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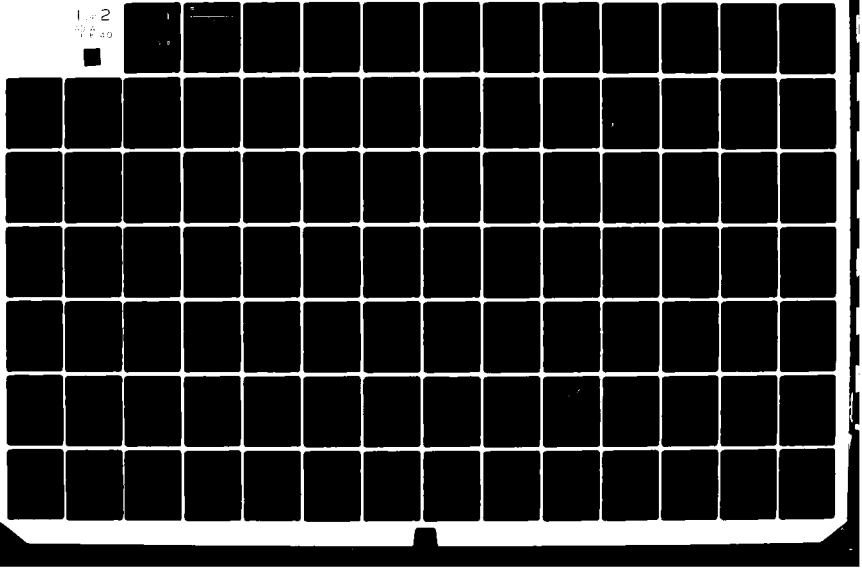

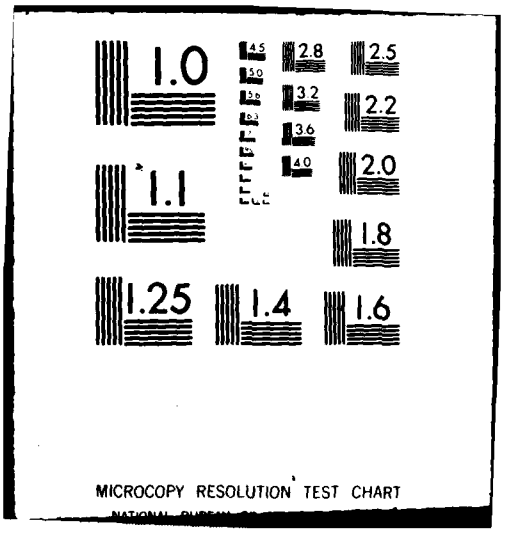
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DETAILED PROJECT REPORT FOR FLOOD CONTROL SNAKE RIVER BELOW WARREN, MINNESOTA SECTION 205

JANUARY 1982

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Flood Control

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

Following the floods of 1965, 1966 and 1969, the Middle River-Snake River Watershed District requested the Corps of Engineers to study flood problems along the Snake River from its mouth upstream to Warren, Minnesota. The basic objective of this study is to identify and develop a flood damage reduction plan that is engineerly and economically feasible and socially and environmentally acceptable. Land use, fish and wildlife conservation, water quality control, recreation, and environmental and social considerations were studied in cooperation with other federal and state agencies.

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SECTION 205
DETAILED PROJECT REPORT
FOR FLOOD CONTROL
SNAKE RIVER BELOW WARREN, MINNESOTA

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DETAILED PROJECT REPORT

FOR FLOOD CONTROL

SNAKE RIVER BELOW WARREN, MINNESOTA

INTRODUCTION

STUDY AUTHORITY

Authority for this report is provided by Section 205 of the Flood Control Act approved 30 June 1948, as amended, which reads as follows:

"The Secretary of the Army is authorized to allot from any appropriations heretofore or hereafter made for flood control, not to exceed $30,000,000 for any one fiscal year, for the construction of small projects for flood control and related purposes not specifically authorized by Congress, which come within the provisions of Section 1 of the Flood Control Act of June 22, 1936, when in the opinion of the Chief of Engineers such work is advisable. The amount allotted for a project shall be sufficient to complete Federal participation in the project. Not more than $2,000,000 shall be allotted under this section for a project at a single locality, except that not more than $3,000,000 shall be allotted under this section for a project at a single locality, if such project protects an area which has been declared to be a major disaster area pursuant to the Disaster Relief Act of 1966 or the Disaster Relief Act of 1970 in the five-year period immediately preceding the date the Chief of Engineers deems such work advisable. The provisions of local cooperation specified in section 3 of the Flood Control Act of June 22, 1936, as amended, shall apply. The work shall be complete in itself and not commit the United States to any additional improvement to insure its successful operation, except as may result from the normal procedure applying to projects authorized after submission of preliminary examination and survey reports."

Following the major floods of 1965, 1966, and 1969, the Middle River-Snake River Watershed District submitted a resolution dated 11 May 1971 asking the Corps of Engineers to study the flood problems along the Snake River from its mouth upstream to Warren, Minnesota. A preliminary investigation was made and a reconnaissance report was submitted on 18 August 1972. The report recommended that the investigation be continued and a detailed project report be prepared.

SCOPE OF THE STUDY

The basic objective of this study is to identify and develop a flood damage reduction plan that is engineeringly and economically feasible and socially and environmentally acceptable. Cost estimates for alternative improvements and economic studies evaluating benefits were prepared. Land use, fish and wildlife conservation, water quality control, recreation, and environmental and social considerations were studied in cooperation with other Federal and State agencies. Formulation of the alternatives depended on the respective economic, social, and environmental feasibilities of the various plans.

STUDY PARTICIPANTS AND COORDINATION

The Corps of Engineers had principal responsibility for conducting the overall study, formulating the plan, consolidating information from other agencies and local interests, and preparing the report. Others participating in the study included the U.S. Fish and Wildlife Service, U.S. Soil Conservation Service, Minnesota Department of Transportation, Minnesota Department of Natural Resources, Middle River-Snake River Watershed District, and cities of Warren and Alvarado, Minnesota.

Public meetings were held in January 1973 and July 1975 so that interested parties had an opportunity to express their views on water resource needs in the area and improvements to meet those needs. A Citizens Advisory Committee has met with Corps representatives several times to furnish continuing local input.

THE REPORT

The report has been arranged into a main report with appendixes. The main report summarizes the study. Plan formulation and selection procedures, division of project responsibilities between Federal and non-Federal interests, and recommendations for implementing the selected plan are included. The appendixes supplement the main report with more detailed data and analysis.

PRIOR STUDIES AND REPORTS

A reconnaissance study was conducted under Section 205 authority to determine the feasibility of local flood control measures for the Snake River at Warren, the upstream limit of the present study. The report, dated 20 October 1969, indicated no solution was economically feasible and recommended no further studies of local flood protection works at Warren.

The report also recommended that a floodplain information study be prepared for Warren to better define the extent of the local flood hazard as an aid to future floodplain management. In a letter dated 12 August 1970, the city requested such a study. The State concurred in the request and forwarded it to the Corps of Engineers on 8 September 1970. The study was completed and a report was published in September 1973.

In October 1971, the Middle River-Snake River Watershed District filed four applications with the Minnesota State Soil and Water Conservation Commission asking that the U.S. Soil Conservation Service consider flood control improvements for the Snake River and several tributaries under the provisions of Public Law 566. The Commission approved these applications and placed them on the inactive waiting list for such projects. Discussions with Soil Conservation Service representatives indicate these applications probably will not receive planning priority and be activated for several years. Thus, the parties involved agree it would be advantageous for the Corps of Engineers to proceed with a study of the Snake River from Warren to the mouth under Section 205 authority. Any subsequent work accomplished by the Soil Conservation Service under Public Law 566 would provide supplemental benefits in the future.

Discussion of the flood-related problems of the Middle-Snake Rivers subbasin and suggested alternative solutions is contained in Appendix D of the "Souris-Red-Rainy River Basins Comprehensive Study," published in 1972.

PROBLEM IDENTIFICATION

This section defines the study area and the problems addressed. The section also produces a set of planning objectives. These objectives are used in succeeding sections to formulate and evaluate alternatives.

NATIONAL OBJECTIVES

The planning objectives must encompass national and local considerations. Corps regulations specify that project objectives shall include National Economic Development (NED), Environmental Quality (EQ), Regional Development (RD), and Social Well-Being (SWB).

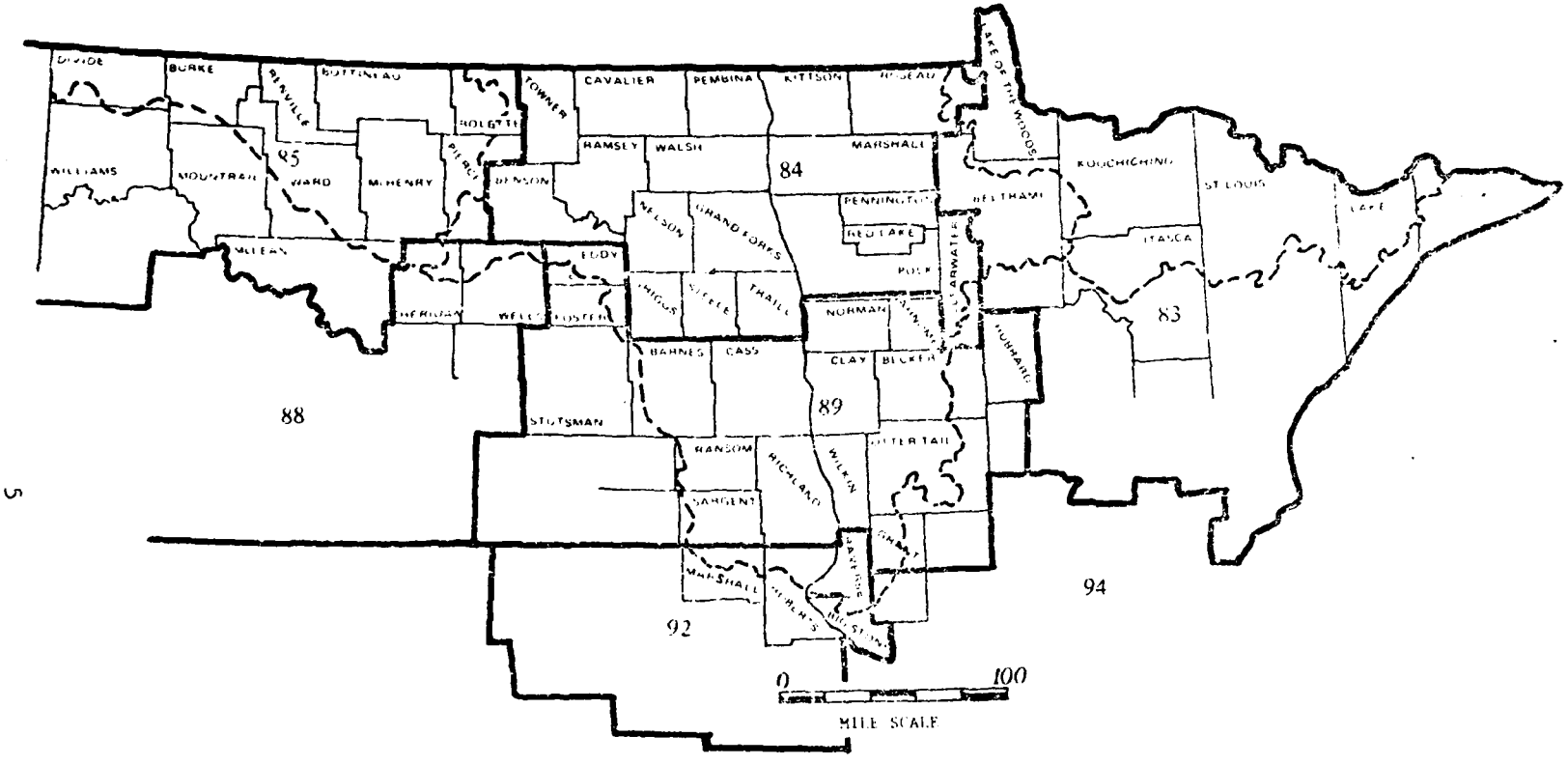
Additional objectives for each project are based on local considerations. These local planning objectives are developed after investigating existing conditions, problems, needs, and opportunities in the study area.

EXISTING CONDITIONS

Study Area

The Snake River subbasin occupies portions of three counties in northwestern Minnesota; Marshall, Polk, and Pennington (see the following figure). It is one of the smaller subbasins of the Red River of the North basin. It is bordered by the Middle River subbasin on the north, Red Lake River subbasin on the east, and Red River main stem subbasin on the south and west. Because the Middle River is tributary to the Snake River, a small portion of the Snake River subbasin curves above the Middle River subbasin. The area has a legal status through the Middle River-Snake River Watershed District; the Snake River is not a separable legal entity.

OBE ECONOMIC AREAS
SOURIS-RED-RAINY REGION



Economic Areas:

83 Duluth-Superior, Minn.
84 Grand Forks, N. D.
85 Minot, N. D.
88 Bismarck, N. D.
89 Fargo, N. D.
92 Brookings Aberdeen, S. D.
94 Minneapolis St. Paul, Minn.

River Basin Boundaries

Topography

The watersheds of the Middle and Snake Rivers are in the featureless plain once covered by ancient glacial Lake Agassiz. The east-central part of the watersheds is crossed by low ridges that are remnants of Lake Agassiz beaches formed during the recession of the lake. These ridges obstruct the runoff of water over the land surface; in some places, marshy areas are on the higher side of the beach ridges (shoreline area). West of the shoreline area is the lake plain area; to the east is the till upland.

The lowest ground in the watersheds is along the Snake River where it flows into the Red River of the North. The ground at this point is between 765 and 770 feet above mean sea level. The highest ground in the watersheds is at the extreme northeast tip of the Middle River watershed, where the elevation is more than 1190 feet above mean sea level. The difference in elevation between the highest and lowest ground is about 425 feet.

The steepest slopes are near the upper parts of the watersheds. The divide between the Middle and Snake River watersheds and the Thief River watershed to the east is a broad, nearly level area. West of the divide, where the slopes are steepest, the stream valleys are moderately deep. Farther west, near the Red River of the North is an area several miles wide where the slopes are slight. In this latter area, the streams originally had no valleys. Artificial channels have been constructed across these flat areas and include State Ditches Nos. 3 and 5 constructed about 1896.

Geology

The entire area was affected by glaciers. The upper portions of the basins are covered by glacial drift, throughout which are numerous deposits of sand and gravel. Soils within this area are generally light and composed of clay or silty, clayey sand. Immediately downstream from the

glacial drift area lies a series of beach ridges formed by glacial Lake Agassiz during successively lower recessional stages. Throughout these ridges, the soils contain much fine sand and are classified generally as clayey or silty sand. The remainder of the watershed, downstream from the ridges, is a nearly flat, lacustrine plain which was the bed of the glacial lake. Lacustrine deposits extend to great depths over this plain, particularly near the Red River of the North.

Soils

Soil types within the Snake River basin can be divided into three categories. In the western portion of the watershed, the soils are predominantly dark-colored, deep, fine-textured, poorly drained soils. Main soil types are Fargo clay, Beardon silty clay, and Colvin silty clay.

The central area of the watershed has soils that are light-colored and moderately coarse to coarse. Internal drainage of these soils is generally poor, but most have poor water-holding capacity. Main soil types are Rockwell fine sandy loam, Cormont, Sioux sandy loam, and Hangaard fine sandy loam. These soils include the gravelly beach ridges.

