesses, industrial structures, churches, schools, automobiles, house trailers, public property and contents are included in the urban damages category. Damages to streets and utilities (including water, gas, electricity, sanitary sewers, storm sewers, and telephone systems) are also taken into consideration. This category also includes loss of wages, loss of profits, expenditures for temporary housing, cleanup costs, and extra expenses for additional fire and police protection and flood relief.

Agricultural flood damages consist of crop and pasture damage, which may include costs of replanting, refertilizing, additional spraying, reduced crop yields, loss of animal pasture days, and other related flood losses.

Other agricultural damages consist of land damage from scour and gully erosion and deposition of flood debris; livestock and poultry losses; damages to machinery and equipment, fences, and farm buildings and contents (excluding residences); and damages to irrigation and drainage facilities.

Transportation damages include all damages to railroads, highways, roads, airports, bridges, culverts, and waterways not included in urban damages. In addition, all added operational costs for railroads and airlines and vehicle detours are included.

Future growth of urban flood damages was estimated to be an uncompounded (straight-line) rate of one percent per year for a 50-year period beginning in the base year, with no growth thereafter.

Agricultural crop flood damages were projected to increase at the same rate as crop income projections published in the 1972 OBERS Series E projection report. These crop income projections were prepared by the U.S. Economic Research Service (ERS) for the Red River of the North region. Other agricultural flood damages were projected to increase at one-half of this rate.

Transportation damages are not expected to change throughout the project life because of the long-term economic life associated with such structures as bridges, railways, roads, and culverts. In addition, it has been found that repairs to these types of structures rarely exceed the cost of a new structure, even with frequent flooding.

Most Probable Environmental Conditions

Successful implementation of point and nonpoint pollution abatement plans should cause water quality conditions to improve to some degree. Most difficult to control will be the nonpoint sources, which will take a considerably longer period of time. Relative to this statement, turbidities and certain nutrients are expected to continue to be main problems in the subbasin's lakes and streams.

Woodland habitats for wildlife are expected to increase slightly barring any changes in land use trends noted from 1969 to 1977. Wetland data for the counties included either wholly or in part by the subbasin indicate that wetland losses will continue; much deterioration has apparently occurred in the North Dakota portion. Improvements in water quality should improve aquatic habitats somewhat, but as indicated above, nonpoint sources will probably continue to be a problem, particularly in Lake Traverse. Low flows in the Bois de Sioux will continue to affect populations of aquatic biota; however, it is still expected that this stream will be an important fishery to the area.

Without Project Conditions

It is likely that the scenario set forth as the most probable future of the subbasin will prevail during the 50-year planning period in the absence of a plan to alter resource management programs.

VI. EXISTING FLOODPLAIN MANAGEMENT PROGRAMS

VI. EXISTING FLOODPLAIN MANAGEMENT PROGRAMS

Institutional

Institutional arrangements in the Bois de Sioux-Mustinka Subbasin are among the most complicated in the entire basin, mainly because portions of three states are included within the boundaries of the area. Minnesota recognizes the common law riparian doctrine modified by state statute. In this state, the owner of land is entitled to any surface or groundwater that comes into contact with his property. State approval, however, is necessary to perfect water rights, and reasonable use is granted to upstream and downstream landowners. In North and South Dakota, the prior appropriation doctrine forms the basis for water rights. According to appropriation, the state is owner of all waters within its boundaries. An individual must acquire state approval to acquire water rights by showing the intention of using the water for beneficial purposes for a specified period of time. If disputes arise, the holder of the permit issued earliest has the greater right.

There are 31 Federal agencies with direct responsibilities for various aspects of water resources planning in the subbasin, a total of 49 state agencies with 23 involved in planning, and numerous county and local entities. Regional organizations include the South Dakota-Minnesota Boundary Waters Commission, the Joint Red River Board, the West Central Regional Development Commission (Minnesota), and the Agassiz Regional Council (North Dakota). The number of agencies involved results in overlaps in jurisdiction that impede efficient and effective plan formulation and implementation of water resources management programs.

There are portions of eight counties within the subbasin; Wilkin, Big Stone, Stevens, Traverse, Grant, and Ottertail in Minnesota; Richland in North Dakota; and Roberts in South Dakota. Soil and Water Conservation Districts are organized for each of the Minnesota counties. There is a water management board in Richland County. Duties of county commissioners in Roberts County correspond to functions performed by North Dakota's water

management boards. All of the above organizations should be consulted in the planning stages of flood control projects within the subbasin. The primary Federal agencies involved would include the Corps of Engineers and the Soil Conservation Service. The South Dakota-Minnesota Boundary Waters Commission has jurisdiction over all boundary waters including Lake Traverse, Mud Lake, and the Bois de Sioux River. Lake Traverse is operated by the Corps of Engineers. In addition, the Bureau of Indian Affairs and the Sisseton Reservation Tribal Council should be consulted for any projects located on Indian lands. Municipalities that would be affected by flood control measures should be encouraged to participate in the planning process to promote local understanding and cooperation in the implementation of projects.

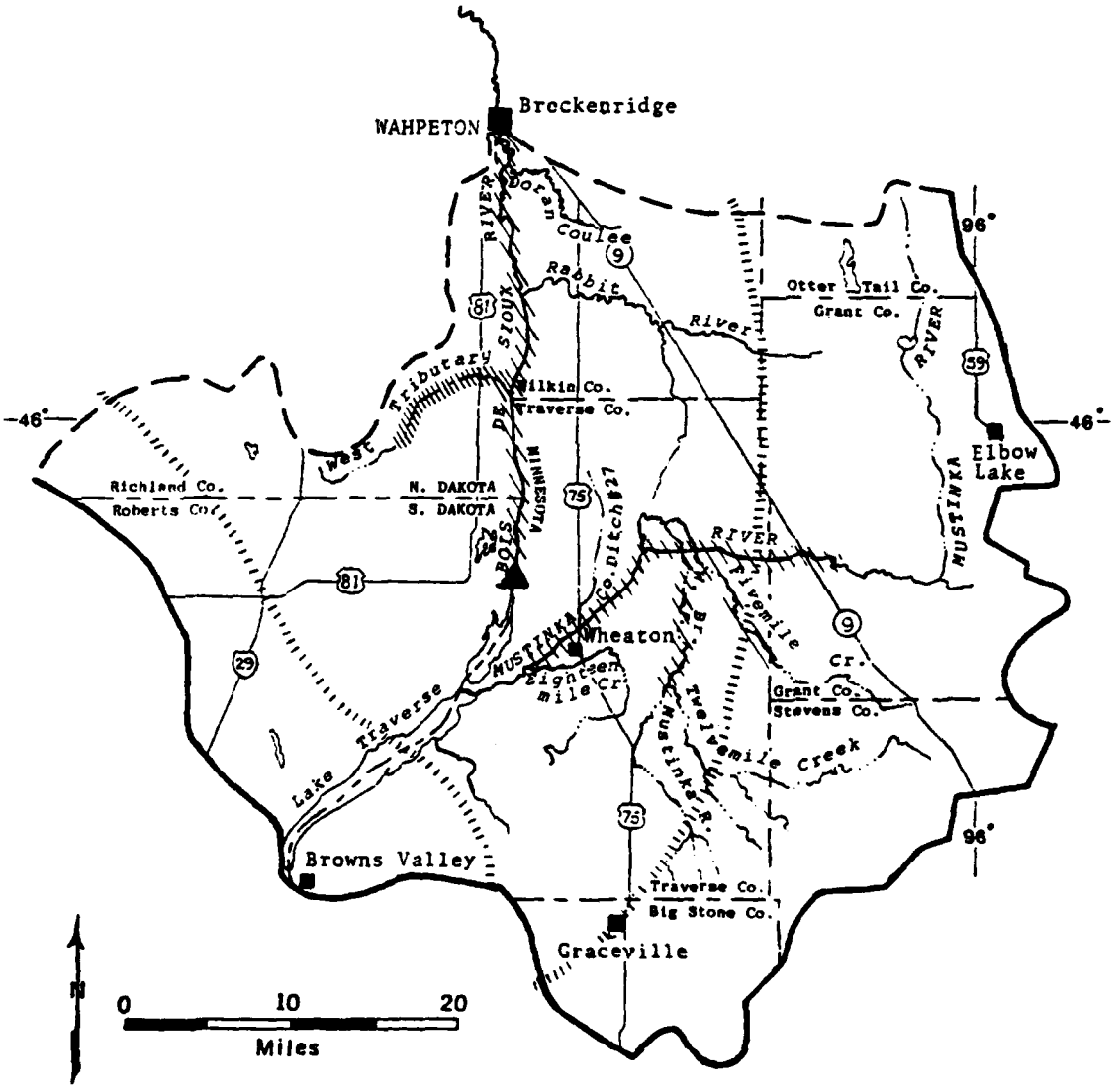
Structural Measures

Numerous state, county and judicial ditches have been constructed throughout this subbasin. Generally, the improved ditches can handle frequent floods of short duration but are inadequate for less frequent and longer duration floods. This is particularly true where channels have not received adequate maintenance.

Floodwater control and agricultural water management (drainage) measures have been constructed by the Corps of Engineers and the Soil Conservation Service (SCS). These structural projects (Figure V) include the following:

1. Lake Traverse and Bois de Sioux River. This project was completed in 1948 by the Corps of Engineers. It included a dam four miles upstream from White Rock, South Dakota; a control structure at the Minnesota State Highway crossing; levees near Browns Valley, Minnesota; and channel improvement in the Bois de Sioux River from White Rock downstream 24 miles. Lake Traverse has a total of 249,000 acre-feet of storage, of which 137,000 acre-feet is available for flood control. This reservoir controls about 1,160 square miles, which is about one-half of the subbasin. Lake Traverse and the improved channel can adequately control floods of 20 percent or more frequency, but only gives limited protection for less frequent floods. However, damages were minimal in 1979, moderate in 1978 and substantial in 1969. Overall, the project functions satisfactorily.

2. Mustinka River and Tributaries. This project was completed by the Corps of Engineers in 1958 and included 36.1 miles of channel improvements along the Mustinka River and its tributaries, Twelve Mile Creek, Five Mile Creek and County Ditch No. 42. The channels of these streams presently can contain floods of about 30 percent or more frequency.



Source: Gulf South Research Institute.

Figure V. EXISTING FLOOD CONTROL MEASURES

3. West Tributary Bois de Sioux. This project was completed in 1962 by the SCS and the South Richland County Soil Conservation and Control District. It included improving a 9.75 mile section of the West Tributary Bois de Sioux in Richland County, North Dakota, and land treatment measures. The project provides 12 percent flood protection for 4,900 acres in Richland County. Presently, it appears to be functioning satisfactorily.

There is another SCS planning project presently being considered in this subbasin: the West Branch of the Mustinka River in Big Stone and Traverse counties, Minnesota. This project has been approved for planning, but no priority for planning has been assigned.

Nonstructural Measures

Nonstructural flood control measures are measures that reduce or eliminate flood damages through procedures that involve little, if any, construction efforts. The major types are flood warning, floodplain zoning, flood insurance, flood proofing, and floodplain evacuation. These measures are primarily applicable to urban areas. Although urban flood damages in the subbasin are small, the counties of the subbasin as well as the towns of Tintah, Wheaton, and Campbell all participate in the Federal flood insurance program.

All of the towns in the subbasin participate in the Red River Valley flood warning system. The flood warning system for the Red River Valley is a coooperative network organized by the National Weather Service in Fargo, North Dakota. Fifty volunteers throughout the basin report to the National Weather Service on a weekly basis during winter and fall and on a daily basis during spring and summer. The reportage covers all precipitation of 0.1 inch or more, including amount of snow and water equivalent. This information is transmitted to the River Forecast Center in Minneapolis, where it is run through a computer system to determine probable flood stages. The predictions are then transmitted to the National Weather Service in Fargo, which releases them to the public through the news media. Communities are then able to engage in emergency actions to protect themselves from flood damages. Contacts with local officials indicate that the flood warning system generally works quite well in the subbasin.

There are other types of measures that could be used in the subbasin to reduce flood damages but that are not directly applicable to urban areas. These measures would include such things as land treatment programs, use of present drainage ditches for floodwater storage, use of natural areas for water retention, and acquisition of previously drained natural areas for reversion to water retention use. Land treatment is used by some farmers in the subbasin, but the SCS has not been called upon to undertake a large-scale program. Present drainage ditches are not used for floodwater storage, and no plans have been developed for future use. Information on natural storage areas and potentialities for increased storage is limited. Indications are, however, that wetlands play a substantial role in controlling runoff, especially in combination with good land treatment practices. Values on storage have averaged about 12 inches per surface-acre of wetlands, and have ranged to four times that amount (Cernohous, 1979).

Adequacy of Existing Measures

The existing Bois de Sioux project is functioning adequately and substantially reduces rural flood damages. The Mustinka channelization project is adequate for floods of 30 percent or more frequency and reduces flood damages somewhat. However, the entire Mustinka watershed sustains significant rural damages from less frequent floods, as evidenced by the damages sustained in 1969, 1978, and 1979. The SCS project in Richland County apparently functions satisfactorily.

VII. CRITERIA AND PLANNING OBJECTIVES

VII. CRITERIA AND PLANNING OBJECTIVES

Floodplain Management Criteria

Technical, economic, and environmental criteria must be considered when formulating and evaluating alternative floodplain management measures for the subbasin.

The technical criteria used in formulating and evaluating alternatives for this report consisted of the application of appropriate Federal engineering standards, regulations, and guidelines.

Economic criteria entailed the identification and comparison of benefits and costs of each measure. Tangible economic benefits must exceed costs; however, in certain instances, considerations of appropriate gains in the other accounts (environmental quality, social well-being and regional development) could alter this requirement. All alternatives considered are scaled to a design which optimizes benefits. Annual costs and benefits are based on an interest rate of 7 1/8 percent and price levels and conditions existing in October 1979. A 50-year amortization schedule is used for the features considered.

Environmental considerations call for the formulation of measures that minimize objectionable or adverse environmental effects and maximize environmental benefits. Also, limited consideration was given to modifications based on coordination with state and Federal agencies, local interests, and citizen groups.

Planning Objectives

The primary planning objective of this study was to contribute to flood reduction needs in the subbasin and thereby provide protection from or reduction of flood losses. In conjunction with this economic objective, the study attempted to develop contributions to the environmental quality of the subbasin.

The development of planning objectives involved a broad-range analysis of the needs, opportunities, concerns, and constraints of the subbasin. On the basis of the identified problems, needs, and desires, the following planning objectives were established:

(1) Contribute to protection from and prevention, reduction, or compensation of flood losses for the flood prone areas of the subbasin during the period of analysis.

(2) Contribute, to the maximum extent possible, to the preservation of the quality of the existing riverine environment and enhance the environmental potential of the subbasin as a whole.

(3) Contribute to the enhancement of recreational opportunities throughout the subbasin, particularly through improvements in water quality.

(4) Contribute to the improvement of water quality in the lakes and streams of the subbasin.

(5) Contribute to the improvement of water supply.

(6) Contribute to the reduction of wind and water erosion throughout the subbasin.

(7) Contribute to the developing trend toward increased irrigation throughout the subbasin.

(8) Contribute to the reduction of wastewater management problems, particularly insofar as they relate to water quality.

VIII. FORMULATION OF ALTERNATIVE MEASURES

VIII. FORMULATION OF ALTERNATIVE MEASURES

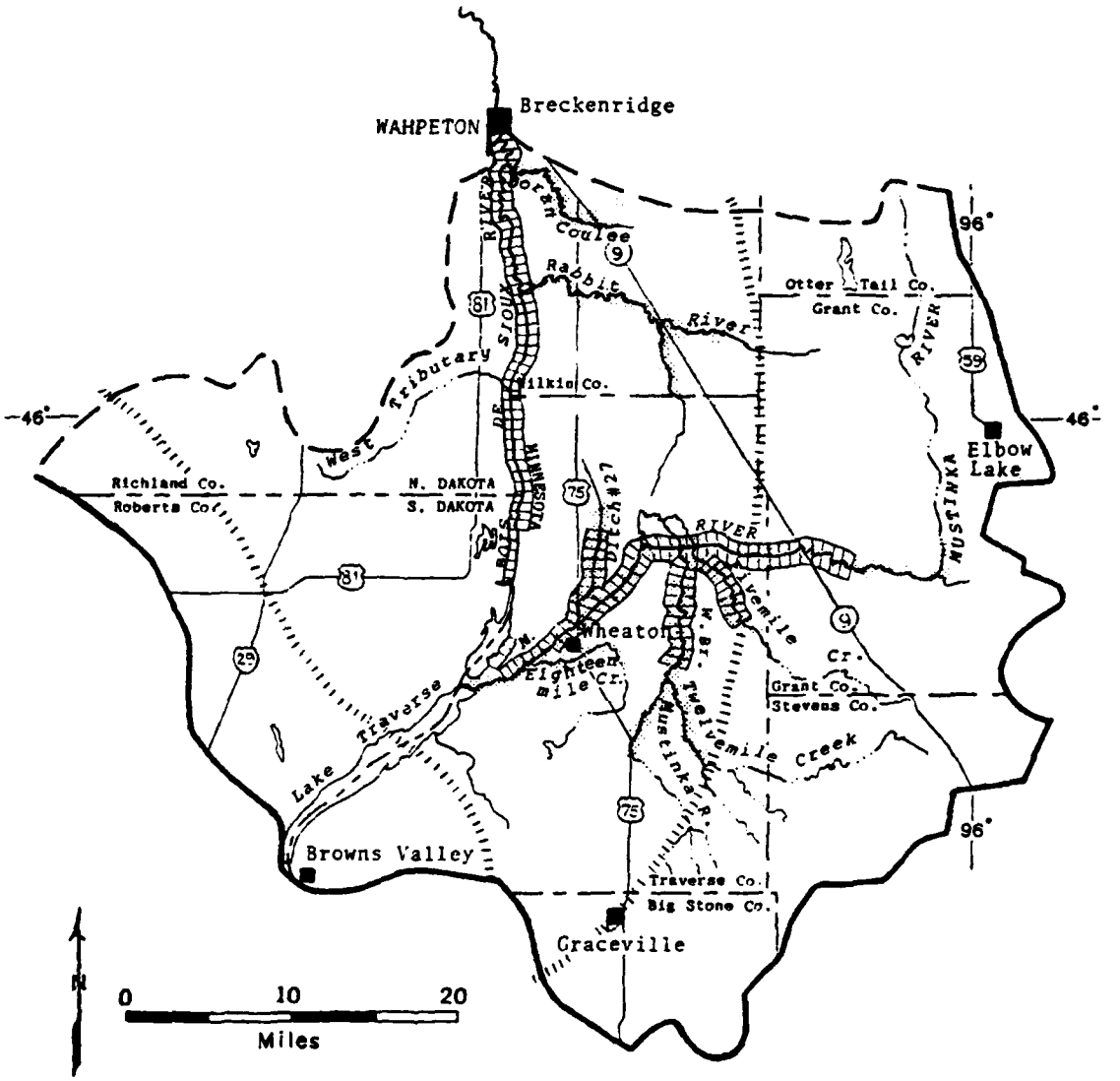
This section contains a discussion of the management measures that have been identified to meet the resource management objectives. In the formulation of measures, prime consideration was given to the resolution of flooding problems. Measures to meet the other planning objectives were considered exclusively as components of the flood control measures.