The eastern section of the watershed consists mainly of dark-colored, medium-to-moderately-fine textured soils of glacial till. The soils of this area generally have a silty clay loam to silty clay surface texture. Viking, Nereson, Rocksbury, and Kittson are the major soil types.

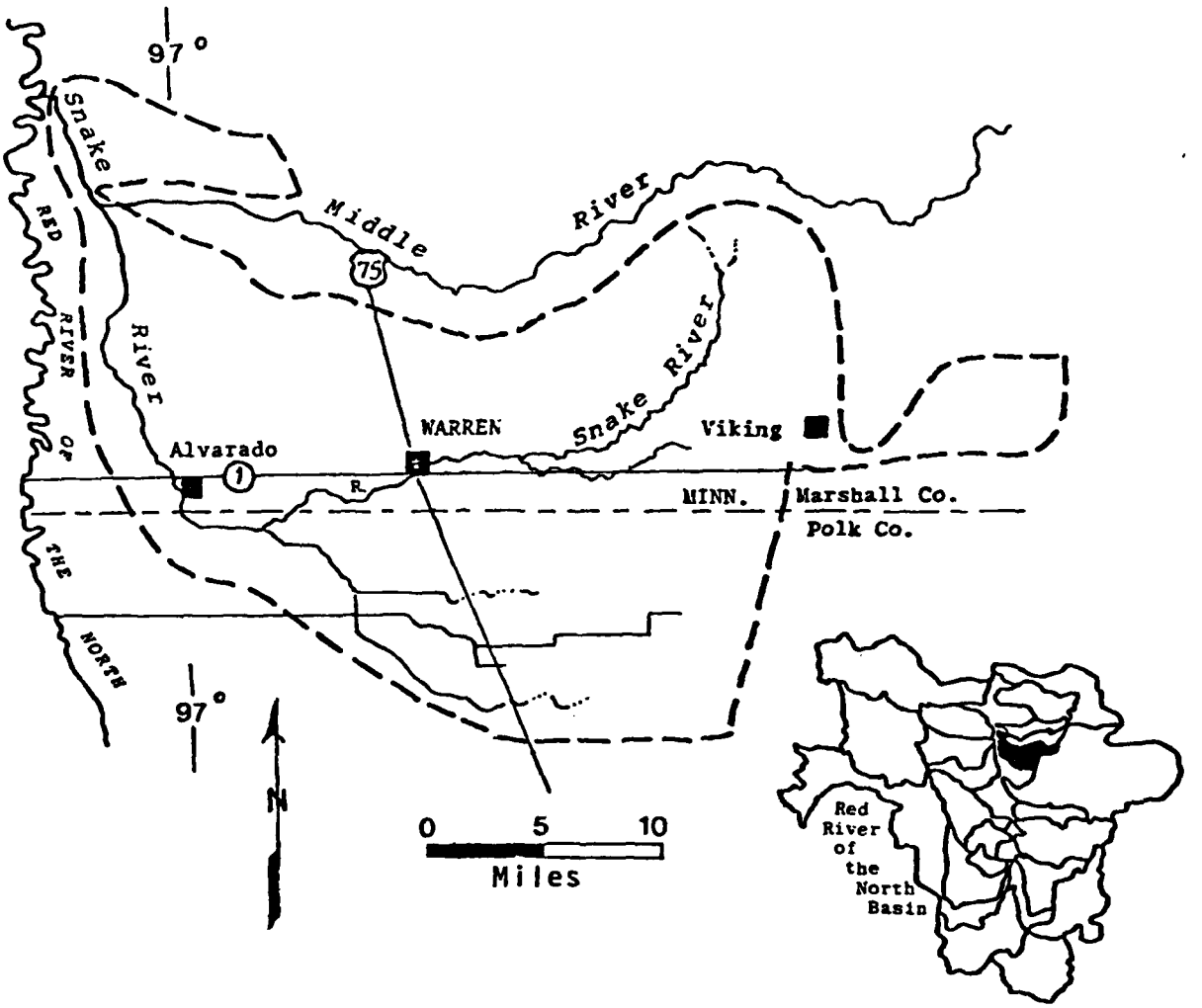
Climate

The climate of the Snake River basin is characterized by wide variations in temperature with moderate rainfall and snowfall. The mean annual precipitation averages 19.73 inches; snow accounts for about 2.6 inches. The average annual temperature is 38° F. Extreme temperatures range from a high of 108° F to a low of -49° F. The frost-free days, as observed at the University of Minnesota Experiment Station at Crookston, Minnesota, average 124 days annually. The average last frost in spring is 19 May; the average first frost in fall is 20 September.

Hydrology

In the Red River basin, frequent flooding of the tributaries and main stem affects much of the Red River Valley floor (the bed of ancient glacial Lake Agassiz). Two types of flooding occur. The usual type is associated with stream bank overflow. Another type is caused by runoff from snowmelt or heavy rainfall entrapped by plugged culverts and ditches within sections of land bounded by raised roadways. This water accumulates, overflows the roadways when it has reached sufficient depth, and inundates sections of land as it moves overland until reaching stream channels. The larger floods which cause most of the urban damages result primarily from spring snowmelt. Summer floods occurring principally along the tributaries as well as spring snowmelt floods cause agricultural damages through destruction of growing crops and delay of seeding. Red River Valley floods affect about 2 million acres of land including 10 cities with 1960 populations over 2,500 and 32 smaller communities.

Typically, the Snake River subbasin encompasses three distinct topographic areas (see the following figure). The central area is marked by the recessional sand and gravel beach ridges overlying glacial till. Farther east and above the beach ridges, the area is nearly flat and poorly drained. Interspersed areas of sandy soil and peat bogs over glacial till drift predominate in this area. The flat and featureless floor of the Red River Valley extends west of the beach ridges.



Source: Gulf South Research Institute.

SNAKE RIVER SUBBASIN

The major problems in the subbasin are flooding, inadequate drainage, and wind erosion. Floods affect about 300 square miles of this subbasin.

According to the 1950 U.S. Census of Agriculture, more than half of the total watershed is in drainage enterprises with some flood removal capabilities. Construction of open ditches for relief from flooding and drainage began in 1870. The tendency has been to dig and open channels during and immediately after a cycle of wet years and neglect maintenance during the dry cycle. Hence, channels become overgrown with vegetation and filled with windblown silt. When the next wet cycle arrives, channels are inadequate. A detailed description of the flood history of the subbasin is presented later in this report.

Water Supply and Quality

Groundwater - Small to moderate supplies of groundwater for domestic use, dairying, creameries, and small municipalities are available in most places in the till upland and eastern part of the shoreline area. Small to inadequate supplies of groundwater for domestic purposes occur throughout most of the lake plain and western part of the shoreline area. Water from most wells in the lake plain contains high dissolved solids and is not suitable for most domestic purposes.

The aquifer underlying the Halma, Minnesota, area is one of the largest known sources of groundwater near the Middle River-Snake River basin. Wells having yields of 1,000 gpm (gallons per minute) could be developed in thicker parts of the aquifer. The quality of this water is suitable for irrigation of potatoes and sugar beets on well-drained land. Aquifers capable of yielding from 50 to 100 gpm to wells are mapped in the vicinity of Stephen, Argyle, Newfolden, Middle River, and Alvarado, Minnesota.

Groundwater supplies for the small communities in the watershed are adequate for present rates of use. Additional amounts of groundwater could be developed for communities by drilling wells at properly spaced

intervals within the mapped aquifers. Potential yield from all groundwater sources is small compared to surface water, but groundwater is important for small local supplies.

Surface Waters - The Middle River is a potential source of water for moderate amounts of industrial, conservation, recreation, agricultural, and municipal uses. Development of water from this intermittent stream requires adequate storage. Storage potential is available from small reservoirs, but large storage capacities are limited by the capacity of the channel at possible reservoir sites and high evaporation losses.

The Red River of the North is the largest potential source of water for the Middle River-Snake River watershed.

Water Quality - The quality of surface water is impaired by municipal and agricultural pollution. During low runoff periods, streamflows are not great enough to assimilate wastes and do not meet requirements for recreational and environmental uses.

The quality of groundwater has been affected by excessive concentrations of total dissolved solids (TDS), iron, manganese, chlorides, and sulfates. The high TDS levels make the water unsuitable for most domestic uses.

Vegetation

The natural vegetation in the area is primarily along the river. However, some native woodlands and planted shelterbelts are on farmsteads. The overstory consists of box elder, green ash, and American elm. A conspicuous feature of the floodplain is a general lack of shrubs. The herb layer, dominated by wood nettle, is also poorly developed.

Fish and Wildlife

Fish species of the Snake River are limited but probably include silver redhorse, northern redhorse, sheepshead, walleye, northern pike, quillback, mooneye, and channel catfish. Smaller fish of the area may include common shiner, spottail shiner, lake chub, yellow perch, and white sucker.

Upland terrestrial wildlife resources of the area are influenced by agricultural use and the distribution of vegetation. Probably the only common big game animal is the white-tailed deer. Other species that use the area are rabbit, skunk, squirrel, raccoon, muskrat, and beaver. Birds of the Snake River watershed include wood ducks, hooded mergansers, mallards, Canada geese, and songbirds. Amphibians and reptiles include various species of frogs and garter snakes.

Archeological Considerations

In compliance with Section 106 of the National Historic Preservation Act of 1966 and Executive Order 11593, the National Register of Historic Places has been consulted. As of 10 July 1979, no sites are listed which would be affected by the project. The Snake River between Warren and its mouth has been surveyed, and 29 archeological sites have been found along the river. Some of these sites could potentially be affected by the project. Sites would either be salvaged or avoided during implementation.

Recreation

The only developed recreational facilities along the Snake River are the municipal parks at Warren and Alvarado. The nearest major camping and recreation center is Old Mill State Park on the Middle River about 15 miles northeast of Warren.

Vegetation along the river has some aesthetic value by providing a variety in the scenery and a break in the extremely flat terrain. The area provides some hunting and fishing opportunities, but these uses are rather limited in the project area.

Population Characteristics

The watershed boundary crosses political subdivisions, making the population of the watershed difficult to establish. However, the largest portion of the watershed is in Marshall County, and the population trends of the watershed and the county are similar.

The population of Marshall County was 13,100 in 1970, representing an average density of 7 persons per square mile compared with 48 persons per square mile for the State of Minnesota. Warren and Alvarado constituted 15 percent and 2 percent, respectively, of the 1979 Marshall County population. Warren, with a population of 1,999, is the largest community in the county. In 1970, the Marshall County population represented about 6 percent of the OBERS, BEA 092, Grand Forks, North Dakota, economic area. Between 1975 and 2030, the population of Warren is expected to increase 13 percent, while the population of Alvarado is expected to remain stable. The population of Marshall County is expected to decrease 4 percent while the population of the Grand Forks economic area is expected to decrease 15 percent. The above population projections and their indexes of growth are discussed in greater detail later.

Income

In Marshall County in 1969, the median family income was $6,294. Of the 3,242 families, 20.9 percent earned less than $3,000 annually and 1.8 percent earned over $25,000. The median income for the 1,732 farmers in the county in 1969 was $5,486.

The projected per capita incomes for the Grand Forks BEA economic area, of which Marshall County is a part, are shown below for the years 1950 to 2030.

Projections of per capita income (1967 dollars)

Area	Per capita income								
	1950	1960	1970	1980	1992	2000	2010	2020	2030
BEA 092									
Grand Forks	$1,557	$1,926	$2,905	$3,948	$5,391	$7,396	$9,933	$13,256	$16,579(1)
United States	2,065	2,488	3,476	4,765	6,166	8,289	10,895	14,260	17,625(1)

(1) Extrapolated.

Economy

Agriculture and related services are the major economic activities in the area. Agricultural production is mainly cereal crops, sugar beets, potatoes, and other specialty crops grown in the western two-fifths of the watershed. The eastern two-fifths of the watershed emphasizes livestock and general crop and hay production.

In the sand beaches of glacial Lake Agassiz are gravel pits which provide material for road and building construction.

Adjacent to the riverbeds are hardwood groves, and aspen is found in the eastern part of the watershed. As yet, little commercial use has been made of these wooded areas. The principal use is for wildlife habitat.

Land Use

Approximately 78 percent of the subbasin is under cultivation, 10.9 percent is pasture, 8 percent is forest, and 1.8 percent is water and marsh. The western half of the subbasin is almost entirely under cultivation, with only small patches of trees along the river. The eastern half of the subbasin has more forested areas, less cultivated land, and a few marsh areas. Urban development is minimal.

Land use in the floodplain of the Snake River does not differ significantly from land use throughout the subbasin. The floodplain is an important agricultural area, especially in the western part of the subbasin. In the eastern part of the subbasin, the floodplain is also under cultivation, but there is more forest acreage.

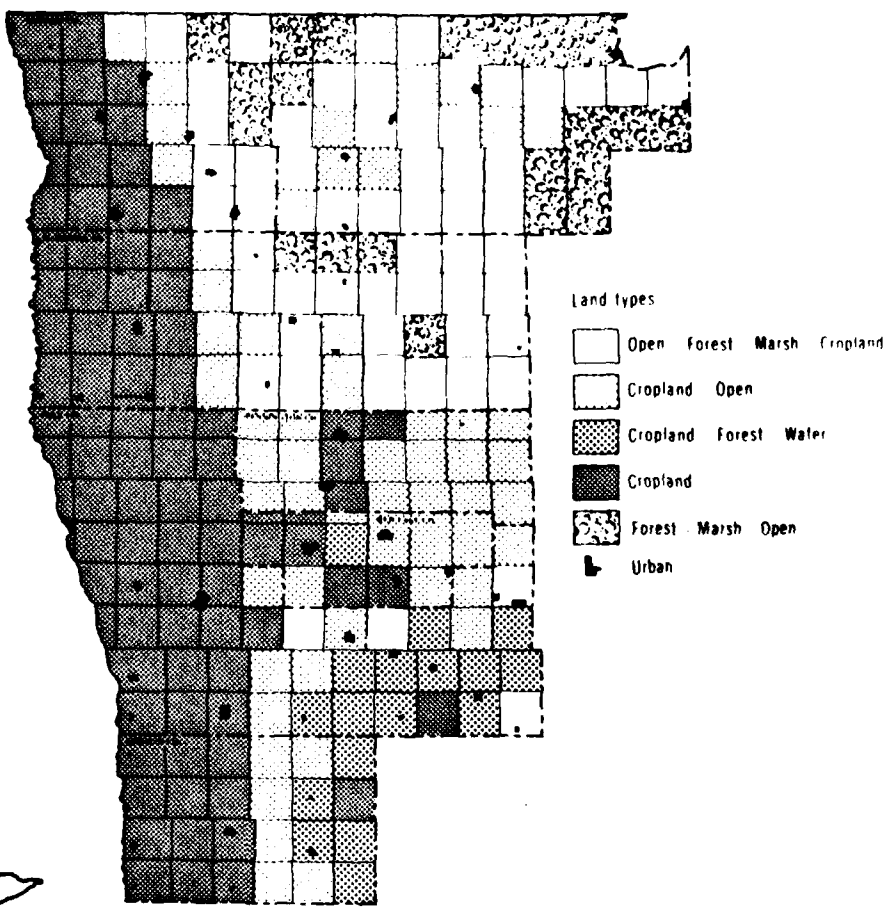
Land use activities in the subbasin have significantly altered the original landscape through wetland drainage, forest clearing, agricultural development, and urban expansion. Most of the remaining forests are near farms or along stream valleys. A detailed tabulation of the typical land uses in the basin is given in the following table and figure.

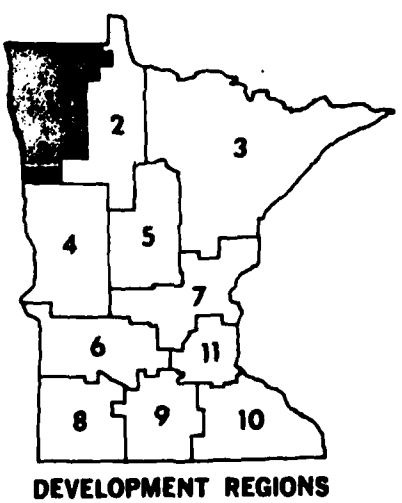
Land use, 1967[1]

Area	Total land area	Noninventory acreages				Inventory average	Land-use acres in inventory				
		Federal noncropland	Urban and built-up	Small water areas	Total		Total inventory	Cropland	Pasture	Forest	Other land
Marshall County	1,152,000	61,660	31,034	7,666	100,360	1,051,640	1,051,640	696,136	66,168	188,900	100,436
Polk County	1,287,680	0	45,050	11,000	56,050	1,231,630	1,231,630	1,018,615	32,940	91,800	88,275
Pennington County	398,080	80	12,566	1,986	14,632	383,448	383,448	281,812	17,000	44,000	40,636
State	51,201,015	3,104,144	1,872,460	301,687	5,381,291	45,820,324	45,820,324	22,990,737	3,038,302	16,166,429	3,624,856

(1) *Source:* Minnesota Soil and Water Conservation Needs Inventory, August 1971. Minnesota Conservation Needs Committee.

LAND-TYPES IN DEVELOPMENT
REGION 1





DEVELOPMENT REGIONS

– Distribution of Forties by Land-Types

SOURCE: Report Number 1, Minnesota Land Management Information System Study, University of Minnesota Center for Urban and Regional Affairs, prepared for the Minnesota State Planning Agency and Upper Great Lakes Regional Commission

Transportation

The system of Federal, State, county, township, and private roads with attendant grades, road ditches, bridges, and culverts is excellent. State Highway 32, oriented north-south, passes through the till upland area of the basin through Holt and Middle River, Minnesota. U.S. Highway 59, another principal artery, crosses the basin from southeast to northwest from Thief River Falls, through Newfolden, and out of the basin toward Strandquist, Minnesota. About 20 miles west of and parallel to U.S. Highway 59 is Highway 75, which traverses the lake plain area, passing through Warren and Argyle. Highways 59 and 75 link the above municipalities to Winnipeg, Manitoba, and other western Canadian cities. At the extreme western edge of the basin, close to the channel of the Red River of the North, is State Highway 220, which crosses the Snake River near its confluence with the Red River of the North. State Highway 1 begins at the Red River of the North at Oslo, Minnesota, and passes through Alvarado and Warren. Approximately 30 miles east of Oslo, State Highway 1 turns southeast and proceeds out of the basin toward Thief River Falls. Between State Highway 220 and the Red River of the North in T 158 N, R 40 W (Fork) are approximately 1 1/2 miles of State Highway 317, which carries traffic from the northwestern part of the basin into North Dakota. In addition, many miles of County-State Aid highways, county highways (many of which are hard-surfaced), and township roads provide access to all parts of the county for movement of agricultural and industrial products and people.

A branch line of the Soo Line Railroad generally parallels State Highway 1 from Oslo to Thief River Falls by way of Alvarado, Viking, and Warren, Minnesota. Important railroad lines cross the basin parallel to U.S. Highways 59 (Soo Line) and 75 (Burlington Northern).

An airport is located at Warren. It has a 75- by 3,200-foot bituminous northwest-southeast runway and a 200- by 2,600-foot turf northeast-southwest runway. Lighting has been installed on the northwest-southeast runway.

PROBLEMS, NEEDS, AND OPPORTUNITIES

Introduction

This section presents a discussion of the problems and needs of the Snake River basin below Warren, emphasizing flood damage, water supply and water quality, erosion, water and land-based recreation, fish and wildlife conservation, and public health and safety. The improvements desired by local interests are also discussed. Not all of these problems and needs can be addressed and solved within the authorities under which this study is being conducted. However, wherever practicable within the alternatives and plans developed, these needs will be considered so that the recommended actions are compatible with programs of other governmental agencies or jurisdictions in meeting these needs.

Flooding

The Snake River is an intermittent stream with little or no discharge during most of the year except for flow caused by runoff from summer thundershowers or spring snowmelt. Depending on antecedent soil conditions; depth, moisture content, and areal distribution of snow; rate of snowmelt; and intensity, duration, and areal distribution of rainfall, the river is capable of overtopping its banks in a matter of hours and remaining above flood stage for several days.

Spring flooding from snowmelt runoff is generally more severe than summer flooding because snow-filled channels and drainage ditches tend to worsen the generally sluggish flow conditions common to the flat terrain of the Red River Valley. The lower 50-mile portion of the Snake River including Warren and Alvarado and approximately 20,000 acres of adjacent farmland has a history of repeated flooding.

Floods of Record - Floods causing significant damage in the Snake River basin occurred in 1896, 1897, 1901, 1941, 1950, 1965, 1966, 1969, 1974, and 1975. No official record exists for floods before 1950. Since that time, intermittent records have been kept by the U.S. Geological Survey along with local efforts. The largest recorded event was the 1969 flood. A tabulation of the four largest floods along with the intermediate regional flood and standard project flood was prepared for the Flood Plain Information Study for Warren and is shown below.

Flood crest elevations, Snake River at Warren, Minnesota, Minnesota Street Bridge

Date of crest	Estimated peak discharge (cfs)(1)	Stage(2)	Elevation(3)
4-6 May 1950	3,510	18.4	853.4
1965	3,250	17.9	852.9
3 April 1966	3,410	18.4	853.4
10 April 1969	4,350	19.4	854.4
100-year flood	5,500		855.7
Standard project flood	10,500		

(1) From elevation-discharge rating curve for old U.S. Geological Survey gage updated through 1978.
(2) From high-water marks.
(3) Feet, mean sea level, 1929 adjustment. Elevations are based on a gage height of 835.0 feet.

The following descriptions of floods at Warren are excerpts from the local newspaper, The Warren Sheaf, and are reprinted from the Flood Plain Information Report.

21 May 1896: "Snake River, swelled by recent rains, overflows its banks. . . . At several places east of town the water overflowed the banks and came rushing in rapid currents onward through the streets and alleys of the city. Sidewalks floated in the water which in many instances was from 1 to 5 feet. . . . All Monday the water surged into the streets, rising continually until evening came. During the following night, the river fell 2 or 3 inches and on Tuesday the waters continued to recede. The damage done by the flood in the city to cellars, buildings, gardens, etc., is quite considerable."

11 July 1901: "The first Fourth of the new century will always be remembered by the citizens of Warren . . . on the morning of the Fourth, the city park where exercises were to have been held was completely submerged. The water rose at the rate of a foot an hour and soon overflowed the banks of the river covering the driving park where the races were to have been held and also inundating the streets. For a while, most of the citizens were more concerned with saving the contents of their cellars and tying up their sidewalks than in the celebration. In view of these conditions, the committee of arrangements decided to postpone the celebration to a more favorable time . . . ."

26 April 1950: "Two flash floods hit Warren over the weekend. The usually meek Snake River in Warren went out of its banks after two flash floods Friday and Saturday and inundated from 35 to 40 blocks, largely in the residential section in the southeast part of the city."

16 April 1969: "Swollen Snake floods city for 36 hours. - Water reaches highest level here this century - Nearly everyone affected. Warren's usually mild-mannered and inconsequential Snake River thundered to life briefly last week to fill the city with water, the effects of which many persons are still recovering from. For about 36 hours most of the city was under water which damaged homes, filled countless basements with water, caused postponement of many scheduled events and generally disrupted the normal life of the city from Wednesday through Sunday. Nearly everyone in the city was affected in some manner with many families evacuated to homes of relatives or friends. . . . Many basements were filled or partially filled with water as pumps could not keep up with seepage and sewer backups. Some homeowners filled their basements

themselves to equalize pressure so their walls would not cave in. Some basements which filled with water had fuel oil tanks in them and the fuel oil was forced out and covered everything with a smelly, difficult to remove film of oil."

Review of the rather limited records indicates that the majority of the damaging floods occurred during April or early May. Summer floods occurred in July 1901 and July 1975.

Largest Recorded Flood - During the record spring flood of 1969, about 20,000 acres of cropland were flooded. Agricultural losses were minimal because seeding was not appreciably delayed. Although Alvarado was protected by a dike constructed by the community following the 1966 flood, about 75 percent of the city was flooded to shallow depths. A record peak discharge of 4,300 cfs (cubic feet per second) occurred on 10 April 1969. The river stage just downstream of the State Highway 1 bridge was 1.5 feet higher than the previous high water in 1950. Flooding was first caused by storm sewer backup, then by the river overtopping the channel banks in the northeast area of the city. For about 3 days, the business district lacked water and sewer service and most basements were flooded. Because most of the city business places and residences are substantially above street levels, first-floor flooding was minimal but water pressure caused collapse of about 15 basements. Damages at Warren totaled about $206,000. Alvarado flood damages totaled about $9,000, including flood fight and cleanup costs. However, an estimated $150,000 in additional damage was prevented by emergency efforts to raise and reinforce the existing ring levee. Over 16,000 acres of farmland were flooded, causing agricultural damages estimated at over $315,000.

100-Year Flood - Over 90 percent of Warren would be flooded by the 100-year flood. This flood, with a 1-percent chance of being equaled or exceeded in any given year, would have a discharge of over 5,500 cfs at Warren. The water surface elevation at the Warren gaging station would be about 1.3 feet above that recorded in 1969.

Damages - Destruction of crops and related agricultural losses constitute the principal damages from flooding. The losses resulting from a flood depend on when the flood occurs. A spring flood immediately preceding or during soil preparation and planting generally would result in reduced yields and poor crop quality of acreages which could still be planted following subsidence of the flood. A summer flood would completely destroy a large percentage of the growing crops, and a flood during harvest season would destroy the unharvested portion of the crop. Physical damage to the area is limited to minor erosion and the spreading of noxious weed seeds. Highway and bridge damages in the area are relatively small.

The local people contend that damaging floods have occurred more frequently and with greater severity in recent years as a result of improvement of the drainage systems and land clearing and improvements in the upstream reaches of the basin. Travels by District personnel throughout the river basins tributary to the Red River of the North have confirmed some of these observations. Comprehensive studies of the river basins more seriously affected are needed.

Water Supply and Water Quality

The Snake River basin is in an area where average annual precipitation and known groundwater resources limit the optimum development of agricultural related processing plants and industrial enterprises. Small to moderate supplies of groundwater are available in the uplands in the eastern part of the basin. In the remainder of the basin, especially the more westerly areas adjacent to the Red River of the North, suitable groundwater supplies are limited and inadequate. Surface waters seem to be the largest potential source of water for the Snake River basin. The best source of surface water for the area appears to be the Red River of the North because the Snake and Middle Rivers have intermittent flows.

Use of groundwater is limited because of the high dissolved solids content. A high level of dissolved solids generally renders groundwater unsuitable for domestic uses.

Needs for good quality water are not considered in this study but should be included in any future basin-wide water resource investigations. Because the area is agriculturally oriented, smaller local sources of water supply, such as groundwater wells of shallow to moderate depths, are needed. Because available groundwater is of poor quality, surface water supplies will have to be developed. They present very difficult and expensive distribution problems.

Recreation

Recreation demand for the study area has not been analyzed. Minnesota's "State Comprehensive Outdoor Recreation Plan - 1974" indicates that this area of Minnesota is deficient in most recreation facilities and more facilities should be provided. The study area is highly developed for agriculture and offers little opportunity for meeting total recreation needs. However, the escarpment and headwaters areas of the Snake River basin offer some opportunities for outdoor recreation development which should be considered by appropriate Federal, State, and local interests in any future water resource investigations and planning.

Fish and Wildlife

The grassland prairie and wetlands in the headwaters of the Snake River basin provide habitat for fish and wildlife. The existing river corridor woodlands in the watershed are especially important to the deer population and other wildlife and provide a corridor for wildlife movement between the habitat areas in the eastern portions of the basin and those along the Red River of the North. Fish species in the Snake River are limited. Acquisition of lands for wildlife habitat would help to satisfy future basin needs.

Public Health and Safety

Epidemiology is a science that deals with the incidence, distribution, and control of disease in a population. Epidemiological data on health damages resulting from waterborne diseases in the study area

are limited. However, a number of known diseases are potentially transmitted by water. The significant diseases in the United States are hepatitis, salmonellosis, shigellosis (bacillary dysentery), amebiosis (amebic dysentery), typhoid fever, and encephalitis. Less acute gastroenteric disorders are probably more prevalent than these six but are among the group of optionally reported diseases, and their incidence is unknown.

On the basis of data compiled for the Souris-Red-Rainy River Basins Comprehensive Study, about 0.4 percent of the Nation's population resides in the Souris-Red-Rainy region. The total number of reported cases of the six diseases for the region is just over 0.2 percent of the total for the Nation. This figure indicates that the incidence of these diseases is lower in the region than throughout the Nation. The one disease with an incidence rate higher for the region than the national average is encephalitis. About 0.77 percent of the cases throughout the Nation have occurred in the Souris-Red-Rainy region. Because certain species of mosquitoes commonly found in the region are vectors of encephalitis, the large mosquito populations in many parts of the region could be responsible.

The major mosquito-producing habitats within the region include:

1. Natural habitats which result from inundation of floodplain areas along rivers and other streams during the snowmelt period and following prolonged or high intensity rainfall.

2. Potholes and other water-holding depressions in coniferous or deciduous forest areas, which include small, shallow ponds; bogs; marshes; and swamps.

3. Ponding areas in open prairie regions which are largely under cultivation and essentially treeless.

All three of these mosquito-producing habitats are abundant in the Snake River watershed.

Because mosquito-producing habitats exist in the study area, mosquito control measures are needed. In addition, domestic water supplies need to be tested during and immediately following floods to ensure that any deterioration of water quality is detected. To ensure that the recommended plan does not create public health hazards, final details of the implementation of the selected plan would be fully coordinated with appropriate health agencies.

EXISTING IMPROVEMENTS

In October 1966, after suffering a severe spring flood, local interests began constructing a ring levee around Alvarado. Although this levee was nearly overtopped by the record-breaking 1969 flood, local citizens succeeded in emergency efforts to raise and reinforce the levee, preventing substantial flood damages to the community.

Following the 1969 flood, funds from the State of Minnesota and the U.S. Office of Emergency Preparedness were used to finance a project to snag and partially clear about 23 miles of the Snake River, from its confluence with the Red River of the North to about 10 miles downstream from Alvarado. The 16 miles of river channel between Alvarado and Warren include about 3 miles of ditch constructed in 1896 as State Ditch No. 5.

Existing flood control improvements at Warren are largely the result of flood emergency preparations undertaken in the spring of 1971 with assistance from the Corps of Engineers. The emergency work included snagging and partial clearing of the riverbanks for about a mile downstream from Warren and some minor channel enlargement at a meander within the city limits.