The following measures, which are illustrated in Figure VI, were devised in response to the flood control planning objective:

1. Agricultural levees constructed along each side of the Bois de Sioux and Mustinka rivers and their tributaries from their mouths upstream to high ground. This measure involves 48 miles of levees along the lower reaches of the Bois de Sioux River and 96 miles along the lower reaches of the Mustinka River and its tributaries. The levees would cause a water level rise in the 1.0 percent flood profile of no more than 0.5 feet and would begin near each stream's mouth. The maximum width of floodplain on any stream would be about 6,300 feet and would narrow to a minimum width of about 800 feet at the upstream termination. The levees would protect about 15,960 acres along the Bois de Sioux River and about 15,042 acres along the Mustinka River and its tributaries. The implementing agency would be the Corps of Engineers.

2. Channel improvement of 220 miles of the Mustinka River and its tributaries, Doran Coulee, and Rabbit River. The Mustinka tributaries are Twelve Mile Creek-West Branch Mustinka, Eighteen Mile Creek, and County Ditch No. 27. Channels of these streams were modified to contain the 10 percent (10-year) frequency flood and would provide protection for about 33,807 acres within their 10 percent floodplains. An analysis of the Bois de Sioux channel in conjunction with flood storage in Lake Traverse revealed that presently it is adequate to contain the 10 percent flood. These streams also were analyzed on the basis of containing the 30 percent (3.3-year) flood. This analysis revealed that all streams in the subbasin generally were adequate to contain the 30 percent flood. Where channels are not adequate for the 30 percent flood, flooding is minimal. The implementing agency for the channel improvements could be either the Corps or SCS.

3. Construction of levees around farmsteads in flood-prone areas. The levees would provide protection against a 1.0 percent (100-year) frequency flood and could be constructed by SCS, the Corps, or private individuals.



ALTERNATIVE PROJECTS

Levees

Channel improvements

Source: Gulf South Research Institute.

Figure VI. ALTERNATIVE FLOOD CONTROL MEASURES

Prior reports, particularly the Souris-Red-Rainy River Basins Study, indicated the possibility of 10 percent (10-year) flood protection along the Mustinka River, Twelve Mile Creek-West Branch Mustinka, and Rabbit River by a combination of upstream reservoirs and channel improvements. The present channel improvement analysis revealed that it is more cost-effective, in all cases, to provide a 10 percent flood channel than the combination of upstream reservoirs and channel improvements.

Besides these structural measures, there is an opportunity for the implementation of nonstructural measures in the subbasin including floodplain zoning ordinances, relocation, flood-proofing, and comprehensive land treatment. Accoring to available information, none of the cities in the subbasin that participate in the Federal flood insurance program have floodplain zoning ordinance. This may be due to the absence of overbank flooding in these towns. However, if overbank flooding is a problem, floodplain zoning ordinances should be instituted.

There is an opportunity for the use of land treatment measures throughout the subbasin that would help to contain water on land as well as reducing erosion damages. Natural retention areas and the utilization of present drainage ditches should also be considered for preservation. However, these would need to be identified.

It should be noted that the Wahpeton-Breckenridge area was not covered in this report. These cities are affected by floods from the Bois de Sioux River, but they are located at the confluence of the Ottertail and Bois de Sioux rivers, which join to form the Red River of the North. Measures are available to solve the flood damage problems at these cities, but these alternatives will be covered in the Main Stem Subbasin report.

IX. ASSESSMENT OF ALTERNATIVES

IX. ASSESSMENT OF ALTERNATIVES

Economic Assessment

The effects of the flood control alternatives for the subbasin along with their costs and benefits are presented in Table 20. Since no information was available on weighted damage per acre for the subbasin, a figure of $85.29 was drawn from the Phase 1 General Design Memorandum for Flood Control and Related Purposes, Sheyenne River, North Dakota, which was completed by the St. Paul District Corps of Engineers in 1980. Since the Sheyenne River is near the Bois de Sioux and Mustinka rivers, it was assumed that a weighted average of the weighted damage per acre figures for the reaches of the Sheyenne River would be representative of conditions along the Bois de Sioux and Mustinka rivers.

All structural alternatives were analyzed on the basis of the effects of 1, 10, and 30 percent frequency floods in the subbasin occurring independently of flooding caused by Red River of the North backwater. In order to develop the various alternatives, flood probability versus discharge curves were used to construct drainage area versus discharge curves. Cross sections from stream data and U.S.G.S. Quadrangle maps and data from gage rating curves were used to delineate the various channel improvements and levee measures. Capital costs for the various alternatives were developed by either updating capital costs from prior studies to October, 1979 price levels or by using October, 1979 unit construction costs. Capital cost estimates for levee measures include the cost of pumping facilities. It should be emphasized that there is very little available hydrological data for this subbasin. This analysis is based on hydrological data from similar subbasins and, in some cases, the contractor's experience and judgment.

The subbasin has historically been subject to frequent and widespread flooding at shallow depths because of the flat topography and inadequate channels. Most flooding typically occurs in the spring when snowmelt exceeds the inadequate channel capacities. The flood control measures analyzed in Table 20 were developed with these particular problems in mind.

Table 20

ECONOMIC EVALUATION OF ALTERNATIVES

Alternative	Acres Protected	Average Annual Acres	Capital Costs	Average Annual Costs	Average Annual Rural Benefits	Average Annual Urban Benefits	Total Acreage Annual Benefits	B/C Ratio
Mustinka River--Agricultural levees	15,042	860	9,789,000	721,000	73,300	--	73,300	0.10
Mustinka river--Channel Improvements	16,811	3,077	4,824,000	355,000	262,400	--	262,400	0.74
12-Mile Creek and West Branch--Channel Improvements	5,495	947	8,351,000	615,000	80,800	--	80,800	0.13
18-Mile Creek--Channel Improvements	804	190	691,000	51,000	16,200	--	16,200	0.32
County Ditch No. 27--Channel Improvements	437	104	767,000	56,000	8,900	--	8,900	0.16
Doran Coulee--Channel Improvements	1,360	232	587,000	43,000	19,800	--	19,800	0.46
Rabbit River--Channel Improvements	8,900	1,538	5,080,000	374,000	131,200	--	131,200	0.35
Bois de Sioux River--Agricultural levees	15,960	913	10,236,000	753,000	77,900	1,700	81,300	0.11
Farmstead levees (per farm)	--	--	5,600	400	840	--	840	2.10

Source: Gulf South Research Institute.

Impact Assessment

Nine measures were investigated for their anticipated effects on key resource elements in the event of implementation. The following discussion elaborates on the rationale pursued in the assignment of ratings presented in Table 21.

Agricultural Levees-Mustinka River

The Mustinka River agricultural levees would afford protection to 15,000 acres and thus would be moderately beneficial from an economic and social standpoint. The levees would provide primary benefits in the way of economic advantages to the agricultural lands in the flood prone areas of the Mustinka River (reduced flooding, earlier planting dates, fewer crops losses, etc). Most of the social benefits would accrue from reduced flood damages to residences and farmsteads, fewer rural community disruptions, and reduced threats to public health and safety during flood periods. Adverse social effects would occur because largely agricultural lands would be needed to provide for rights-of-way and easements.

Moderate to maximum beneficial effects are anticipated for wildlife resources, since the large setbacks would induce development of a riparian community. Adverse effects would occur to water quality as a result of increased turbidity from construction activities, but the effect would be minimal because of the large setback of the levees. It is not known how land use, water supply, and cultural elements would be affected, if at all. Minimum beneficial recreation benefits would accrue from fishing activities in borrow areas.

Channel Improvements

Channel improvement measures were considered for several Bois de Sioux tributaries, particularly the Mustinka and Rabbit rivers and several smaller creeks, coulees, and ditches. By and large these improvements would yield minimum to moderate beneficial social and economic effects and adverse biological and water quality effects. No known effects would take place with respect to water supply, cultural and recreational elements, and land use.

Table 21

ASSESSMENT OF MEASURES, BY RESOURCE ELEMENT, BOIS DE SIOUX-MUSTINKA RIVERS SUBBASIN

Measures	Social	Economics	Land Use	Biology	Water Quality	Water Supply	Cultural	Recreation
Mustinka River--Agricultural Levees	MoB	MoB	NKE	MoB-MaB	MiA	NKE	NKE	MiB
Mustinka River--Channel Improvements	MoB	MoB	NKE	MaA	MaA	NKE	NKE	NKE
12-Mile Creek and West Branch--Channel Improvements	MoB	MoB	NKE	MaA	MaA	NKE	NKE	NKE
18-Mile Creek--Channel Improvements	MiB	MiB	NKE	MaA	MaA	NKE	NKE	NKE
County Ditch No. 27--Channel Improvements	MiB	MiB	NKE	MiA	MiA	NKE	NKE	NKE
Doran Coulee--Channel Improvements	MiB	MiB	NKE	MoA	MoA	NKE	NKE	NKE
Rabbit River--Channel Improvements	MoB	MoB	NKE	MaA	MaA	NKE	NKE	NKE
Bois de Sioux River--Agricultural Levees	MoB	MoB	NKE	MoB-MaB	MiA	NKE	NKE	MiB
Farmstead Levees	MiB	MiB	NKE	NKE	NKE	NKE	NKE	NKE

Note: NKE = No Known Effect
MiA = Minimally Adverse
MoA = Moderately Adverse
MaA = Maximally Adverse
MiB = Minimally Beneficial
MoB = Moderately Beneficial
MaB = Maximally Beneficial

Source: Gulf South Research Institute.