IMPROVEMENTS DESIRED BY LOCAL INTERESTS

Residents of the Snake River basin are unanimous in their desire for some form of flood control. Two measures of particular interest to area residents are snagging and clearing along the lower reaches of the river and flood control reservoirs upstream of Warren. Upstream reservoirs will

eventually be investigated by the Soil Conservation Service in connection with the Public Law 566 applications filed by the Middle River-Snake River Watershed District. However, the Soil Conservation Service will not be able to begin its investigation for several years. Consequently, the present study by the Corps of Engineers will evaluate upstream reservoirs as an alternative means of reducing damages at and downstream of Warren.

Other measures suggested by local interests include overflow or bypass channel construction, floodwater diversion through the existing legal drainage system, improvement of the Snake River outlet, and establishment of shelterbelts to protect improvements from wind and water erosion and prevent watercourses from becoming filled with winter snows which hinder spring runoff. These measures will be considered during detailed studies.

FORMULATION OF PRELIMINARY PLANS

INTRODUCTION

The principal purpose of plan formulation is to develop a plan that will provide the best use, or combination of uses, of water and related land resources to meet foreseeable short- and long-term needs of the Snake River basin below Warren. In accordance with the principles and standards for planning water and related land resources, as published in the Federal Register, Volume 38, No. 174, Part III, dated 10 September 1973, national economic development and environmental quality are considered the two principal planning objectives. In addition, the accounts of social well-being and regional economic development are also considered important. The viable alternatives to solve current and prospective water and related land resource problems and needs of the study area are evaluated and examined with the goal of increasing national economic gains, enhancing the quality of the environment, and improving social well-being and regional economic gains. An interdisciplinary approach was used to evaluate alternatives.

Beneficial and adverse effects of the plans being analyzed are measured by comparing the estimated conditions with these plans to conditions expected without a plan. Thus, in addition to projecting the beneficial and adverse effects expected with the plan in operation, a projection of conditions likely to occur without the plan is required. Only the new or additional changes to the social, economic, and environmental conditions that can be attributed to a plan are credited to that plan.

FORMULATION AND EVALUATION CRITERIA

Criteria under the following five main categories were adopted to permit an objective appraisal of the merits of various alternatives to reduce flood damages and meet other water management needs of the study area:

1. Technical.

2. National economic development.

3. Environmental quality.

4. Social well-being

5. Regional economic development.

Technical Criteria

The following technical criteria were adopted and used:

1. The plan must be technically feasible.

2. The plan should be complete within itself and not require additional improvements.

3. The optimum scale of project development should be provided by analyzing the effects of trade-offs between national economic development and environmental quality.

4. The plan should ensure against worsening upstream or downstream flooding.

National Economic Development

The national economic development criteria are those included in Senate Document No. 97, 87th Congress, entitled "Policies, Standards, and Procedures in the Formulation, Evaluation, and Review of Plans for Use and Development of Water and Related Land Resources." Economic criteria used in evaluating each alternative plan include:

1. Tangible benefits exceed project economic costs.

2. The scope of the proposed development is scaled to provide maximum net benefits. However, proposed developments providing less than the economic optimum can be recommended if appropriate gains in environmental quality and social well-being can be shown.

3. No more economic means, evaluated on a comparable basis, would accomplish the same purpose(s) which would be precluded from development if the plan were undertaken. This limitation applies only to those alternatives that would be physically displaced or economically precluded from development if the project were undertaken.

Average annual benefits and costs are based on an interest rate of 7 3/8 percent and price levels and conditions prevailing in October 1980. The economic life depends on the type of improvement considered and for this report was assumed to be 100 years for reservoirs and floodplain evacuation and 50 years for channelization, rural levee systems, and other nonstructural measures.

Environmental Quality

Environmental factors considered include:

1. Management, protection, enhancement, or creation of areas of natural beauty and human enjoyment.

2. Management, protection, and enhancement of especially valuable or outstanding archeological, historical, biological, and geological resources and ecological systems.

3. Enhancement of quality aspects of water, land, and air while recognizing the need to harmonize land-use objectives in terms of productivity for economic use and development with conservation of the resource.

4. Evaluation of the environmental impact of any proposed action, any adverse environmental effects which could not be avoided if a proposal were implemented, and alternatives to the proposed action.

5. Determination of the relationship between local short-term uses and the maintenance and enhancement of long-term productivity.

6. Determination of any irreversible and irretrievable commitment of natural resources and biological systems of any proposed action.

Social Well-Being

Social well-being factors considered include:

1. Loss of life potential and hazards to public health and safety.

2. Preservation and enhancement of social, cultural, educational, and historical values.

3. Preservation of aesthetic values.

4. Effect on local community patterns.

Regional Economic Development

Factors considered which affect the regional economic development of the area include most of the factors described in the national economic development account and:

1. The effect on the area tax base of taking private lands and placing them in public ownership.

2. Employment changes in the area as a result of the project.

3. Expenditures of nonarea residents in the study area.

4. Disruption of desirable community and regional growth.

ALTERNATIVES CONSIDERED

Introduction

Alternative solutions considered were classified under three principal categories: no action, nonstructural measures, and structural measures. The extent of study given to each alternative was established by screening it for suitability, applicability, and merit in meeting identified problems and needs. Each alternative was tested for its technical and economic feasibility; social acceptability; and capacity to preserve and, where practicable, to enhance the quality of the natural and human environment. Alternatives passing these initial tests were compared with other potential solutions to eliminate duplication of functions and ensure a coordinated area-wide plan. Alternatives considered for flood damage reduction and related purposes are listed below.

1. No Action

2. Nonstructural Measures

   a. Flood warning and emergency protection.
   b. Flood insurance.
   c. Flood proofing.
   d. Floodplain regulation.
   e. Permanent floodplain evacuation.

3. Structural Measures

   a. Levee and floodway system.
   b. Diversion channel to Red River of the North.
   c. Channel modification.
   d. Upstream reservoir storage.
   e. Snagging and clearing.

On the basis of the above kinds of measures, 10 flood damage reduction plans were considered for the Snake River area below Warren. In addition, maintaining the status quo or recommending that no action be taken to alleviate flood problems was considered. Each plan is described in the following paragraphs, and the major effects on the social, environmental, and economic factors are discussed. The following table presents a summary of the economic, environmental, and social impacts which the plans would have on the study area over the project life, if implemented.

Impacts of alternative flood damage reduction plans for the Snake River basin below Warren, Minnesota

Item	No action	Plan 1 Flood warning and emergency protection(1)	Plan 2 Flood insurance(1)	Plan 3 Flood proofing(1)	Plan 4 Floodplain regulation(1)	Plan 5 Evacuation(1)	Plan 6 Levee and floodway	Plan 7 Channel modification	Plan 8 Diversion channel	Plan 9 Three upstream reservoirs	Plan 10 Snagging and clearing(2)
NATIONAL ECONOMIC DEVELOPMENT											
Total first cost ($ million)(3)	0		0	8.3	0.4	55.5	16.5	12.4	3.4	15.3	0.7
1. Federal first cost ($ million)	0		0	6.6	-	44.4	11.3	10.4	2.2	12.8	0.6
2. Non-Federal first cost (4 million)	0		0	1.7	-	11.1	5.2	2.0	1.2	2.5	0.1
Total annual operation, maintenance, and replacement cost (non-Federal) ($1,000)	0		424.0	73.0	35.0	0	36.0	21.0	21.0	40.0	15.0
Total average annual cost ($1,000) (4)	0		424.0	703.0	65.0	4,100.0	1,289.0	962.0	279.0	1,170.0	67.9
Total average annual benefits ($1,000)	0	11.0	0	50.0	33.0	95.0	258.0	258.0	61.0	114.0	162.8
Net average annual benefits ($1,000) (5)	0		0	-653.0	-32.0	-4,005.0	-1,031.0	-704.0	-218.0	-1,056.0	+94.9
Remaining average annual flood damages ($1,000)	495.0	484.0	495.0	445.0	462.0	400.0	237.0	237.0	434.0	381.0	332.2
Benefit-cost ratio	-	-	-	0.07	0.51	0.02	0.20	0.27	0.22	0.10	2.4

Impacts of alternative flood damage reduction plans for the Snake River basin below Warren, Minnesota

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ENVIRONMENTAL QUALITY(2)											
Woodland lost or gained (± acres)											
1. Upland	0	0	0	0	0	0	0	0	0	80	0
2. Lowland	0	0	0	0	0	0	-5	-450	-15	160	-122
3. Windbreak	0	0	0	0	0	0	-10	-10	)	-	15
Wetlands lost or gained (± acres)											
1. Meadow or marsh	0	0	0	0	0	0	0	0	0	+300	0
2. Conifer bog	0	0	0	0	0	0	0	0	0	0	0
Lake area lost or gained (± acres)											
1. Fish	0	0	0	0	0	0	0	0	0	0	0
2. Marginal	0	0	0	0	0	0	0	0	0	+460	0
Steams affected											
1. Existing unchannelized											
a. Linear miles of stream	0	0	0	0	0	0	-45	-45	0	-10	-45
b. Low-flow water surface area (± acres)	0	0	0	0	0	0	0	+200	0	+460	0
c. Secondary channel & bank area (± acres)(6)	0	0	0	0	0	0	+800	+800	+1	+2,990	0
2. Existing channelized											
a. Linear miles of stream	0	0	0	0	0	0	+3	+3	+7.6	0	0
b. Low-flow water surface area (± acres)	0	0	0	0	0	0	0	+23	+15.0	0	0
c. Secondary channel and bank area (± acres)(6)	0	0	0	0	0	0	+54	-	+125	0	0
Effect on wildlife management area and refuge	0	0	0	0	0	0	Adverse effect on 0	51 m. of river	0	+2,960	Adverse effect on 52 m. of river
Effect on river water quality	Same	Same	Same	Same	Same	Temp. reduc.	Temp. reduc.	Temp. reduc.	Temp. reduc.	Temp. reduc.	Temp. reduc.
Effect on air quality	None	None	None	None	None	None	None	None	None	None	None
Effect on local life forms											
1. Terrestrial	None	None	None	None	None	None	Loss of veg. & w.l. hab.	Loss of veg. & w.l. hab.	Loss of veg. & w.l.hab.	Loss & gain of veg. & w.l. hab.	Loss of veg. & w.l. hab.
2. Aquatic	None	None	None	None	None	None	Disruption of 50 mi. of channel bottom		None	Conversion to lake ecosystem	Removal of aquatic hab.
Unique threatened or endangered animal species affected	None	None	None	None	None	None	None	None	None	None	None
Rare or unique vegetation systems affected	None	None	None	None	None	None	None	None	None	None	None
Scenic, recreation or wilderness sites and aesthetic qualities affected	None	None	None	None	None	None	All alternatives would affect aesthetic qualities.				
Historical and/or archeological sites affected (specify)	----------Effects unknown----------						----------Not surveyed----------			Approx. 20 known sites in river corridor	
Effect on river erosion	None	None	None	None	None	None	None	None	None	None	None
Mineral resources affected	None	None	None	None	None	None	None	None	None	None	None

Impacts of alternative flood damage reduction plans for the Snake River basin below Warren, Minnesota (Cont)

Item	No action	Plan 1 Flood warning and emergency protection(1)	Plan 2 Flood insurance(1)	Plan 3 Flood proofing(1)	Plan 4 Floodplain regulation(1)	Plan 5 Evacuation(1)	Plan 6 Levee and floodway	Plan 7 Channel modification	Plan 8 Diversion channel	Plan 9 Three upstream reservoirs	Plan 10 Snagging and clearing(2)
SOCIAL WELL-BEING (7)											
Flood protection											
1. Residences protected	0	0	0	120		120	120	120	120	700	120
2. Businesses protected	0	0	0	13		13	13	13	13	96	13
3. Persons protected	0	0	0	900		900	900	900	500	3,100	900
4. Total flood damage reduction (percent)	0	1.0	0	17.0	23.0	20.0	46.0	46.0	53.0	30.0	17.3
5. Agricultural lands protected	0	0	0	0	0	0	20,000	20,000	10,000	20,000	20,000
a. Farmsteads protected			0	262	10	262	262	262	130	262	262
6. Effects on downstream flood protection	Same	Same	Same	Same	Same	Same	Slight Decrease	Slight Decrease	Slight Increase	Slight Increase	Slight Increase
Relocations required											
1. Farmsteads	0	0	0	0	0	262	30	5	0	1	0
2. Businesses	0	0	0	0	0	13	0	0	0	0	0
3. Residences	0	0	0	0	0	120	0	0	0	0	0
4. Persons	0	0	0	0	0	1,100	100	20	0	4	0
5. Highways and roads (miles)	0	0	0	0	0	0	0	0	0	2	0
6. Utilities (miles)(8)	0	0	0	0	0	6	0	0	0	2	0
Lands required (acres)											
1. Cropland	0	0	0	0	0	100	580	750	325	200	100
2. Pasture	0	0	0	0	0	100	0	0	0	250	50
3. Natural habitat	0	0	0	0	0	200	5	450	5	3,000	0
4. Park and open space	0	0	0	0	0	0	0	0	0	0	0
5. Other lands(9)	0	0	0	0	0	0	0	0	0	0	0
Bridge replacements	0	0	0	0	0	0	1	1	5	1	0
Roads severed	0	0	0	0	0	0	0	0	5	1	0
Socially important sites affected(10)	0	0	0	0	0	0	0	0	0	0	0
Effect on community patterns	None	None	None	None	Minor	Major	Minor	None	None	None	None
Improvement of public health and safety	None	None	None	Minor	Minor	Major	Moderate	Moderate	Moderate	Moderate	Moderate

Impacts of alternative flood damage reduction plans for the Snake River basin below Warren, Minnesota (Cont)

Item	No action	Plan 1 Flood warning and emergency protection(1)	Plan 2 Flood insurance(1)	Plan 3 Flood proofing(1)	Plan 4 Floodplain regulation(1)	Plan 5 Evacuation(1)	Plan 6 Levee and floodway	Plan 7 Channel modification	Plan 8 Diversion channel	Plan 9 Three upstream reservoirs	Plan 10 Snagging and clearing(2)
SOCIAL WELL-BEING (Cont)											
Increased potential for usable water supply	None	None	None	None	None	None	None	None	None	None	None
Recreation opportunities affected											
1. Hunting	None	None	None	None	None	Minor Increase	Minor Loss	Major Loss	Minor Increase	Increase	Minor Loss
2. Fishing	None	None	None	None	None	Minor Increase	Minor Loss	Major Loss	Minor Increase	Minor	Minor Loss
3. Trapping	None	None	None	None	None	Minor Increase	Minor Loss	Major Loss	Minor Increase	None	Minor Loss
4. Boating	None	None	None	None	None	None	None	None	None	None	None
5. Camping	None	None	None	None	None	None	None	None	None	None	None
6. Canoeing	None	None	None	None	None	None	None	None	None	Minor Increase	Minor Increase
Reduction in snow accumulation in channel	None	None	None	None	None	None	Yes	Yes	None	None	Yes
REGIONAL ECONOMIC DEVELOPMENT											
Loss in area tax base	None	None	None	None	None	None	Minor	Minor	Minor	Minor	None
Area redevelopment benefits	None	None	None	None	None	Yes	Yes	Yes	Yes	Yes	Yes
Increased recreation expenditures	No	No	No	No	No	No	No	No	No	Yes	No
Effect on regional economic growth	None	None	Slight Increase	Slight Decrease	Slight Decrease	Decrease	Increase	Increase	Increase	Increase	Increase

(1) Costs do not include the city of Warren.
(2) Plan includes clearing the lower two-thirds of the channel.
(3) Based on October 1980 price levels.
(4) Includes annual operation, maintenance and replacement costs plus interest and amortization charges based on a 7 3/8 percent interest rate.
(5) Total average annual benefits minus total average annual costs.
(6) Does not include lowlands, woods, and brush area.
(7) Flood protection refers to reduction of threat to safety and well-being of individuals due to floods; it does not imply complete flood protection from the intermediate regional flood and does not include protection to downstream areas.
(8) Includes water, sewer, electric and telephone lines but excludes private sanitary systems.
(9) Includes urban area, farmsteads, roads, highways, railroads, windbreaks, existing drainage ditches, etc.
(10) Includes cultural sites, cemeteries, developed parks, town halls, etc.

No Action - Maintain Status Quo

Maintaining the status quo or recommending that no action be taken to alleviate flood and related problems would not burden local interests and the Federal Government with the financial costs associated with other alternatives. Nevertheless, average annual damages estimated at $495,000 would remain and, as such, would be a severe social and economic burden to the people. Floodplain farmers would continue to sustain substantial loss of income resulting from periodic inundation of about 20,000 acres of cropland; soil erosion; and damage to houses, barns, stored crops, machinery, and other farm property. No changes in land use would be anticipated because the floodplain area under study is highly productive agricultural land almost totally under cultivation. Accordingly, the social well-being and environmental quality of the area would not be affected.

Nonstructural Measures

Because flooding is the major water-related problem under study, and nonstructural measures can often be employed effectively in reducing flood damages, such measures were considered for flood-prone areas along the Snake River below Warren. Nonstructural measures applicable to the flood-prone area include flood warning and emergency protection, flood insurance, flood proofing, floodplain regulation, and permanent floodplain evacuation.

1. Plan 1 - Flood Warning and Emergency Protection

An emergency protection plan depends on a flood warning system to provide for timely action. Flood warning consists of predicting the timing and magnitude of floods to allow for evacuation of flood-prone areas or construction of emergency flood protection measures.

The National Weather Service provides area officials and local news media with flood forecasts and warnings for the Snake River at Warren and Alvarado. A spring snowmelt flood can be reasonably predicted by available methods. Large major floods that result from excessive summer rainfall can also be predicted. However, the time interval between rainfall occurrence, issuance of a flood warning, and beginning of flooding is much shorter than for snowmelt floods. Emergency evacuation of persons and belongings or construction of emergency measures might well be undertaken for the spring snowmelt floods. However, these emergency measures would be much less effective in preventing damages from floods resulting from excessive rainfall runoff.

Emergency measures in the Snake River basin have been limited to local levee construction at Alvarado and at several farms adjacent to the Snake River to protect fields. Most of the emergency levees were constructed and financed by local interests and do not meet standards for permanent levees; therefore, the levees require constant maintenance and repair during floods. Temporary evacuation of the protected area as a safety precaution also places a burden on the manpower and finances of those affected. Local and other agency resources are further strained in providing necessary and often specialized transportation, equipment, temporary lodging, and personal services.

Implementation of this plan would not significantly benefit the economic development, environmental quality, and social well-being of the study area. Flood warnings with subsequent emergency actions could alleviate about 2 percent of the total flood damages in the watershed. Over $480,000 in average annual flood damages would remain. Because the costs for providing flood warnings and emergency measures are uncertain, the net benefits of this plan cannot be estimated, and it is not known whether this plan would be beneficial. Accuracy of the flood warnings and adequacy of the emergency actions taken would play a large role in determining the actual costs and benefits of the plan. On a short-term

basis and in the absence of any other means of flood damage reduction, flood warning and subsequent emergency actions may reduce flood damages in the urban areas. However, as a means of permanent flood damage reduction and a long-term solution to flood problems for the Snake River area below Warren, this plan would not be effective.

2. Plan 2 - Flood Insurance

Federally subsidized flood insurance is available to area residents in the Snake River basin below Warren. The National Flood Insurance Program under the Federal Emergency Management Agency offers insurance coverage for farm homes, other farm buildings, and their contents up to prescribed limits. Unsubsidized crop insurance is available under the U.S. Department of Agriculture Federal Crop Insurance Program which covers all natural disasters including floods. Indications are that only a small percentage of qualified property owners are taking full advantage of these programs, probably because of the high remaining costs involved. On the basis of actuarial rates and the Federal subsidized limits, the total cost for complete flood insurance coverage would approximate $1,476,400 annually of which the Federal and non-Federal annual costs would be $1,052,000 and $424,400, respectively. Flood insurance does not solve flood problems and does not reduce the damages but merely spreads the monetary loss over a wider population sector. Average annual damages of $495,000 would remain. Accordingly, flood insurance cannot be considered an acceptable long-term solution to the flood problem under study or a very suitable short-term solution because of the lack of acceptance resulting from high costs involved.

3. Plan 3 - Flood Proofing

Flood proofing is a combination of structural changes and adjustments to flood-prone properties to reduce flood damages. Several days duration of flooding and appreciable flood depths would cause seepage through the walls of most structures, even with effective sealing of doorways and windows. Even if farmstead and residential structures could be successfully protected by flood proofing, only 9 percent of the estimated total

average annual flood damages would be alleviated. Average annual remaining damages would approximate $445,000. The sociological effects of flooding, such as disruption of transportation, isolation of residents from their homes and farming operations, well contamination, vector production, and interrupted access to flood proofed structures during severe floods, would remain. Implementation of this plan would not benefit agricultural land or reduce crop damage. Also, no changes in land use would be anticipated. Accordingly, the social well-being and environmental quality in the study area would not be altered.

4. Plan 4 - Floodplain Regulation

Measures for modifying floodplain land use and development do not control or eliminate flooding but are designed to shape floodplain development to lessen the future effects of floods. Such measures require adoption and use of legal tools by local governmental units to control the extent and type of future development permitted in the floodplain. This requires public understanding of the general flood problem, degree of risk, and various means of controlling land use. Floodplain regulation measures include zoning regulations, subdivision regulations, building codes, and bridge construction regulations. However, damages to crop production and existing developments rather than potential increased damages to future structures and facilities constitute the major flood problem under study. Thus, floodplain regulations would not reduce flood damages to a significant degree because they could alleviate only about 6.0 percent of the total estimated annual damages. With floodplain regulations in effect, remaining average annual damages to crop production and existing development would approximate $460,000. No significant land use changes would be anticipated because of the highly fertile and productive agricultural lands involved. Thus, floodplain regulation would have little effect on the social well-being of the people in the area or little impact on environmental quality. Natural vegetation and wildlife would benefit only to the extent that developments were regulated.

5. Plan 5 - Permanent Floodplain Evacuation

Permanent evacuation of the floodplain and conversion of land use involves removal and relocation of all improvements including farmsteads, other buildings, equipment, and stored crops from the floodplain; evacuation and resettlement of the rural population; and permanent conversion of such lands to uses less susceptible to flood damage. Floodplain evacuation, although completely unacceptable to local interests, has been analyzed for the buildings located within the 1969 flooded area (approximately the 4-percent chance flood) which involves about 262 farmsteads and residences. Evacuation of the rural community to a flood-free area would require moving the above-mentioned improvements and population an average distance of 12 miles eastward into the escarpment area. This plan was not economically feasible with average annual benefits and costs estimated at $95,000 and $4,100,000, respectively (a benefit-cost ratio of 0.02). This plan would alleviate only about 20 percent of the total flood damages while remaining average annual damages would approximate $400,000. In addition, massive social, institutional, and physical problems make the practicality of this plan highly questionable. Rural community cohesion would be severely disrupted and long-standing sociological ties would be lost. Further, the affected farming businesses may not be able to continue to function as a viable economic operation because the farm equipment and manpower would require mobilization and demobilization an average distance of 12 miles. In addition, this alternative would require about 400 acres of land including 150 acres of cropland, 100 acres of grassland pasture, and 150 acres of upland woods in the Agassiz beach ridge area. Accordingly, this alternative has unacceptable impacts on wildlife habitat, lacks necessary economic feasibility, and is not socially acceptable.

Structural Alternatives

Structural measures applicable to the flood problems along the Snake River below Warren include a levee and floodway system, channel modifications, a diversion channel, upstream reservoir storage, and snagging and clearing.

1. Plan 6 - Levee and Floodway System

This plan consists of a floodway system formed primarily by levees along both sides of the Snake River from just below Warren to its mouth. The floodway width between levees would range from 500 feet through the flatter downstream reach (mile 0 to mile 23±) to 400 feet in the steeper upper reach (mile 23± to mile 48±). Levee heights would range from 5 feet to 7 feet, and the side slopes would be 3 on 1. The base widths of the levees would vary from 40 feet to 52 feet. The levees would contain the 10-percent chance flood and more frequent floods with about 2 feet of freeboard.

The flanking levees required with this plan would enclose about 1,700 acres of river corridor, which includes approximately 1,000 acres of bottomland woods, 300 acres of pastureland, and 400 acres of cropland. The levees would be constructed on about 580 acres of adjacent cropland. Approximately 5 acres of wooded area at the upstream and downstream ends of the levee system would have to be cleared for the levee right-of-way. In addition to the cropland affected, approximately 30 farmsteads would have to be relocated at least partially to provide the necessary levee alignment and right-of-way. The plan would benefit about 20,000 acres of agricultural land by reducing total estimated average annual damages by about 52 percent. Remaining average annual damages would be approximately $237,000. This plan is the most expensive structural alternative considered with an estimated first cost of $16.5 million.

The plan has a benefit-cost ratio of 0.20 and therefore lacks economic feasibility by a wide margin. In addition, removal of 580 acres of highly productive cropland from production and relocation of 30 farmsteads and residences would be somewhat unacceptable to local interests.

This plan would provide some overall net environmental benefits to biological systems because the required agricultural lands would be maintained as grassed floodway and levee slopes and significant clearing of existing natural wooded and brushy habitat in the floodway would not be required. The net biological benefit would be enhanced by planting of

native prairie grassland species in lieu of the standard mixture of brome and bluegrass used in the past. This plan would also allow for some continued natural recovery of aquatic biological systems along the "ditch." However, development of woody vegetation immediately adjacent to stream banks (where it performs a variety of significant biological functions) would be precluded because of requirements for maintenance of the floodway channel.

2. Plan 7 - Channel Modifications

With this plan, the channel of the Snake River would be enlarged to contain the 10-percent chance and more frequent floods. The extent of channel enlargement depends on the slope of the river channel. In the flatter downstream reaches of the river (mile 0 to mile 23), a channel having a 90-foot bottom width would be required, and, in the upper reach (mile 23 to mile 46), a channel with a 20-foot bottom width would be needed. Along with numerous side ditch inlets, a drop inlet structure would be required at the confluence of the Snake and Middle Rivers. Extensive slope protection would be provided at the drop inlet structure, side ditch inlets, and all bridges crossing the modified channel. Review of the available bridge data disclosed that one bridge would have to be replaced to provide adequate flow capacity. This plan would require about 750 acres of cropland and 450 acres of natural habitat consisting of woods and brush along the river corridor. Losses of lowland woods habitat would decrease wildlife values of the area, which are already limited. Another adverse impact would be the destruction of woodland.

This plan lacks economic feasibility with average annual benefits and costs estimated at $258,000 and $962,000, respectively, resulting in a benefit-cost ratio of 0.27. The plan would alleviate about 54 percent of the total flood damages along the Snake River below Warren. The major reduction would occur to agricultural crop damages of which about 45 percent would be alleviated. Average annual flood damages of $237,000 would remain in the study area.

3. Plan 8 - Diversion Channel to the Red River of the North

This plan consists of a 6.8-mile diversion channel from the Snake River to the Red River of the North. The upstream end of the diversion from the Snake River would be upstream from Alvarado at mile 35 and would join the Red River of the North at mile 273.5. The diversion would consist of a channel having a bottom width of 14 feet and a depth of about 12 feet, five new bridges, flow control structures at the inlet and outlet ends of the diversion, and side ditch inlets at each road crossing and intersection with existing watercourses. This plan would require about 325 acres of land consisting of 310 acres of cropland and 15 acres of bottomland woods.

This alternative would contain the 10-percent chance and more frequent floods and would benefit about 10,000 acres of agricultural land, most of which is located downstream of the diversion. The total annual damages would be reduced by about 13 percent, with about $434,000 in remaining average annual damages. Estimated first costs for the alternative are $3.4 million with average annual benefits and costs of $61,000 and $279,000, respectively. The benefit-cost ratio is 0.22. Therefore, this plan lacks economic feasibility.

This alternative would meet with considerable local opposition because many landowners on the North Dakota side of the Red River believe that high flows from the ditches (State Ditch No. 1) draining the area south of the Snake River watershed have increased water surface elevations at Oslo and areas immediately upstream. The affected landowners asked the Middle River-Snake River Watershed District Board to review the feasibility of installing a control structure in the State Ditch No. 1 system that could divert high flows from the system into the Snake River. The landowners believe that during recent years there were several periods of high flows in the State Ditch No. 1 system that could have been diverted into the Snake River without damaging effects.

Of the structural alternatives investigated, this alternative would have the least detrimental biological effects. The natural habitat disturbed by this plan would consist of 15 acres of bottomland hardwoods at

each end of the diversion. A wildlife corridor could be created along the diversion channel by planting the channel and the dredged material banks with a native prairie grassland species and maintaining the channel as a grassed floodway. Rows of trees, planted parallel to the channel to serve as windbreaks to prevent the channel from becoming filled with snow, would provide additional wildlife habitat.

In summary, the plan could have some favorable effects on wildlife habitat; however, the lack of economic feasibility and the social impacts associated with the removal of 310 acres of cropland from production result in the plan being unacceptable.

4. Plan 9 - Three Upstream Reservoirs

This alternative would involve construction of three small reservoirs on the Snake River and South Branch of the Snake River upstream of Warren. One reservoir would be on the Snake River at about mile 77. The other reservoirs would be on the South Branch at approximately miles 15 and 22. The total surface area of the conservation pools would be 460 acres, and the design flood pools would be about 3,450 acres. Flood control storage of these reservoirs would be approximately 15,000 acre-feet; however, 11,500 acre-feet of the total would be provided by the upstream site on the South Branch of the Snake River.

This alternative would require about 3,500 acres of land, including 300 acres of cropland, 80 acres of pastureland, 160 acres of bottomland woods, and 2,960 acres of wetlands. The conservation pools of the reservoirs would inundate 460 acres of land, including 160 acres of bottomland woods and 300 acres of wetlands. The remaining 3,040 acres would be subject to short-term inundation during periods requiring floodwater storage.

This alternative lacks economic feasibility with average annual benefits and costs estimated at $114,000 and $1,170,000, respectively, which represents a benefit-cost ratio of 0.10. Average annual flood damages of $381,000 would still be present in the Snake River basin.

Biological effects of this alternative would include a decrease in wildlife habitat as a result of the permanent inundation of 460 acres of habitat. Hunting opportunities for deer and upland game would suffer from loss of habitat; however, waterfowl habitat would increase substantially as a result of maintenance of a conservation pool in the larger reservoir.