Social and economic benefits would accrue through various levels of flood protection afforded by the specific measures. Protection would range from over 400 acres, if the 15 miles of improvements to County Ditch 27 were implemented, to nearly 17,000 acres if 45 miles of the Mustinka River channel were improved. All channel improvements would contain the 10 percent flood.

Only the County Ditch 27 improvements would have minimal adverse effects on fish and wildlife resources and water quality, since the channel is not highly productive. All other channel improvements would have maximum/moderate adverse effects on these elements, mostly due to changes in the character of the existing water bodies and their habitat features.

Agricultural Levees-Bois de Sioux River

As with the agricultural levees suggested as measures for the Mustinka River, moderate economic and social benefits would accrue from similar structures along the Bois de Sioux River that would protect 16,000 acres from the one percent flood. Similar beneficial effects would be anticipated for wildlife resources, since the large setback would induce establishment of a riparian community along the river. Minimal adverse water quality effects would be anticipated from turbidity during construction.

The agricultural levees rated minimally beneficial to recreation due to the resultant availability of borrow pits for fishing purposes. High quality recreational opportunities exist at a number of other sites in the subbasin. No known effects were noted on cultural and land use elements and water supply.

Farmstead Levees

Localized minimally beneficial economic and social effects would result from the protection of farmsteads from frequent floods by development of ring levees. Other resource elements would not be notably affected, although aesthetic, sanitary, and maintenance factors would need to be considered.

X. EVALUATION

X. EVALUATION

Only the farmstead levees have benefits that exceed unity. These measures are also the only ones that maximize economic benefits for the subbasin, but they afford only extremely localized protection. Some average annual urban benefits are associated with the agricultural levees proposed for the Bois de Sioux River. However, the average annual costs are much larger than the average annual benefits. The channel improvement measures considered for the Mustinka River had a benefit to cost ratio of 0.74, the highest following the farmstead levees. The degree of variance which might arise from the necessarily broad nature of this reconnaissance-level evaluation merits further investigation into the economic feasibility of this alternative.

The greatest environmental enhancement would result from the agricultural levees on the Mustinka and Bois de Sioux rivers, where the large setbacks would provide protection to the riparian belt and would create or expand habitats.

National Economic Development (NED) and Environmental Quality (EQ) plans will be tentatively formulated in association with the Red River of the North basin reconnaissance report.

XI. ADDITIONAL STUDY NEEDS

XI. ADDITIONAL STUDY NEEDS

This report was developed almost entirely on the basis of secondary information from readily available planning documents. Data available from state and Federal agencies was not fully canvassed, and only a limited number of calls were made to the area. In particular, state university libraries and departmental resources could not be fully utilized. Thus, the document aims only at a broad-brush perspective. In order to provide a more detailed and in-depth analysis of subbasin resources, problems, and potential solutions, the following additional study needs would have to be fulfilled:

1. Subbasin boundaries need to be better defined on the basis of hydrologic conditions, and total acreage in the subbasin needs to be precisely measured.

2. An adequate 100-year floodplain map needs to be developed. Also, the extent of floodplains for smaller frequency storms needs to be delineated.

3. Land use within the floodplain needs to be precisely identified.

4. The people of the subbasin need to be included in further water resource planning efforts. A public involvement program would provide a better fix on water resource problems and opportunities than is presently available.

5. Primary water and sediment quality data are needed for the subbasin to more accurately define stream quality problems and to provide a foundation upon which environmental impacts can be developed to evaluate the proposed structural measures. The latter is especially true in those stream reaches designated for possible channel modification.

6. A literature search is needed to obtain all available biological information, much of which is located in libraries and agency depositories. In addition, fieldwork should be planned to fill data gaps, such as baseline conditions for fish and benthic populations. This baseline is needed to adequately assess environmental impacts.

7. Areas of high environmental quality should be identified and inventoried.

8. Studies are needed to determine additional demand for recreational facilities, usage of existing facilities, and potential sites.

9. More study is needed to determine the precise nature of the water supply problems and potential solutions.

10. A review of secondary sources and systematic field reconnaissance is needed to identify archeological and historical sites. Also, architectural history should be investigated.

11. Crop distribution in the floodplain needs to be precisely identified through contact with county agents, and average annual rural damages need to be updated.

12. Urban damages need to be recomputed in a systematic fashion.

13. More gauging stations need to be developed to provide hydrologic data for establishing flood frequencies and rating curves.

14. Channel cross sections of the various streams need to be prepared for flood control planning purposes.

15. The effect of drainage works on flood discharges and stages is unknown at present. It would take additional, more detailed studies to determine the extent and effect of reduced natural storage.

16. Potentialities for natural storage need to be thoroughly investigated.

17. Potentialities for floodwater storage in present drainage ditches needs to be investigated.

18. A detailed social profile of the subbasin is needed.

19. Knowledge of the location, areal extent, and types of wetlands in the subbasin would be useful in determining whether wetland restoration would assist in alleviating flooding problems.

20. The potentiality for land treatment measures needs to be thoroughly investigated.

21. The irrigation potentials of the subbasin soils needs to be investigated.

22. Information on wastewater management needs to be updated through studies of existing point discharges. This would provide better baseline data upon which the impacts of channelization can be evaluated.

23. A lake management program should be established at Lake Traverse and Mud Lake to alleviate or eliminate the advanced eutrophication.

24. A detailed institutional analysis of the subbasin is needed.

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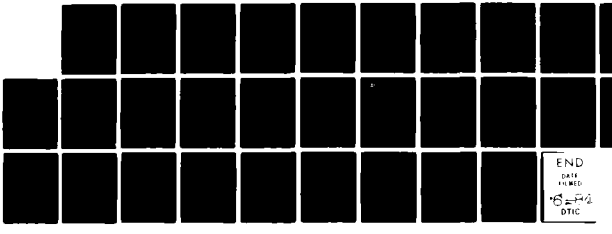

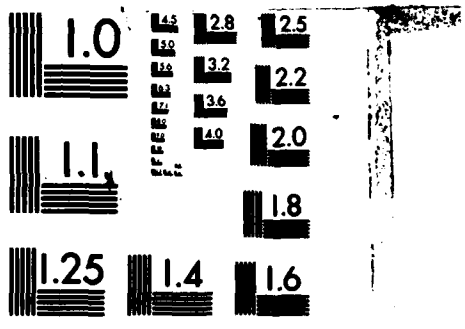

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Appendix A
FLOODPLAIN DELINEATION

Appendix A

FLOODPLAIN DELINEATION

Prior to this study, no attempt was made to publish even a generalized delineation of the entire Bois de Sioux-Mustinka River floodplain. In undertaking this task, the present study utilized all known secondary sources to provide the best available data for generalized delineation at a scale of 1:250,000. Principal sources were: USGS Flood Prone Area Maps (scale 1:24,000), Federal Insurance Administration flood maps (various scales), other published secondary data, U.S. Geological Survey (USGS) 7 1/2 minute topographic maps, and other sources, including derived data where necessary.

The Flood Prone Area Maps published by the USGS provided detailed and accurate information for the area mapped. Three maps provided coverage along the Bois de Sioux River from approximately 5 miles north of the South Dakota border to the northern tip of the subbasin.

Federal Insurance Administration Flood Hazard Boundary Maps and Flood Insurance Rate Maps provide important coverage of the Minnesota portion of the Red River Basin. The former are designed only to delineate the 100-year floodplain. The latter are much more detailed and are therefore usually more accurate. The approximate northern one-fourth of the Minnesota side of the subbasin (Wilkin and Ottertail counties) was covered by Rate Maps. Boundary Maps were available for Traverse, Grant, and Stevens counties.

Other secondary sources, such as the West Tributary Bois de Sioux River Watershed Work Plan, were used to provide additional floodplain delineations. Where published data was lacking, as in certain parts of the North and South Dakota portions of the subbasin, data was inferred from abrupt endings of published delineations or marsh patterns in the immediate vicinity on USGS 250,000- and 24,000-scale maps.

As noted in Section III of this report, the Souris-Red-Rainy River Basins Comprehensive Study contained a floodplain description differing significantly from delineated sources, particularly in the central portion of the subbasin. For this reason, an additional crosshatched pattern was utilized to depict these broad areas in Figure II.

Data from the above sources (both delineated and descriptive) were compiled and delineated on USGS 250,000-scale maps. The floodplain indicated was then planimetered in whole and by segment with figures converted into land measure and rounded to the nearest 2,000 acres. The less definitive crosshatched areas were rounded to the nearest 5,000 acres.