5. Plan 10 - Snagging and Clearing

With this alternative the lower 50 miles of the Snake River would be snagged and cleared of fallen timber and other debris which are obstructing the natural free-flowing capacity of the existing channel. Except for the reach of river through Warren (river miles 48 to 51), the river upstream from mile 20 has not been previously cleared. Work in the lower reach of the river from the mouth to river mile 20, would consist of debris removal only, because this reach was snagged and cleared by the Middle River-Snake River Watershed District in 1969 and 1970. This work was funded by the State of Minnesota and the U.S. Office of Emergency Preparedness following the 1969 flood. From river miles 20 to 50, all debris and snags within 20 feet of the primary channel area would be removed.

The removal of standing timber and brush would be limited to the lower two-thirds of the channel bank so that the canopy provided by the existing wooded corridor would not be affected significantly. The only standing trees to be removed beyond the lower two-thirds of the channel bank would be those leaning trees in danger of falling into the river channel and causing a future flow obstruction. All vegetation which aids in maintaining bank stability or provides fish and wildlife habitat but does not interfere with the natural unobstructed flow-carrying capacity of the channel would remain.

Materials and debris from the snagging and clearing operation would be removed from the site and disposed of in the most environmentally acceptable way. All material would be stockpiled for salvage or disposed of by burial or burning in a manner agreeable to the local landowner and in compliance with Federal, State, and local regulations. Stockpiled material would be placed in a suitable location where it would not interfere with existing land use practices and could be left as habitat for small animals.

At various points along the river, the wooded corridor is not continuous. At these points the unprotected channel becomes filled with snow preventing full use of the channel capacity during initial spring runoff. To remedy this problem, rows of trees would be planted parallel to the river channel approximately [illegible] feet from the top of bank. The tree planting program would require about 100 acres of cropland and 50 acres of pasture.

Of the plans investigated, this alternative is the only economically feasible flood damage reduction alternative. The average annual benefits and costs are $162,800 and $67,900, respectively, with the shelterbelt included, or benefits and costs of $128,800 and $58,500, respectively, if the shelterbelt is excluded. These benefits and costs result in benefit-cost ratios of 2.4 and 2.2 for the with and without conditions, respectively. These alternatives would provide substantial flood protection at the least cost and with the least requirement for additional agricultural land and natural habitat of the structural alternatives considered.

The snagging and clearing project as proposed would be preferable to other structural alternatives, considering the expected ecological impact. Besides preventing soil erosion and keeping the channels from becoming filled with snow, the proposed man-made corridor would replace some of the trees removed by the snagging and clearing operation and provide additional wildlife habitat along the continuous river corridor. A reduction in the frequency of flooding of these wooded areas as a result of the proposed snagging and clearing should have beneficial effects on wildlife and wildlife habitat.

PLAN FORMULATION RATIONALE

Selection of the plan of improvement is based on the respective contributions of the various alternatives toward meeting the water resource needs of the basin, recognizing the degree to which each plan increases gains in national economic development and enhances environmental quality. Advantages and disadvantages of each alternative with regard to social well-being and regional economic development aspects were also considered. The economic principles of net benefit maximization and the assessment principles of with and without project conditions were the principal planning tools used. Alternatives are identified which provide optimum contributions to the national objectives of environmental quality and economic development.

DISCUSSION OF PLANS

Impacts and effects of the alternatives on national economic development are summarized in the table on page 32.

The no action alternative would not meet any of the water resource needs in the basin, especially with regard to flood control. No gains would result to national economic development, environmental quality, social well-being, or regional economic development. The no action approach is not considered an acceptable answer to the problems and needs identified in the basin.

Flood warning and emergency protection (plan 1) would provide only a very limited reduction of the flood damages of the basin. Limited gains to national economic development might result; however, this would be somewhat speculative. The environmental quality account would be essentially unchanged, and changes to the social well-being and regional economic development would be relatively minor. The unreliability and incompleteness of this solution to the problems and needs of the basin is the basic measure by which it is considered an unacceptable plan.

Flood insurance (plan 2) would not reduce flood damages but would distribute the loss over a broader sector of the public. There would be net losses to national economic development, limited gains to the regional economy and social well-being, and negligible effects on environmental quality. This plan is not considered an acceptable solution to the problems and needs of the area.

Flood proofing (plan 3) would not adequately protect the basin from floods. This plan would cause major net losses to national economic development, would not significantly improve the social well-being of the area, and would not enhance environmental quality. Flood proofing is not considered a viable solution to the flood problems of this agrarian area.

Floodplain regulation (plan 4) would provide reductions in the future structural flood damages in the basin, but would reduce total flood damages by only about 6 percent. Net gains to national economic development would result; however, regional economic development, social well-being, and environmental quality would not be significantly affected. Floodplain regulation could be considered only a partial solution to the problems and needs of the basin. Although not an acceptable plan by itself, floodplain regulation might be a desirable feature of a more comprehensive and acceptable plan if incrementally justified.

Permanent floodplain evacuation (plan 5) would substantially reduce structural flood damages; however, total flood damages in the basin would be reduced by only 20 percent. Major net losses to national and regional economic development would occur. The social well-being aspects of this plan would involve a complete disruption of the existing social, cultural, and economic structure of the area. Local interests have indicated that the social disruptions of this plan would greatly outweigh any social gains and that total evacuation of the floodplain would be completely undesirable. Although gains may accrue to the environmental quality, they would be minor. Primarily because of the great economic and social drawbacks, this plan is not considered an acceptable solution to the problems and needs of the basin.

The levee-floodway system (plan 6) would reduce total flood damages in the basin 52 percent, with reductions in all categories. This degree of flood protection is considered reasonable; however, net losses to national economic development would occur with an unfavorable benefit-cost ratio of 0.2. Dedicating the river corridor to passage of floodwaters would preserve and enhance the environmental quality of the lower basin. However, relocation of about 30 farmsteads is undesirable to the basin residents. The plan is considered unacceptable from the economic and social well-being aspects, but it is considered an environmentally acceptable solution to the problems and needs of the basin.

Channel modifications on the Snake River (plan 7) would reduce flood damages to an acceptable degree (about 52 percent) with reductions in all categories of flood damages. However, net losses would occur to the national economic development and environmental quality. The unfavorable benefit-cost ratio plus the adverse environmental effects of clearing about 450 acres of streamside forest outweigh the social well-being gains of flood protection. This plan is not considered economically and environmentally acceptable, even though it provides a reasonable degree of flood damage reduction for the basin.

The 6.8-mile diversion channel (plan 8) would reduce total flood damages 13 percent, with reductions in all categories. The greatest reduction would be in agricultural crop damages. Net national economic losses would result from this plan. However, environmental quality and social well-being aspects are relatively minor with no relocations and about 310 acres of cropland required. This plan is not considered acceptable with respect to economic development criteria and as a solution to the basin flood problems. If suitable treatment were provided to the diversion channel and associated excavated material banks, this plan might meet some of the environmental quality needs of the basin and be considered acceptable from the environmental quality standpoint.

The three upstream reservoirs (plan 9) would provide a limited reduction (about 23 percent) in total flood damages in the basin. Net losses to national economic development and probable losses to environmental quality would occur. The social well-being aspects include road relocations to several farmsteads and about 300 acres of cropland affected by

the reservoir development. This plan would not sufficiently reduce flood damages to be considered an acceptable solution to the problems and needs of the basin.

Snagging and clearing (plan 10) would provide a somewhat limited reduction in total damages in the basin, but would show national and regional net economic gains and gains to social well-being. The net effects on environmental quality may be slightly negative because a portion of the wildlife habitat along the stream bank would be removed. The negative environmental effects could be somewhat compensated by provision of windbreaks included in this plan. This plan is an acceptable solution to the major problems and needs of the basin from both the economic and social well-being accounts. However, it cannot be considered an entirely desirable plan from the environmental quality standpoint.

The structural plans considered are illustrated on plate 1.

OPTIMUM ENVIRONMENTAL QUALITY PLAN

Of the alternatives studied, plan 10, snagging, clearing, and shelterbelt plan, would meet the needs of the basin and the environmental quality objective. Therefore, Plan 10 is the environmental quality plan.

Snagging and clearing has been generally considered somewhat undesirable from the point of view of the environmental account; however, limiting clearing operations to the lower two-thirds of the river channel and other restrictions have minimized the adverse environmental impacts. The provision of shelterbelts at various points along the river channel, where

the wooded corridor is not continuous, causes the snagging and clearing and shelterbelt plan to make a net positive contribution to the environmental quality of the area.

OPTIMUM ECONOMIC DEVELOPMENT PLAN

Of the alternatives evaluated, plan 10, snagging and clearing, would meet the needs of the basin and best meet the national economic development objectives. The total project benefits are approximately equal to the costs and total flood damages in the basin would be substantially reduced. In addition, no farmsteads would have to be relocated. Environmental quality changes would occur, several of which are negative.

RATIONALE FOR SELECTION OF PLAN 10

The plan selected as that which best solves the water and related problems and needs of the basin and best meets the overall planning objectives of national economic development and environmental quality, recognizing social well-being and regional economic aspects, is plan 10, snagging and clearing. The plan would provide the desired and needed reductions to flood damages in the basin without taking valuable cropland out of production or relocating any of the adjacent farmsteads or residences. The changes in environmental quality are not so adverse as to offset the beneficial aspects and render this plan unacceptable.

DETAILED ASSESSMENT AND EVALUATION OF THE SELECTED PLAN

SCALE OF DEVELOPMENT

Development of the selected plan to the optimum level considers the evaluation of the economic and environmental aspects of various degrees of the snagging and clearing operation. Because snagging and clearing has adverse effects on wildlife habitat, the selected plan was evaluated for three alternative snagging and clearing plans to determine their effects on the flow capacities of the river channel.

To evaluate the effects of snagging and clearing on the flow capacity of the river channel, three alternatives were considered for a range of flood flows. The three alternatives are (1) clearing the lower two-thirds of the riverbank, (2) clearing to the top of the riverbank, and (3) clearing to 10 feet beyond the top of the riverbank. Flooded overbank areas were computed for the above conditions and are shown in the following table.

Effects of selected clearing conditions

Discharges at Alvarado (cfs)	Overbank area flooded (acres)		
	Two-thirds bank	Top of bank	Top of bank plus 10 feet
1,170	3,190	3,150	3,140
1,900	9,040	8,970	8,930
3,305	16,530	16,300	16,220

As shown in the table, the reduction in area flooded by clearing to the top of bank or 10 feet beyond the top of riverbank is almost insignificant. On the basis of the above analysis and considering the attendant greater loss of wildlife habitat associated with the more extensive clearing, the proposed clearing would be limited to the lower two-thirds of the riverbank.

PLAN DESCRIPTION

This section describes the plan selected to meet the water and related land resource needs of the Snake River basin. The selected plan consists of snagging and clearing the lower 50 miles of the Snake River of fallen timber and other debris obstructing the natural free-flowing capacity of the river (see plates 2, 3, and 4). The plan is consistent with the economic, environmental, and social criteria and desires presented in previous sections of this report.

Snagging and Clearing

All fallen trees, smaller standing trees, and dense stands of brush would be removed in the wetted channel area and on the channel banks along the lower two-thirds of the primary bank. The larger healthy trees along the channel banks could remain but any branches which might obstruct flows would be pruned.

Leaning trees in imminent danger of falling into the channel along the upper one-third of the primary bank and within 20 feet of the top of the primary bank would be removed. All fallen trees and debris lodged along this section of the channel and overbank area would also be removed. All trees would be cut to a height not exceeding 6 inches above the ground surface. Stumps from broken or previously cut trees along the channel reaches to be snagged and cleared, as well as any piling encountered within these limits, would be cut as nearly flush to the ground as practicable.

Any brush over 2 feet high within the clearing limits would be cut as low as practicable but no higher than 6 inches above the ground surface. Stands of brush above the two-thirds line would remain.

In the interest of conservation, the contract plans and specifications would include provisions to establish the limits of cleared area under the direction of a District biologist.

Disposal of Materials

Materials and debris from the snagging and clearing operation would be removed from the site and disposed of in the most environmentally acceptable way. Salvageable material would be stockpiled where it would not interfere with existing land use practices. In the interest of conservation, all suitable time could be used to produce marketable sawlogs, posts, or cordwood. All unsalvageable material would be disposed of by burning (when and where allowable), burial, or hauling to an approved disposal site. Debris disposal would be accomplished in a manner most agreeable to the local landowners and in compliance with Federal, State, and local regulations.

Members of the Snake River-Middle River Watershed District Board have commented that the demand for cordwood has increased significantly in recent years. The board recommended that as much of the salvageable material as possible be made available for this use. The board also recommended that any salvageable materials from the downstream reaches of the river be stockpiled at a selected upland site substantially removed from the Red River of the North floodplain.

Environmental Protection

Land, water, and fish and wildlife resources and any historical and archeological finds within the project boundaries and adjacent access and work areas would be preserved or restored to natural conditions after completion of the proposed work. To ensure minimum damage to adjacent lands and trees in the access and work areas, clearing work would be completed during the winter on frozen ground and from the frozen riverbed.

To minimize landscape defacement, removal of trees within the access areas would be permitted only to provide for maneuvering of clearing equipment. Special efforts would be made to protect trees and shrubs on adjacent land from injury, defacement, or destruction. Any trees or landscape features scarred or damaged during the clearing operation would be restored as nearly as possible to their original or natural condition. All signs of temporary construction, such as haul roads, work areas, and stockpiles of excess waste materials, would be obliterated and the area would be restored to near natural conditions which would permit the growth of vegetation.

During snagging and clearing, care would be taken to preserve all items discovered having apparent historical or archeological interest. The contractor would be instructed to leave such finds undisturbed, and proper authorities would be notified.

Additional Measures Considered

Local interests have promoted the use of windbreaks to prevent snow from blocking the channels, hampering spring runoff, and causing overland flooding. In 1968, a landowner along the State Ditch No. 5 segment of the Snake River planted a short section of windbreak along his property approximately 100 feet from the top of the north or right riverbank. Local interests consider this windbreak to be effective; however, in their opinion, windbreaks provide greater protection if the distance from the top of the primary bank and the windbreak is 150 feet. Soil Conservation Service Agriculture Information Bulletin 339 recommends distances of 125 to 150 feet between windbreaks and protected areas.

In conjunction with the selected plan, windbreaks are proposed along the bank of the river channel as shown on plates 2, 3, and 4. The sections of windbreaks would be planted along the riverbank at the recommended distance of 150 feet from the top of the bank and at spacings set forth in available publications and as recommended by Federal, State, and county agencies. The species of trees to be used would depend on the soil types at the proposed windbreak locations.

Maintenance

Maintenance of the flood-carrying capacity of the improved channels would be essential to ensure effective operation of the overall drainage system and realize anticipated project benefits. To properly evaluate the condition of the river channel within the project limits, annual inspections are recommended as a minimum requirement. Debris removal at bridge crossings and from isolated reaches of the channel may be required annually or after each flood. Minor clearing of new growth within the critical sections of the primary channel may be needed every 3 to 4 years. Project maintenance would be the responsibility of the project sponsor, the Middle River-Snake River Watershed District, and is part of the local cooperation requirements discussed later in this report.

IMPACT ASSESSMENT

This section discusses the economic, environmental, and social impacts of the proposed snagging and clearing.

Economic Impacts

The economic analysis considers present and future conditions. Average annual benefits and costs were estimated to determine a benefit-cost ratio for the proposed project.

Damages. - Flood damages for urban, agricultural and other agricultural, and transportation categories were estimated. October 1980 price levels were used for urban damages. Agricultural damages were calculated on the basis of current Minnesota normalized agricultural prices.

The following table summarizes average annual flood damages in the study area.

Average annual flood damages

Category	Amount
Urban	$95,500
Rural	393,500
Agricultural	(299,300)
Other agricultural	(94,200)
Transportation	6,000
Total	495,000

Benefits. - The proposed project would reduce flood damages. The amount of this reduction is a benefit of the project. Another benefit is increased local employment. Including shelterbelts in the project reduces flood damages further, providing more benefits. The following table summarizes the average annual benefits.

Average annual benefits[1]

Category	Amount
Flood damage reduction	
Urban	
Warren	$13,900
Alvarado	8,500
Agricultural and other agricultural	104,300
Transportation	2,100
Total	128,800
Reduced damages with shelterbelt protection	34,000
Total (with shelterbelts)	162,800

(1) Including future growth.

Costs. - Costs are based on field survey data adjusted to reflect average bids received for similar work by the St. Paul District. Because of the nature of the work and difficulties in determining quantities and construction methods, 20 percent is allowed for contingencies.

The detailed first costs in the following table are based on October 1980 price levels.

First costs

Item	Unit	Quantity	Total cost
Federal first costs			
Snagging and clearing	Job	Sum	$407,500
Planting of shelterbelt	Job	Sum	53,000
Contingencies			92,100
Total Federal construction cost			552,600
Engineering and design			55,300
Supervision and administration			24,900
Supervision and inspection			24,900
Overhead			14,400
Total supervision and administration			39,300
Total Federal first costs			647,200
Non-Federal first costs			
Lands, easements, and rights-of-way			50,000
Total cost			697,200

Average annual costs are based on an interest rate of 7 3/8 percent and an amortization period of 50 years. Interest during construction is not included because construction is expected to be completed within one construction season. Because there are no structures, annual costs for operation and replacement have not been added. However, $15,000 per year has been included to cover maintenance required to ensure the flow carrying capacity of the improved channel. Average annual costs are summarized in the following table.

Item	Average annual costs Amount	
Federal		
First cost	$647,200	
Average annual charges (interest plus amortization)		$49,100
Non-Federal		
First cost	50,000	
Average annual charges (interest plus amortization)		3,800
Operation and maintenance		15,000
Total annual costs		67,900

Benefit-cost ratio. - Average annual benefits and costs are compared to determine the benefit-cost ratio for the proposed project. Average annual benefits of $162,800 and costs of $67,900 result in a benefit-cost ratio of 2.4.

Environmental Impacts

The proposed plan would have a variety of beneficial and adverse environmental effects. While effects on the environment are characterized by their nonmarket, nonmonetary nature, they provide important evidence for judging the value of proposed plans.

Beneficial environmental effects are contributions resulting from management, preservation, or restoration of environmental characteristics of the study area or other areas in the Nation. Such contributions generally enhance the quality of life. Conversely, adverse environmental effects are consequences of the proposed plan that result in deterioration of environmental characteristics; for example, acres of open and green space, wilderness area, or wildlife habitat inundated or altered.

Fish and Wildlife - The greatest effect on fish and wildlife from snagging and clearing would be removal of natural habitat. The severity of the impact would vary with the amount of clearing done. Normal precautions and restraints would be exercised to minimize the project's effects.

The project would affect aquatic life as a result of removal of debris from the river and trees from the bank. The debris provides habitat for fish and the aquatic organisms that fish eat. The removal of the debris would affect the growth of small aquatic organisms which in turn could affect the fish that feed upon them in the Snake River and also the Red River of the North. The project would be conducted in the winter and would not remove any submerged debris, thereby allowing some aquatic habitat to remain. However, the above-ice portions of partially submerged debris would be removed.

The project would also affect other wildlife such as ducks and mammals. Snagging and clearing would remove some existing and potential nesting sites. Some species of birds, such as nuthatch, chickadee, bluebird, wood duck, woodpecker, and barred owl, nest in the cavities of trees. Some of these birds are present in this area and the removal of debris and trees would affect them. Resting, nesting, and feeding areas for species such as herons, bitterns, kingfishers, wood ducks, and hooded mergansers would be affected. The project would also remove habitat for other wildlife, such as the beaver, that use the stream bottoms.

Vegetation - The proposed project would remove all debris and some live vegetation from the river channel. Specific types of vegetation exist in a floodplain because they are able to withstand periodic flooding. The future reduction in the amount of flooding can affect the productivity of the woodland. This effect could be expressed by a change in species composition, reduced growth rate, or a combination of these. The long-term effect of less frequent flooding on species composition and productivity would depend on the degree to which the flooding is reduced. Because the snagging and clearing would have a minimal effect on the flooding regime, the usual decreased productivity and altered species composition should not be significant.

Air and Water Quality - Some air and water pollution could result from the use of construction equipment. Water pollution would include oil, grease, or fuel that may spill into the channel or leak from machinery. Airborne dust would not be a problem because the work would be done during the winter from frozen ground. The removal of riparian vegetation would reduce the amount of shade in the channel and result in more variability in daily and average temperatures. The change in water temperature would probably not be significant and would have little effect on fish populations although it may affect small aquatic organisms.

Land Use - Marshall, Polk, and Pennington Counties have not adopted any State approved floodplain regulations. However, Marshall County is formulating floodplain regulations. In addition, Marshall and Polk Counties were requested by the State to formulate regulations for the 100-year floodplain of the Red River of the North. This would involve portions of the Snake River drainage system.

The snagging and clearing project is not expected to have any adverse effects on the climate, soils, topography, or geological features. The recreational and aesthetic qualities would be adversely affected, but this reach of the river apparently supports little recreation at this time. Land use would be affected only to the extent that flooding would be reduced and agricultural operations could be made more efficient.

The Minnesota Department of Natural Resources is considering the acquisition of a tract of land upstream of Alvarado for a wildlife management area. This tract of land would receive somewhat different snagging and clearing work. The lower two-thirds of the primary channel usually has few trees. Therefore, the reach of river that flows through this tract of land would be cleared of all fallen trees and debris in the channel and up to 10 feet from the top of the bank. The river would be selectively cleared of leaning trees in imminent danger of falling into the channel. The purpose of this more restrictive project is to retain as much of the existing wildlife habitat as possible. However, even the proposed minimal snagging and clearing of this portion of the river would affect fish and wildlife that use the river corridor and potential land use.

Historical and Archeological Sites - See "Archeological Considerations" on page 12.

Social Impacts

The selected plan would provide intangible, nonmonetary benefits, such as reducing the interruptions and disruptions of family life, civic activities, and business activities associated with floods. The human hardships and health hazards associated with flooding, such as water-filled basements, rotting debris, flooded septic tanks, contaminated water supplies, and the filth of the silt-laden floodwaters could also be reduced.

The project would have tangible favorable social effects by reducing average annual flood damages. Local employment would also benefit as a result of increased employment related to project construction and maintenance.

From the environmental viewpoint, some local and regional social impacts may result from the loss of aesthetic values and fish and wildlife habitat.

COORDINATION

The study was coordinated closely with local, State, and Federal interests to ensure proper evaluation of the flooding problems and the development of the best plan to meet the study objectives. The focal point of this effort was the Middle River-Snake River Watershed District which helped organize the citizens committee. Several meetings were held with the citizens committee during the study including two joint meetings with the watershed district board. At the start of the detailed project study, a public hearing was held at Alvarado. During the final stages of the study, a plan formulation public meeting was held in Warren to discuss alternatives considered and the recommended plan. In addition, meetings were held with the Minnesota Department of Natural Resources and the U.S. Fish and Wildlife Service to discuss certain controversial environmental issues.

The draft detailed project report and environmental impact statement were coordinated with all known interested agencies and groups. Some suggestions for minor changes were received; however, no serious objections have been documented. In its comments on the draft report, the Fish and Wildlife Service restated its earlier views that the project should not have a degrading effect on this riverine floodplain area or have more than a minimal adverse impact on fish and wildlife in the area.

Because of the nature of the proposed improvements, the provisions of Section 404 of the Clean Water Act (Public Law 92-217) have been determined to not apply.

Comments on the draft report and the Corps responses are contained in Appendix 3.

ENVIRONMENTAL IMPACT STATEMENT

An environmental assessment of the project and alternatives indicated that the recommended Federal action would significantly affect the quality of the human environment. Therefore, an environmental impact statement has been prepared.

SUMMARY AND CONCLUSIONS

The Snake River watershed is located in northwestern Minnesota in Marshall, Polk, and Pennington Counties. The majority of its drainage basin is in Marshall County. The project area traverses the intensively farmed, relatively flat Red River Valley. The Snake River is an intermittent stream with little or no discharge during most of the year except for flow caused by runoff from summer thunderstorms or spring snowmelt. Depending on hydrologic conditions and the areal distribution of snow or rainfall, the river can overtop its banks in a matter of hours and remain above flood stage for several days. Spring flooding from snowmelt runoff is generally more severe because snow-filled channels tend to worsen the sluggish flow conditions.

The study investigated several nonstructural and structural alternatives to reduce flood damages. The alternatives are flood warning and emergency protection, flood insurance, flood proofing, floodplain regulation, permanent floodplain evacuation, levee and floodway, channel modifications, diversion channel, upstream reservoirs, and snagging and clearing. The last alternative, along with shelterbelts along critical reaches, is the most favorable from the standpoint of economic and environmental feasibility and acceptability to local interests.

A resolution adopted by the Middle River-Snake River Watershed District board reaffirmed the watershed district's willingness to sponsor the project as presented and stated that written notification of the district's intention to meet the requirements of local cooperation should be sent to the St. Paul District, Corps of Engineers. The plan conforms to all applicable Federal and State criteria and regulations, and, accordingly, the project could be implemented in an expeditious manner.

RECOMMENDATIONS

I recommend that the snagging and clearing and shelterbelt plan be implemented as proposed with such modifications that the Chief of Engineers deems advisable, under the authority of Section 205 of the 1948 Flood Control Act as amended. The estimated cost is $647,200 for construction. Before construction can begin, local interests must enter into a written agreement in accordance with the provisions of Section 221 of Public Law 91-611 to provide assurances of local cooperation satisfactory to the Secretary of the Army that they will:

1. Provide without cost to the United States all lands, easements, rights-of-way, utility relocations and alterations, and highway or highway bridge construction and alterations necessary for project construction. The non-Federal participation in nonstructural measures shall not exceed 20 percent of the costs.

2. Hold and save the United States free from damages caused by the construction works and adjust all claims concerning water rights, but not including damages during construction, operation, and maintenance which are the fault or caused by the negligence of the United States or its contractors.

3. Maintain and operate the project after completion without cost to the United States in accordance with regulations prescribed by the Secretary of the Army.

4. Assume full responsibility for all project costs in excess of the Federal cost limit.

5. Prevent future encroachment which might interfere with proper functioning of the project for flood control.

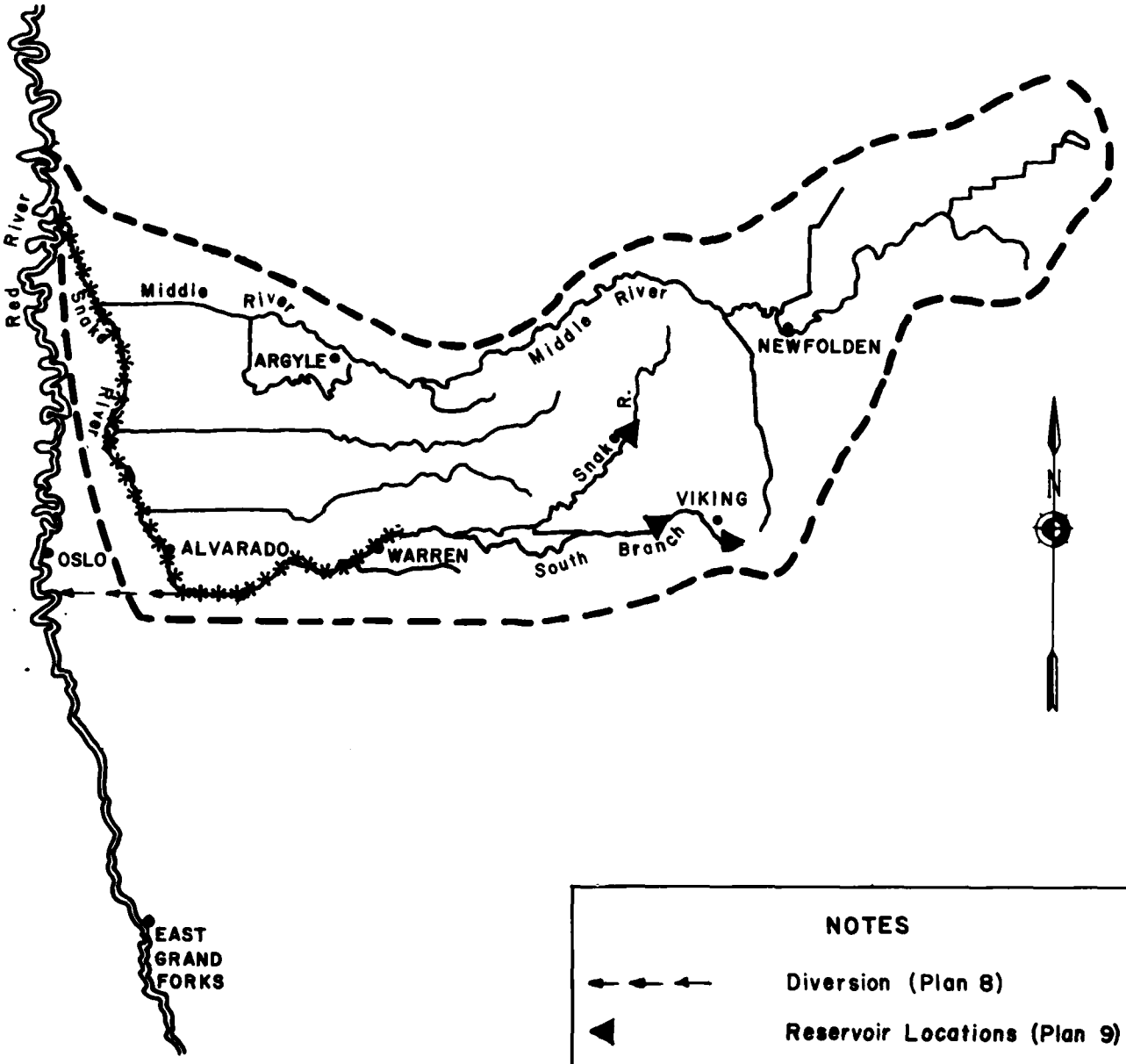
6. Provide a contribution toward construction costs where special local benefits will accrue in accordance with existing policies for regularly authorized projects.

7. Provide a cash contribution for project costs assigned to project features other than flood control.

8. Comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (Public Law 91-646) in acquiring lands, easements, and rights-of-way for the project.