Appendix B

INVENTORY OF OUTDOOR RECREATIONAL FACILITIES, BOIS DE SIOUX SUBBASIN

App

INVENTORY OF OUTDOOR
BOIS DE S

Number	Name	Own	Administration	Location	Boundary Acres	Number of Resort Units	Campground Primitive	Modern	Group
1	Borem WMA	State	DNR[6]	Otter Tail Co. 13144W17	56.9				
2	Western Township Co. Gravel Pit	State	DNR	Otter Tail Co. 13144W21 Rabbit River	15.0				
3	Copeland WMA	State	DNR	Otter Tail Co. 13144W32	120.0				
4	Aastad WMA			Otter Tail Co. 13143W22 Aastad Township	471.9				
5	Hubo-Swift WMA	State	DNR	Grant Co. 13044W11 Lawrence Township	403.0				
6	Shank WMA	State	DNR	Grant Co. 13044W24 Stony Brook Township	63.2				
7	Murple WMA	State	DNR	Grant Co. 13044W23 Ash Lake Lawrence Township	119.0				
8	Bergerud WMA	State	DNR	Grant Co. 13043W08 Pleten Lake Stony Brook Township	61.6				
9	Spotiska WMA	State	DNR	Grant Co. 12943W11 West Elbow Lake	778.1				
10	Halsens WMA	State	DNR	Grant Co. 12843W28 Moose Lake	293.2				
11	Blakesley WMA	State	DNR	Grant Co. 12843W33 Blakesy Lake	106.0				
12	Wilds WMA	State	DNR	Grant Co. 12743W09 West of Burr Lake	147.0				

Appendix B

RY OF OUTDOOR RECREATIONAL FACILITIES[1]
BOIS DE SIOUX SUBBASIN

Resort Units	Campground				Athletic Field Acres		Marina				Trails (Miles)										
	Primitive	Modern	Group	Wildlife Management Acres		Golf	Canoe	Rental[2]	Storage[3]	Playground	Park[4] Lamp	Picnic Table	Beach	Pool	Nature	Horse	Snow	Hike	Bike	Ski	Trail	Shooting Range	Boat Area	Fairground	Docks[5]
				56.9																				71
				15.0																				71
																								71
				302.0																				76
				328.0																				71
				51.0																				71
				73.0																				71
				54.0																				71
				698.0																				71
				262.0																				71
																								77
				147.0																				71

-continued-

INVENTORY OF OUTDOOR RECR
BOIS DE SIOUX

Number	Name	Own	Administration	Location	Boundary Acres	Number of Resort Units	Campground: Primitive	Campground: Modern	Campground: Group	Wildlife
13	Macoville WMA	State	DNR[6]	Grant Co. 12743W27 Niemaki Lake	281.8					257
14	Towner WMA	State	DNR	Grant Co. 12743W33 Niemaki Lake	99.0					86
15	White Rock Dam WMA	Federal	DNR	Traverse Co. 12847W27 Bois de Sioux River, North of Mud Lake	73.5					73
16	Reservation Dam WMA	Federal	DNR	Traverse Co. 12747W31 Mud Lake	872.4					872.4
17	Morning Pit WMA	State	DNR	Stevens Co. 12644W18 West of Donnelly	55.0					
18	Buckholt Grove WMA	State	DNR	Stevens Co. 12644W14 West of Donnelly	25.0					25.0
19	Thodin WMA	State	DNR	Stevens Co. 12643W07 West of Donnelly	27.0					27.0
20	Everglade WMA	State	DNR	Stevens Co. 12644W36 Donnelly	99.9					99.9
21	Clin WMA	State	DNR	Stevens Co. 12543W19 Northwest of Alberta	132.8					132.8
22	West Toqua WMA	State	DNR	Big Stone Co. 12446W17 West Toqua Lake	379.3					
23	Shoog WMA	State	DNR	Big Stone Co. 12447W26 Clinton	246.1					187.0

Appendix B

OUTDOOR RECREATIONAL FACILITIES[1]
DIS DE SIOUX SUBBASIN

Campground					Marina									Trails (Miles)									
Modern	Group	Wildlife Management Area	Athletic Field Area	Golf	Canoe	Rental[2]	Storage[3]	Playground	Park[4]	Ramp	Picnic Table	Beach	Pool	Nature	Horse	Snow	Hike	Bike	Ski	Trail	Shooting Range	Rest Area	Fairground	Date[5]
		267.0																						71
		86.0																						71
		73.0																						71
		872.0																						71
																								71
		25.0																						71
		27.0																						71
		99.9																						71
		132.8																						71
																								71
		187.0																						

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INVENTORY OF OUTDOOR RE
BOIS DE SIOU

Number	Name	Own	Administration	Location	Boundary Acres	Number of Resort Units	Campground: Primitive	Campground: Modern	Campground: Group
24	Dobberstein GPA[8]	State	DGFP[9]	Roberts Co. 1 mile West of New Effington	80.0				
25	Bretten GPA	State	DGFP	Roberts Co. 1 mile East, 2 miles South of Victor	22.0				
26	Crawford Area GPA	State	DGFP	Roberts Co. 1 mile East, 2 miles South of New Effington	218.0				
27	Victor GPA	State	DGFP	Roberts Co. 1 mile East of Victor	120.0				
28	White Rock GPA	State	DGFP	Roberts Co. 6 miles East of Rosholt	1,828.0				
29	Upper Dry Run GPA	State	DGFP	Roberts Co. 4½ miles South, 4 miles East of New Effington	76.0				
30	Diamond Area GPA	State	DGFP	Roberts Co. 9½ miles South, 1½ miles West of Rosholt	32.0				
⚠	Herman Municipal Camping Fairgrounds	Municipal		Grant Co. 12744W13 Pullman Lake	40.0			10	
⚠	White Rock Dam Recreation Area	Federal	USFW[7]	Traverse Co. 12847W27 Bois de Sioux River	3.0				
⚠	Rainbow Island Resort	Private		Traverse Co. 12648W29 Lake Traverse	48.9	10			

Appendix B

OUTDOOR RECREATIONAL FACILITIES[1]
IS DE SIOUX SUBBASIN

Campground					Marina									Trails (Miles)									
Modern	Group	Wildlife Management Acres	Athletic Field Acres	Golf	Canoe	Rental[2]	Storage[3]	Playground	Park[4]	Ramp	Picnic Table	Beach	Pool	Nature	Horse	Snow	Hike	Bike	Ski	Trout	Shooting Range	Boat Area	Fairground[5]	Date
10																							X	78
											5													75
						X			18															76

-continued-

Appendix

INVENTORY OF OUTDOOR RE
BOIS DE SIOU

Number	Name	Own	Administration	Location	Boundary Acres	Number of Resort Units	Campground: Primitive	Campground: Modern	Campground: Group	Campground:
4	Traverse County Park	County		Traverse Co. 12549W02 Lake Traverse	16.5					
5	Toqua Lake Public Access	County	County	Big Stone Co. 12446W16 East Toqua Lake	40.0					
1	Hammer Lake	State	DGFP[9]	Roberts Co. 1½ miles North of Hammer	159.77					
2	North Hammer Lakes (2)	State	DGFP	Roberts Co. 4 miles Northeast of Hammer	142.15					
3	Bde-Sake Lake	State	DGFP	Roberts Co. 7 miles South of Victor	448.0					
4	Club House Lake	State	DGFP	Roberts Co. 5½ miles East, 1 mile North of Rosholt	1,676.8					
5	Mud Lake	State	DGFP	Roberts Co. 6 miles East, 1 mile South of Rosholt	1,723.7					
6	Lake Traverse	State	DGFP	Roberts Co. North of Brown's Valley, Minn.	1,200 acres (South Dakota portion)					
1	Larson Hunting Camp	Private		Traverse Co. 12747W09 Mud Lake	206.0					
2	Johnson's Hunting Camp	Private		Traverse Co. 12747W29 Mud Lake	145.0					25

Appendix B

OUTDOOR RECREATIONAL FACILITIES[1]
OIS DE SIOUX SUBBASIN

Campground					Marina								Trails (Miles)									
Modern	Group	Wildlife Management Acres	Athletic Field Acres	Golf	Canoe	Rental[2]	Storage[3]	Playground	Park[4]	Ramp	Picnic Table	Beach	Pool	Nature	Horse	Snow	Hike	Bike	Ski	Trail	Shooting Range	Rest Area	Fairground	Data[5]
									15 X															76
																								73
																								74
	25																							

-continued-

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App

INVENTORY OF OUTDOOR
BOIS DE SI

Number	Name	Own	Administration	Location	Boundary Acres	Number of Resort Units	Campground: Primitive	Campground: Modern
(3)	Wheaton Country Club	Private		Traverse Co. 127N47W27	55.1			
(4)	Rosholt Independent School Playground	School		Roberts Co. 128N48W Rosholt	24.0			

[1]Facilities included are limited to those with 15 or more acres.

[2]Boat rental.

[3]Boat storage.

[4]Parking spaces.

[5]Date of latest facility information.

[6]Department of Natural Resources.

[7]United States Fish and Wildlife Service.

[8]Game Production Area.

[9]Department of Game, Fish and Parks, State of South Dakota.

Source: Department of Natural Resources, Division of Parks and Recreation, State of Minnesota and State of South Dakota Department of Game, Fish and Parks.

Appendix B

OUTDOOR RECREATIONAL FACILITIES[1]
OIS DE SIOUX SUBBASIN

Campground							Marina								Trails (Miles)										
Primitive	Modern	Group	Wildlife Management Acres	Athletic Field Acres	Golf	Canoe	Rental[2]	Storage[3]	Playground	Park[4]	Ramp	Picnic Table	Beach	Pool	Nature	Horse	Snow	Hike	Bike	Ski	Trail	Shooting Range	Boat Area	Fairground	Data[5]
					9																	X			76
				24					X																

Minnesota

1

2

Appendix C
COMMENTS

Appendix C
COMMENTS

The purpose of this subbasin report was to provide an overview of the water and related resource problems and needs and to assess potential solutions. Toward this end, draft copies of this report were circulated to Federal, State, and local agencies and comments were sought.

This review resulted in complete and factual documentation. Thus, the study should serve as a building block for the timely completion of future water resource efforts within the subbasin. Further cooperative efforts are, however, needed to evaluate these tentative results and to develop potential solutions.

A distribution list and copies of the comments made with respect to the draft report are included as part of this appendix. Comments that resulted in specific modifications to the draft text are marked by an asterisk.

DEPARTMENT OF THE ARMY
ST PAUL DISTRICT CORPS OF ENGINEERS
1135 U S POST OFFICE & CUSTOM HOUSE
ST PAUL, MINNESOTA 55101

REPLY TO
ATTENTION OF:

NCSED-PB

3 July 1980

Mr. Mike Liffmann
Project Manager
Gulf South Research Institute
8000 GSRI Avenue
Baton Rouge, Louisiana 70808

Dear Mr. Liffmann:

The draft Bois de Sioux-Mustinka Rivers Subbasin report was distributed for review and comment. Most of the reviewers have sent their comments to us.

a. Inclosure 1 includes letters from various Federal and State agencies.

b. Inclosure 2 is the general office comments that need to be considered when preparing the final Bois de Sioux-Mustinka River Subbasin report and the remaining subbasin reports.

c. Inclosure 3 identifies specific office concerns that are applicable to the Bois de Sioux-Mustinka subbasin report.

If you have any questions on our comments or proposed modifications, please contact us.

Sincerely,

Louis E. Kowalski

LOUIS E. KOWALSKI
Chief, Planning Branch
Engineering Division

3 Incl
As stated

United States Department of the Interior

FISH AND WILDLIFE SERVICE

IN REPLY REFER TO:

St Paul Field Office, Ecological Services
538 Federal Building and U.S. Court House
316 North Robert Street
St. Paul, Minnesota 55101

June 9, 1980

Colonel William W. Badger
District Engineer, St. Paul District
U.S. Army Corps of Engineers
1135 U.S. Post Office & Custom House
St. Paul, Minnesota 55101

Dear Colonel Badger:

This provides U.S. Fish and Wildlife Service comments on the Draft Reconnaissance Report recently compiled by Gulf South Research Institute for the Bois de Sioux - Mustinka Rivers Subbasin in Traverse, Big Stone, Stevens, Grant, Ottertail, and Wilkin Counties in Minnesota, Richland County in North Dakota, and Roberts County in South Dakota.

As expressed in our comments on previous Subbasin Reports, our major concerns are associated with the woodland, grassland, wetland, riverine, and riparian floodplain habitats that continue to exist within the Bois de Sioux - Mustinka Rivers Subbasin. Most of the native grassland and woodland vegetation within the Subbasin has been eliminated by agricultural production or altered by heavy grazing of livestock. Less than one percent of the Subbasin continues to contain woodland vegetation and this is predominantly in the form of windbreaks and farm woodlots. However, some small stands of natural woodland vegetation remain (such as along the bluffs around Lake Traverse and in a few areas along the Bois de Sioux River) and these areas should be preserved within the Subbasin. We agree with the statement (on page 39 of the Report) that these remaining woodland areas of the Subbasin are significant habitats for wildlife resources because of the areas they afford for breeding, nesting, feeding, and resting, or as migratory or travel corridors. The drainage of wetlands has also been substantial and is a major problem in the Subbasin. The majority of the remaining wetlands are located in the morainic hills of the eastern and western reaches of the Subbasin. We agree with the statement on page 11 of the Report that there is an urgent need for the preservation of wetlands and development of replacement habitats due to the continued destruction of these habitat types. We also agree with the statement on page 36 that existing scenic areas (major lakes, forest areas, and wetlands) need to be maintained as a valuable resource in the Subbasin.

Many of the lakes and streams in the Subbasin have water quality problems and are being significantly degraded. This is particularly evident

Encl 1

in Lake Traverse and Mud Lake. Effective land treatment measures and plans for correcting these pollution problems need to be implemented within the Subbasin.

Another area of particular concern is the Bois de Sioux River itself which supports a significant river fishery including channel catfish, walleye, sauger, northern pike, smallmouth bass, rock bass, and yellow perch. As such, no actions and/or measures should be undertaken within the Subbasin that would inappropriately degrade or adversely impact this important riverine resource.

The Subbasin contains numerous State Wildlife Management Areas (WMA's) and Federal Waterfowl Production Areas (WPA's). These areas, in many locations, provide the only available habitat for wildlife within this heavily farmed Subbasin and are also significant because of the outdoor recreational opportunities they provide.

The report addressed three structural alternative measures that have been identified to date to meet the flood control planning objective within the Subbasin. These measures, and our comments relative to each of these alternative measures, are as follows:

Alternative 1 (Construction of agricultural levees along each side of the Bois de Sioux and Mustinka Rivers and their tributaries from their mouths upstream to high ground - 48 miles along the lower reaches of the Bois de Sioux River and 96 miles along the lower reaches of the Mustinka River and its tributaries).

Our comments here are the same as those previously provided in our May 8, 1980 letter relative to Alternatives 2a and 2b in the Draft Reconnaissance Report on the Tamarac River Subbasin. Page 66 of the Report indicates that moderate to maximum beneficial effects are anticipated for wildlife resources since the large setback of the levees away from these river channels would provide protection of the riparian belt and induce the reestablishment of a riparian community (woodland and/or brushland habitat) between the levees in these areas. We suspect, in many instances, this would only occur if these areas are "zoned" to prevent agricultural activities from being undertaken between the levees and the existing river channel. Page 66 also indicates that minimal recreational benefits would accrue from fishing activities in the borrow areas that would be created in order to construct the levees. We also feel these borrow areas would only have minimal fishery value. Instead, we would suggest that wetland areas be constructed in these borrow site locations as a mitigation feature for the project. The general design specifications for these wetland areas, however, should be coordinated with the Fish and Wildlife Service.

Alternative 2 (Channelization of 220 miles of the Mustinka River and its tributaries, Doran Coulee, and the Rabbit River to contain the 10% flood).

Our comments here are the same as those previously provided in our

comment letter relative to Alternative 1 in the Draft Reconnaissance Report on the Tamarac River Subbasin. As previously mentioned, we have substantial problems with these channelization proposals. We concur (as indicated on pages 66 and 67 of the Report) that most of these "improvements" would result in maximum adverse impacts on fish and wildlife resources and water quality, while at the same time only yield minimum to moderate social and economic benefits. Our contact with the Minnesota Department of Natural Resources Area Fisheries Manager revealed that northern pike, crappies, and white bass are found in certain reaches of the Mustinka River and, particularly, in the area between Wheaton and Lake Traverse. The Rabbit River also contains northern pike in its lower reaches from the town of Campbell to the Bois de Sioux River.

Alternative 3 (Construction of levees around farmsteads in flood-prone areas to provide protection against a 1% (100 year) flood).

We do not anticipate any significant adverse environmental impacts due to this alternative provided that the dikes are not constructed through wetland areas and impacts to existing woodland and grassland vegetation are avoided to the extent possible.

Some nonstructural measures were also briefly discussed on pages 57, 58, 63, and 71 of the Report. We believe a plan involving a combination of structural and nonstructural measures (as provided on page 4 of our previous comment letter on the Draft Reconnaissance Report for the Tamarac River Subbasin) should be implemented. In addition, we believe that special efforts should be undertaken in the Subbasin to reduce non-point sources of pollution from farming operations and cattle yards and the eutrophication problems in Lake Traverse and Mud Lake.

We agree that additional studies (particularly numbers 3, 15, 16, 17, 19, 20, and 23 addressed on pages 70 and 71 of the Report) need to be undertaken in order to provide a more detailed and in-depth analysis of existing Subbasin problems and the potential solutions to many of these problems.

Generally, we believe the Draft Report was well written. We suggest, however, that the following changes be made in the Final Report:

* 1. Page 38, 1st paragraph - put the last sentence pertaining to waterfowl production areas at the beginning of this paragraph and change it to read as follows:

   In addition, there are numerous federal waterfowl production areas within the Subbasin that are open to the public for hunting.

* 2. Page 41, 1st paragraph - change this to read as follows:

   Wetland data for Type 1, 3, 4, and 5 wetlands in the six

counties within the Minnesota portion of the Subbasin are presented in Table 12. The figures were obtained during a 1964 inventory based on a 25 percent sampling of the wetlands within these counties. The number and acreage of all Type 3, 4, and 5 wetlands were multiplied by four to expand the 25 percent sample to 100 percent. Type 1 and 2 wetlands were not measured in the 1964 survey. The number and acreage of Type 1 wetlands, however, were estimated based on previous studies which indicated that they comprise about 60 percent of the total wetland numbers and 10-15 percent of the total wetland acres in the Prairie Pothole Region.

*3. Page 42, table 12 - scratch Type 2: Fresh Meadows under this table since no data is available on these areas.

*4. Page 41, 2nd paragraph, 1st sentence - change this to read as follows:

Table 13 shows wetland data obtained during a 1974 inventory based on a 100 percent sampling of Type 3 through 8 wetlands and stock ponds within these six Minnesota counties.

*5. Page 41, 2nd paragraph, last sentence - change this to read as follows:

These data show that the wetland numbers and acreages have been reduced by 7,638 and 4,591 acres, respectively, in the counties included wholly or in part within the Subbasin during this 10-year period.

*6. Page 41, last paragraph (under the heading Waterfowl Production Areas) - change this paragraph to read as follows:

These Waterfowl Production Areas (WPA's) are wetland areas that the U.S. Fish and Wildlife Service (USFWS) has either acquired through fee title or obtained an easement interest on to preserve valuable breeding, nesting, and feeding habitat for migratory waterfowl. These wetland areas are purchased, or an easement interest obtained, with funds received from the sale of Migratory Bird Hunting and Conservation Stamps ("Duck Stamps"). These WPA's are significant because they provide the public with a great variety of wildlife-oriented recreational opportunities as well as providing valuable habitat for migratory waterfowl and many other forms of wildlife. The USFWS is responsible for the compatibility determinations (uses) and the issuance or denial of permits involving these lands. The approximate locations of these WPA's (fee tracts) within the Subbasin are shown in Figure IV. Total acreage of these WPA's (fee and easement) within Big Stone, Grant, Ottertail, Stevens, Traverse, and Wilkin Counties, Minnesota are given in Table 16.

*7. Page 46, Table 16 - remove the cost column which is not necessary in this report and simply put Fee (Acres) and Easement (Acres) above the appropriate acreage columns. In addition, change the title to read ACRES OF FEDERAL WATERFOWL PRODUCTION AREAS (FEE AND EASEMENT) WITHIN THE BOIX DE SIOUX - MUSTINKA RIVERS SUBBASIN. The acreage figures for Traverse County (which was omitted from the Table) are 2,655 acres in fee title and 903 acres under easement and these should also be included in Table 16.

*8. Page 47, 1st paragraph - we suggest this paragraph be changed to read: Reptile and amphibian species of special interest known to exist within the counties of the Subbasin consist of--.

*9. Page 58, 1st paragraph, last sentence - we recommend this be changed to read: Information on natural storage areas and potentialities for increased storage is very limited. Indications are, however, that wetlands play a substantial role in controlling runoff, especially in combination with good land treatment practices. Values on storage have averaged about 12 inches per surface-acre of wetlands, and have ranged to four times that amount (Cernohous, 1979).

*10. Page 63, 3rd paragraph - the potential use of present drainage ditches for floodwater storage, use of natural areas for water retention, and acquisition of previously drained natural areas for reversion to water retention use should also be addressed in this paragraph.

*11. Page 73, BIBLIOGRAPHY - include the following reference on this page:

Cernohous, L. 1979. The Value of Wetlands for Flood Control. U.S. Fish and Wildlife Service, Bismarck Area Office, Bismarck, N.D. 7 pp.

These comments have been prepared under the authority of and in accordance with provisions of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et. seq.) and are consistent with the intent of the National Environmental Policy Act of 1969.

Sincerely,

Richard F. Berry

Richard F. Berry
Field Office Supervisor

cc: Minn. DNR, St. Paul
S. Bittner, Gulf South Res. Inst., New Iberia

United States Department of Agriculture
Soil Conservation Service
316 North Robert St., Room 200
St. Paul, Minnesota
55101

May 19, 1980

Colonel William Badger
District Engineer
St. Paul District, Corps of Engineers
1135 Post Office Building & Custom House
St. Paul, Minnesota 55101

Dear Colonel Badger:

Following are comments we have on the draft report Bois De Sioux-Mustinka Rivers Subbasin:

*Page 7 - last paragraph - scientific is misspelled.

Page 8 and 45 - we feel that it would help if this map had a legend.

*Page 10 - Table 1 on this page shows that other flood damages are $11.8 when this should be total flood damages.

*Page 11 - average annual damage should total 598.8 in Table 2.

*Page 22 - Table 5 - there needs to be an explanation of what S I C means.

Page 27 - 2nd paragraph - northern prairie "skunk" is misspelled.

*Page 27 - 3rd paragraph - this paragraph conflicts with what is stated in the 2nd paragraph on page 5.

We hope these comments will be useful to your report.

Sincerely,

Jon V. DeGroot
Assistant State Conservationist

IR-8

STATE OF
MINNESOTA
DEPARTMENT OF NATURAL RESOURCES
444 Lafayette Road, Space Center Bldg., St. Paul, MN 55101
PHONE 612/296-4800

File No.

May 29, 1980

Colonel William W. Badger
St. Paul District
Corps of Engineers
1135 U.S. Post Office & Custom House
St. Paul, MN 55101

Dear Colonel Badger:

COMMENTS ON BOIS DE SIOUX - MUSTINKA AND OTTERTAIL RIVER SUBBASIN REPORTS

Thank you for the opportunity to review the above referenced documents.

The documents do a good job of presenting the existing information on each subbasin. There is still however, not enough detailed information provided on non-structural alternatives. The only feasible alternative identified in either of these reports is farmstead ring-dikes. Since most structural alternatives do not appear to be feasible it is necessary to provide much more information on the costs and benifits of non-structural alternatives including relocation, flood proofing, flood insurance, flood plain zoning and land treatment. It may not be possible for the Corps of Engineers to participate in some of these programs, but it is critical that all potentially feasible alternatives be investigated.

Attached are specific comments on the two subbasin reports. If you have any questions, please contact Joe Gibson at 612/296-0438 or Ron Harnack at 612/296-0440.

Sincerely,

DIVISION OF WATERS

Larry Seymour
Director

LS/JG:ph

cc: Joe Gibson
Ron Harnack

BOIS DE SIOUX - MUSTINKA RIVERS SUBBASIN

*PAGE 54 - 1st PARAGRAPH -

It is unclear,draw riparian doctrine vs. appropriation doctrine affects comprehensive flood plain management in the subbasin.

*PAGE 63 -

The adoption of flood plain zoning ordinances, relocation and flood-proofing should be examined in detail as an alternative.

Comprehensive land treatment at various levels (30% 50% 70% & 90%) of lands adequately protected is another alternative that should be examined in great detail in terms of both flood damage reduction and water quality improvements.

*PAGE 64 -

The costs, benefits and effects of the two above mentioned non-structural alternatives should be displayed also.

OTTERTAIL RIVER SUBBASIN

*PAGE 10 -

How are average annual damages being determined for this subbasin and all other subbasins.

PAGE 63 -

The lakes in this part of the state have a wide range of level fluctuation. It is highly unlikely that water levels will continue to rise unchecked. This is currently a period of generally higher than normal precipitation and water levels will fall during years of less than normal precipitation. An alternative that should be examined is moving back homes that were constructed in or near the lake bed during periods of low water.

PAGE 63 - LAST PARAGRAPH -

It is unlikely that conditions such as this are prevalent throughout the upland portions of the subbasin.

*PAGE 65 -

Communities and counties are required to adopt flood plain zoning ordinances once sufficient data are available. Other non-structional measures such as flood proofing relocation and insurance should be looked at as one or more non-structural alternatives.

*PAGE 65 -

Various levels of land treatment for flood damage reduction, erosion, control and water quality improvement purposes should be evaluated as alternatives.

(continued)

PAGE 66 -

On page 11 it only shows $1300 of total residential damages. Not all of this occurs in the Cormorant Lake area.

PAGE 66 -

Other proposed non-structural alternatives should be examined in detail.

Corps of Engineers
North Central Division
Comments on the
Bois de Sioux-Mustinka Rivers Subbasin
Red River of the North Reconnaissance Study
(30 May 1980)

1. Page 8 -- This map is inadequate. Where is the legend? The map should be revised to make it more readable.

2. Pages 7-9 -- The discussion on the location and extent of the 100-year floodplain should be clarified. Suggest inclusion of a table for comparison, contrast, or just listing of acreages.

3. Page 10 -- The present average annual damages in the Ottertail River basin are less than half of this amount. If $610,000 is "a very small figure," give an amount for comparison.

*4. Pages 15 and 28 -- These two discussions imply sufficient water for both irrigation and municipal/industrial use. Is this the case? Refer to objective 5, page 60, regarding water supply. There appears to be a contradiction here.

5. Public perception -- Why hasn't the Corps held any workshops or meetings in this subbasin? How can there be an intelligent discussion of needs without this type of input?

*6. Page 20 -- Discussion of Amerind groups in the area should address these people as either American Indians or native Americans.

*7. Architectural history should also be discussed. The numerous artisan styles should help to show the evolution of man's (Euro-American) adaptation in this area. If no work has been done, state so and include in additional study needs.

8. Page 48 -- Please include a table comparing the OBERS projections and growth rates to the projections and rates depicted in table 17.

*9. Page 69 -- The evaluation suggests that it be noted that the present study is very much a "broad-brush" approach and that the figures contain a large degree of variance. Therefore, alternatives such as the channel improvement along the Mustinka River with a B/C ratio of 0.74 should be recommended for further study. Also, note in this section that the Mustinka River channel improvement provides the most protection of all the alternatives.

*10. Page 60 -- The list of objectives is basically good. However, include phrases in each objective to indicate the purpose for the objective (for example, objective 2 should include a phrase about enhancing the environment for the preservation of a wildlife species or improving the quality of life or scenic diversity). All of the objectives are awkwardly phrased. Rearrange words to increase readability. Include a brief discussion of the national objectives (NED-EQ).

11. Page 61-63 -- Discussion of alternative formulation needs expansion. A series of alternatives is not presented, just one each - structural and non-structural. What about a combination? The figure also does not clearly show the location of alternatives.

GENERAL COMMENTS
DRAFT BOIS DE SIOUX-MUSTINKA RIVERS SUBBASIN REPORT
(MAY 1980)

(These comments apply to the entire report and all subsequent subbasin documents.)

1. This document generally needs additional detailed information concerning nonstructural alternatives. Few of the structural alternatives appear feasible; therefore, unless economics are ignored, nonstructural solutions remain important to reduce the magnitude of future flood damages. The overall report should address and clarify this aspect of flood damage reduction planning.

2. Comments from Federal, State, and local agencies and a letter from the St. Paul District will be included in an appendix in each final subbasin and in the overall report. The format for the appendix will be:

a. Introduction - This section should stress:

(1) The importance of completing the study on time.

(2) That the purpose of the study is to advise other agencies and interests.

(3) The need for a selected review by various interests to provide complete and factual documentation.

(4) The use of the study as a building block for future water resource efforts.

(5) That cooperative efforts to evaluate results and develop solutions to remaining problems will be incorporated.

(6) A complete public involvement program when the study is finished.

b. The distribution list.

c. Copies of letters of comment.

Only comments that identify significant errors or need specific attention will be addressed in the final subbasin report. However, all comments incorporated should be identified with a marking system. The distribution list for the Bois de Sioux-Mustinka River Basin Report is given below:

Agencies receiving draft report	Date sent	Date comments received
Federal		
Soil Conservation Service	9 May 80	19 May 80
Fish and Wildlife Service	9 May 80	9 Jun 80
Corps of Engineers, North Central Division	7 May 80	30 May 80
Corps of Engineers, St. Paul District	7 May 80	20 May 80

State

Water Planning Board	9 May 80	
Department of Natural Resources	9 May 80	29 May 80
Planning Agency	9 May 80	-
Water Resources Board	9 May 80	-

Local

Watershed District	9 May 80	-
City of Breckenridge	9 May 80	-

3. The source for most information identified in the majority of the tables is Gulf South Research Institute. If other sources were used, an appropriate reference should be made.

SPECIFIC COMMENTS
DRAFT BOIS DE SIOUX-MUSTINKA RIVERS SUBBASIN REPORT
(May 1980)

*1. Page 2 - After the last sentence, add: "The main report will consider the possibility of various water resource-oriented agencies serving as vehicles for implementing flood damage reduction actions and undertaking additional study needs."

*2. Page 3, last paragraph - The dominant water features of the subbasin should include the Rabbit River as referenced on pages 5 and 14.

3. Page 4, Figure I - The towns of Norcross, Fairmont, and Campbell should be identified because they are referred to in the document.

*4. Page 5, 2nd paragraph, last sentence - "Completed" is misspelled.

*5. Page 6, line 5 - Bois de Sioux is misspelled.

*6. Page 7, 2nd paragraph, last sentence - It is not clear whether the 6.5-percent contribution of runoff is intended to be a volume or peak reference. This should be clarified.

*7. Page 7, 3rd paragraph - The statement of no generalized delineation of the subbasin is not quite true. The Souris-Red-Rainy type II study did provide this delineation, although the numbers may vary from the provisional data identified in this draft. These numbers may be just as valid as yours. A table comparing watersheds may be an appropriate way to identify differences and to highlight areas needing additional refinement of the floodplain delineation.

*8. Page 10, table 1 - "Other" should read "total."

9. Page 10 - The flood damage information for the 1975 flood indicates that there were no rural or urban damages sustained during that year. On page 21 it is suggested that income declined sharply in 1975 as a result of severe flooding. Descrepancies such as this should be avoided and corrected in the final document.

*10. Page 11, table 2 - The total average annual should read "$598.8."

*11. Page 16, Public Perception of Problems and Solutions section - Although no official public meetings have been held for residents in the Bois de Sioux-Mustinka Rivers area, there have been many informal meetings and discussions with local interests. The Corps representative at our facility provides a good avenue for interaction between the public and us. Local interests have been well represented at meetings held throughout the basin and have actively participated in discussions and on various committees concerning water resource problems, needs and solutions.

12. Page 17, table 3, column 5 - "MNL" should be identified.

*13. Page 19, first line - "Discusses" is misspelled.

14. Page 19, Social Characteristics Section - Although in-migration may be occurring, care should be taken in using Otter Tail, Richard and Grant counties for the basis. It may be that the out-migration in Traverse County is more representative of the basin. This implies that the population may still be declining and would probably be more realistic given the location in the basin and existing resources available in this subbasin.

*15. Page 20, 3rd paragraph - Establishment of a watershed district which would encompass the entire subbasin would be difficult because three States are involved. Each has different policies and regulations concerning the organization and responsibilities of districts. Possibly some other institutional arrangement would be more appropriate.

16. Page 21, Income Section - The per capita income figure is high because a portion of the subbasin is located in Grant, Otter Tail and Richland Counties. A lower figure would be more appropriate if only Traverse County were used as a basis. Also, the State average is different than previously recorded in other subbasin reports. This should be clarified.

*17. Page 22, Manufacturing Section - The last sentence states that no manufacturing has more than 25 employees; however, table 5 indicates otherwise.

*18. Page 23, Transportation Section - State Highway 55, a major highway connection with Minneapolis-St. Paul, crosses the area through Elbow Lake, Wendell, and Tintah and connects with North Dakota. In addition, Interstate Highway 94 is accessible from many points in the area. The route from the subbasin to Duluth is not the I-35 connection from I-94. While it is true that I-35 goes north to Duluth from the Twin Cities, it is far out of the way. Grain haulers from the subbasin, in particular, make use of the Port of Duluth but do so by more northern routes.

*19. Page 23, Land Use Section - The land use percentages total about 98 percent. Is the remaining percentage urban? If so, this should be identified.

*20. Page 24, 2nd paragraph, first sentence - The last word should be "land" not "and."

*21. Page 24, Geology Section - The first sentence on physiography is not the same as geology.

*22. Page 25, Biology Section, first paragraph - This paragraph should indicate that there are limited stands of riparian woods along the rivers and various tributaries located in the subbasin. The data for the forest type map referred to were computed using a 40-acre parcel grid which meant that at least 50% of the parcel had to be classified as being forested. As a result many of the areas which have riparian woods are not identified.

*23. Page 26, 3rd paragraph - The second sentence should be deleted.

*24. Page 27, 3rd and 4th paragraph - Discussions on flows and flooding are covered in another portion of the document.

25. Pages 27-28 - The paragraph on the fisheries resources of Lake Traverse is confusing and should be rewritten. The paragraph discusses only those conditions that are considered to be adverse to fisheries populations; i.e., algal blooms and winter kills. Under what conditions are fisheries resources benefited, as indicated by the opening sentence (The fisheries resources... vary seasonally)? Are aquatic invertebrates or the fisheries resource being referenced when discussing the variations in populations in relation to the aquatic vegetation that is present? Also, rotifers are not crustaceans.

26. Page 36, 2nd paragraph - It is difficult to tell whether there are any prehistoric sites on the National Register because this paragraph only identifies historic sites. This fact should be clarified.

* 27. Page 39, Cultural Section - It is unclear whether the historical sites are standing structures or archaeological sites.

28. Page 39, Soils Section - Soil losses are not really minimized during the winter; in fact, area farmers report that they worsen. Wind conditions worsen during this period; and, due to the flat, open nature of the land, most snow is drifted into pileups at farmsteads and drainage ditches. This exposes the soil to erosion because of fall plowing. Wind erosion is one of the major causes for overland flooding in the area. The soil collects with the snow at drainage ditches, plugging them and exacerbating the problem. A program of farm windbreaks would do much to solve both flooding and erosion problems.

29. Page 47, 1st paragraph - What is the Great Plains toad and why does the State need more information on it?

30. Page 49, 1st paragraph - The out-migration might not be less than in-migration when considering the subbasin alone.

* 31. Page 54, 1st paragraph - There is a fundamental difference in the legal approach to water rights in the Dakota's and Minnesota. It is doubtful if this matter complicates water resource planning to a degree which would limit implementation of a particular plan.

* 32. Page 55, 1st paragraph - It should be mentioned that the Corps of Engineers operates the existing lake Traverse project.

* 33. Page 55, structural measure #1 - Lake Traverse can adequately control floods having about a 20 percent chance or greater (meaning more frequent) of occurring.

* 34. Page 55, structural measure #2 - The agency constructing, operating, and maintaining the project should be identified.

* 35. Page 59, 2nd paragraph - Add "Federal" between "appropriate" and "engineering."

* 36. Page 60, planning objective #5 - This item conflicts with the statements made on pages 15 and 28.

* 37. Page 63 - Additional information on nonstructural alternatives should be provided as indicated in our general comment #1 and by the State of Minnesota. At a minimum, discussions on nonstructural alternatives should be expanded.

*38. Page 64-68 - References to impacts of various alternatives on the cultural elements of the subbasin should be classified as being unknown. There has been no systematic cultural resources survey completed for the area. Table 21 should show the impacts on cultural elements as being "unknown."

39. Page 68, Agricultural Levee Section - In most cases, it is not reasonable to assume that habitats will be created riverward of the agricultural levees. Farmers will probably continue to farm whatever land is possible in this area, although the type of crop may vary. If there are some beneficial effects, it is reasonable to assume that they will probably be offset by an increase in erosion and sedimentation problems. At best, the total adverse effects may equal the total beneficial effects. Even if the recreation in this area is greatly improved, borrow pits would not be utilized. Discussions on this alternative should also include information on any necessary easements, review of the levee, and potential effects on habitat, etc., if the local interests continue to farm the riverward land where practical.

*40. Page 69 - See comment #9 provided by Corps of Engineers, North Central Division.

*41. Page 69, 2nd paragraph - See comment #39.

*42. Page 71, item #10 - It would be desirable to complete this study need before initiating further evaluations on alternatives.


DATE
FILME