9. Comply with the provisions of Title VI of the Civil Rights Act of 1964 (Public Law 33-352).

WILLIAM W. BADGER
Colonel, Corps of Engineers
District Engineer



NOTES

- Diversion (Plan 8)
- Reservoir Locations (Plan 9)
- ******** Study Limits for Plan 1-7 & 10

0 5 10 20

Scale in Miles

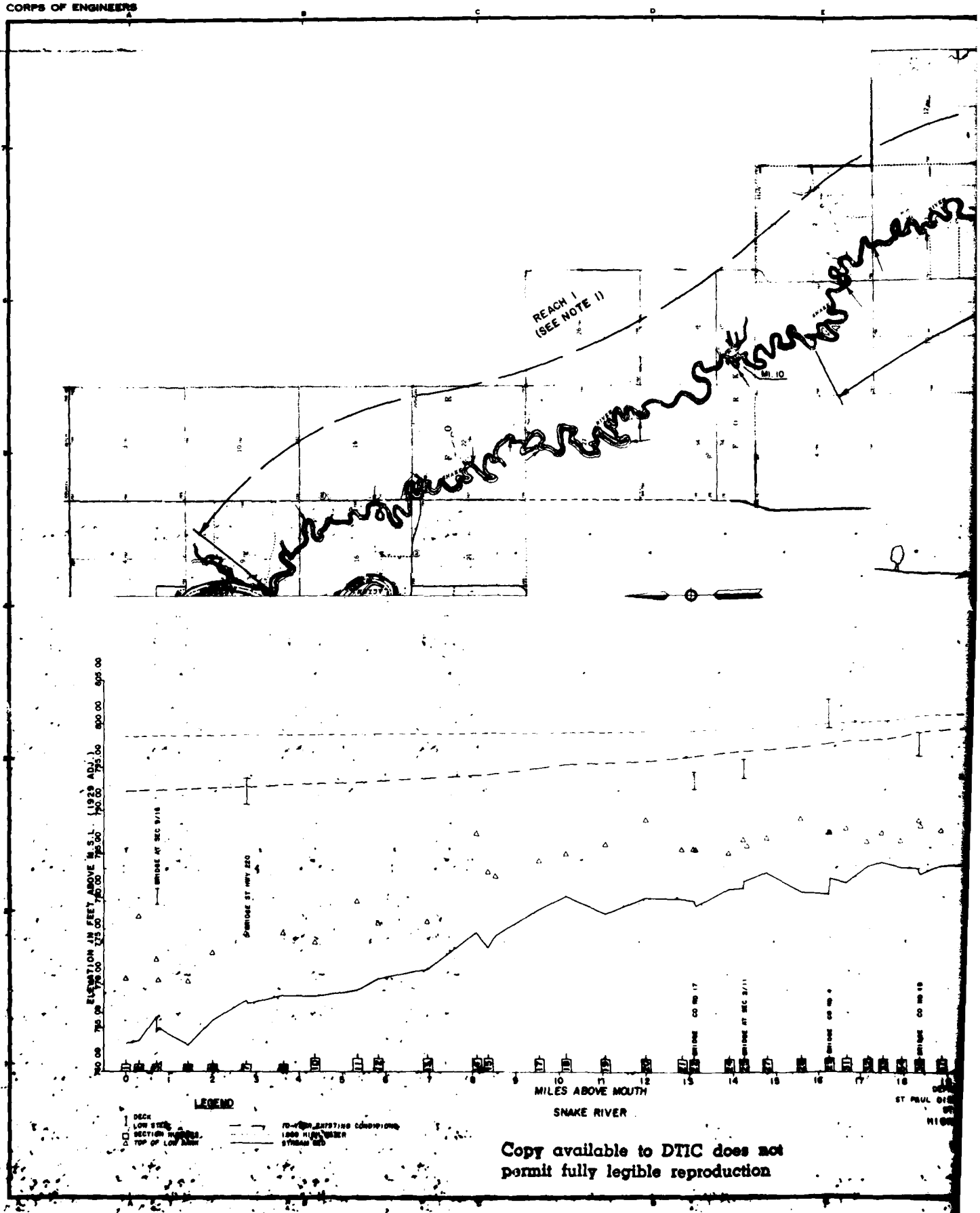
SECTION 205 - DETAILED PROJECT REPORT
FLOOD CONTROL - SNAKE RIVER
BELOW WARREN, MINNESOTA

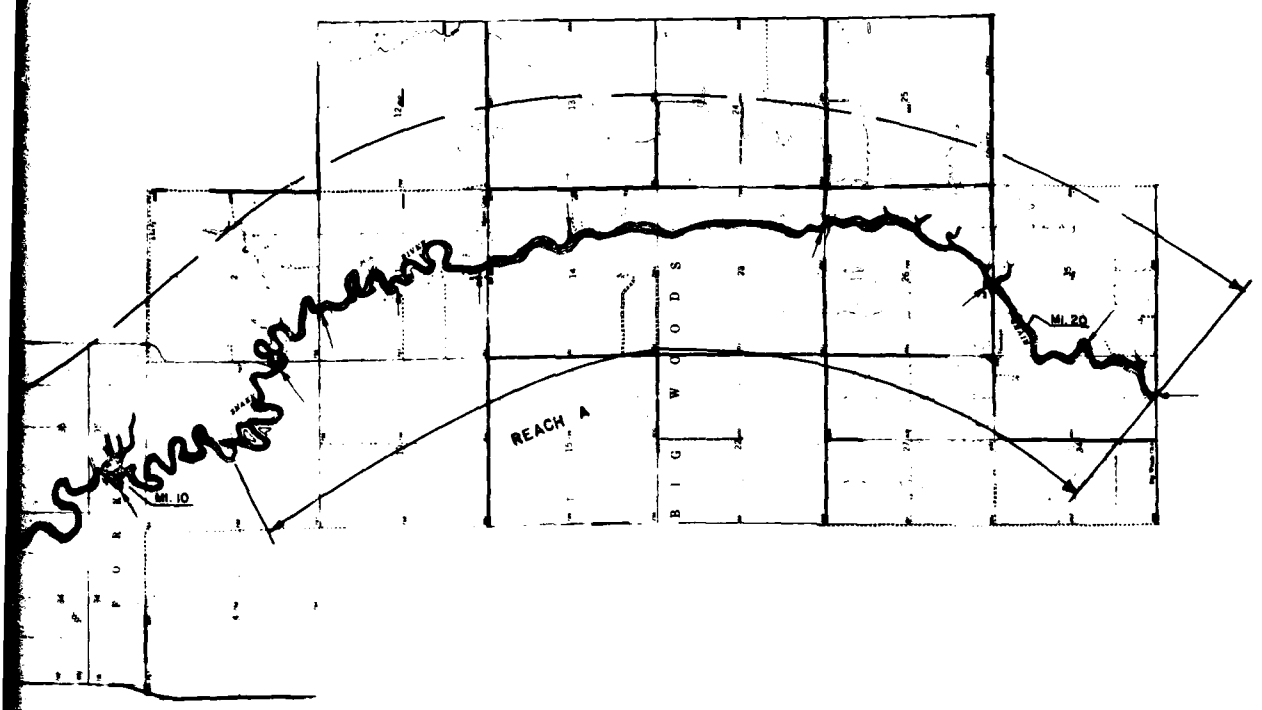
MIDDLE - SNAKE RIVERS BASIN MAP

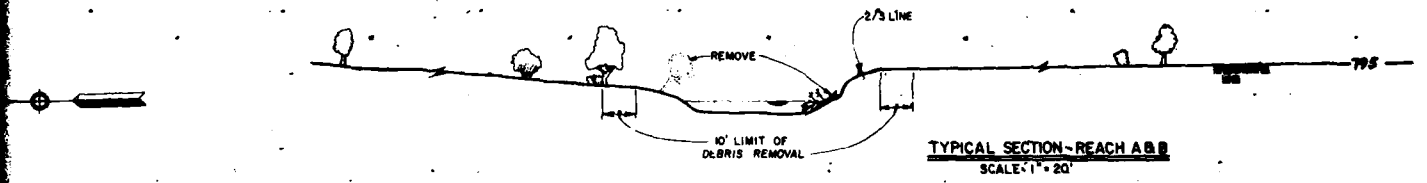
ST. PAUL, MINN. DISTRICT

PLATE 1

CORPS OF ENGINEERS







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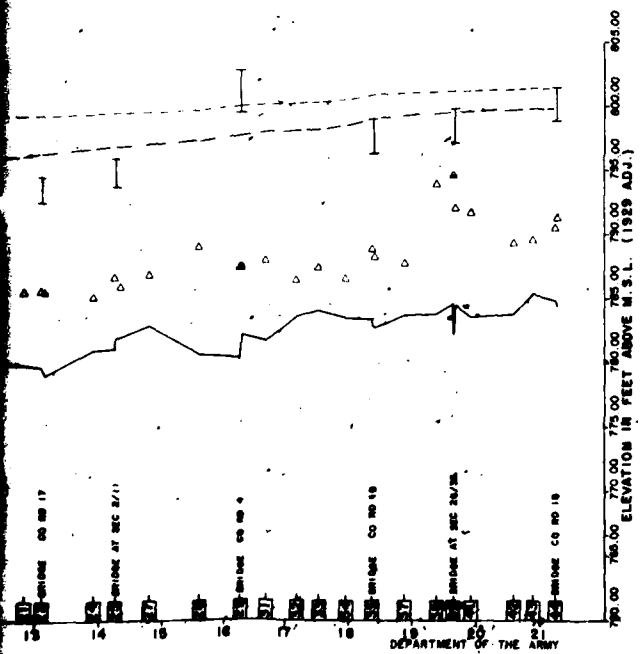


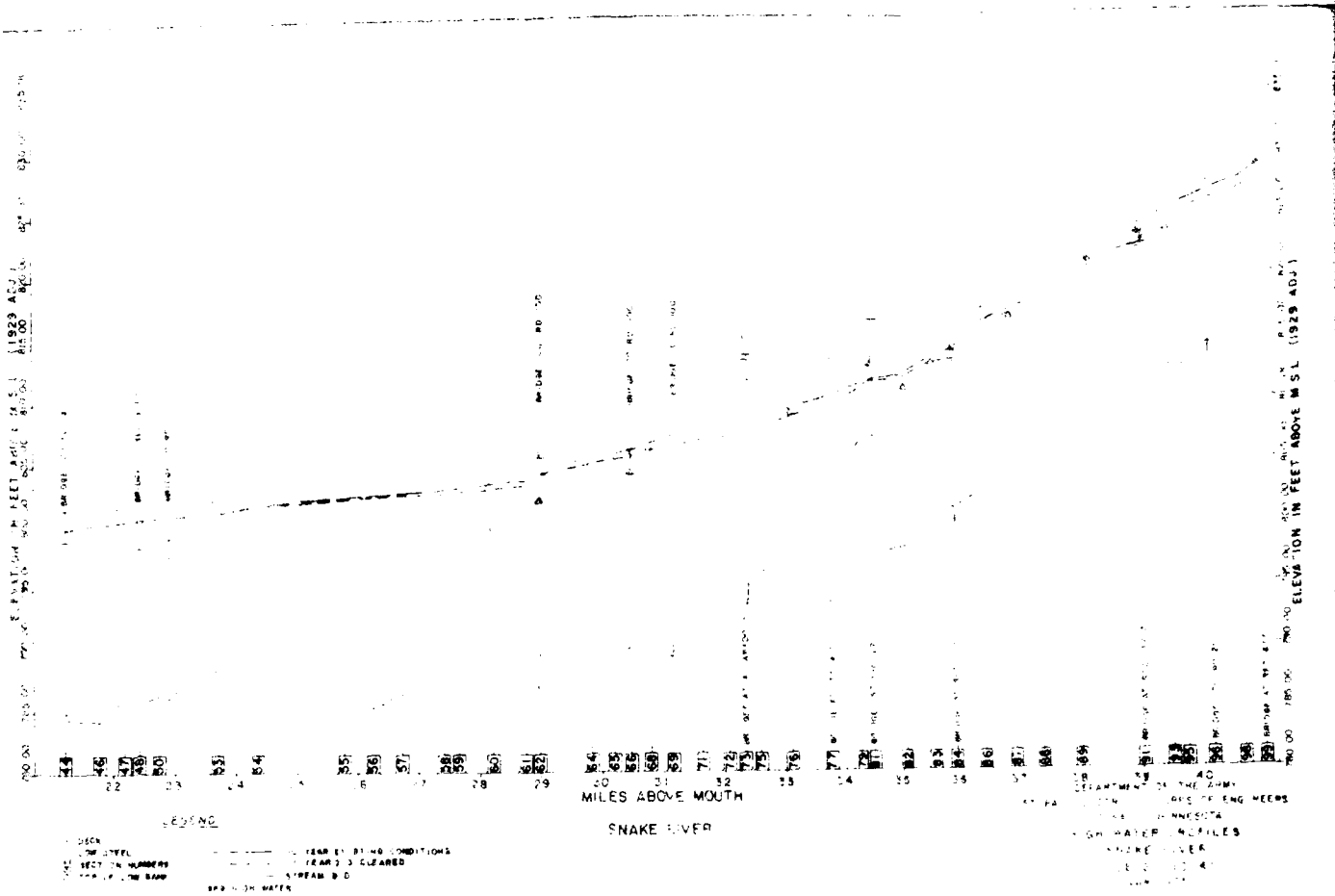
DEPARTMENT OF THE ARMY
ST PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA
HIGH WATER PROFILES
SNAKE RIVER
MILE 0 TO 21
JAN 1975

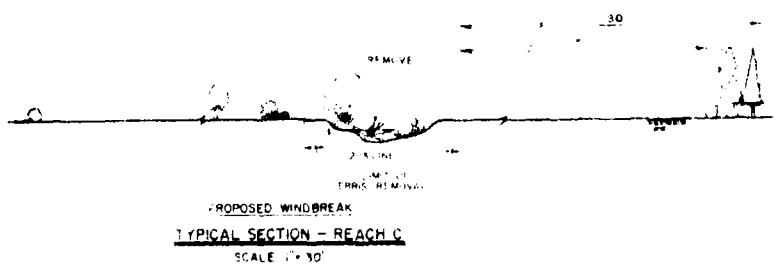
NOTES

1. REACH 1 OF SNAKE RIVER PREVIOUSLY CLEARED AND SNAGGED; PRESENT CONDITION - LIGHT CLEARING AND SNAGGING REQUIRED

SECTION 205, DETAILED PROJECT REPORT
FLOOD CONTROL - SNAKE RIVER
BELOW
WARREN, MINNESOTA
PROPOSED ALTERNATIVE
PLAN, PROFILE, & SECTIONS

IN 4 SHEETS — SHEET NO. 2
SCALE AS SHOWN
ST. PAUL DISTRICT — CORPS OF ENGINEERS
SUBMITTED: — RECOMMENDED: — APPROVED:
DRAWN BY: T.A.B. — TRACED BY:
CHECKED BY: R.A.R.
PLATE 2





PROPOSED WINDBREAK

TYPICAL SECTION – REACH C

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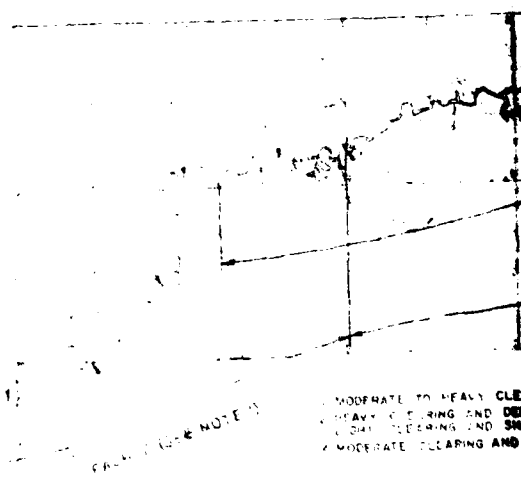

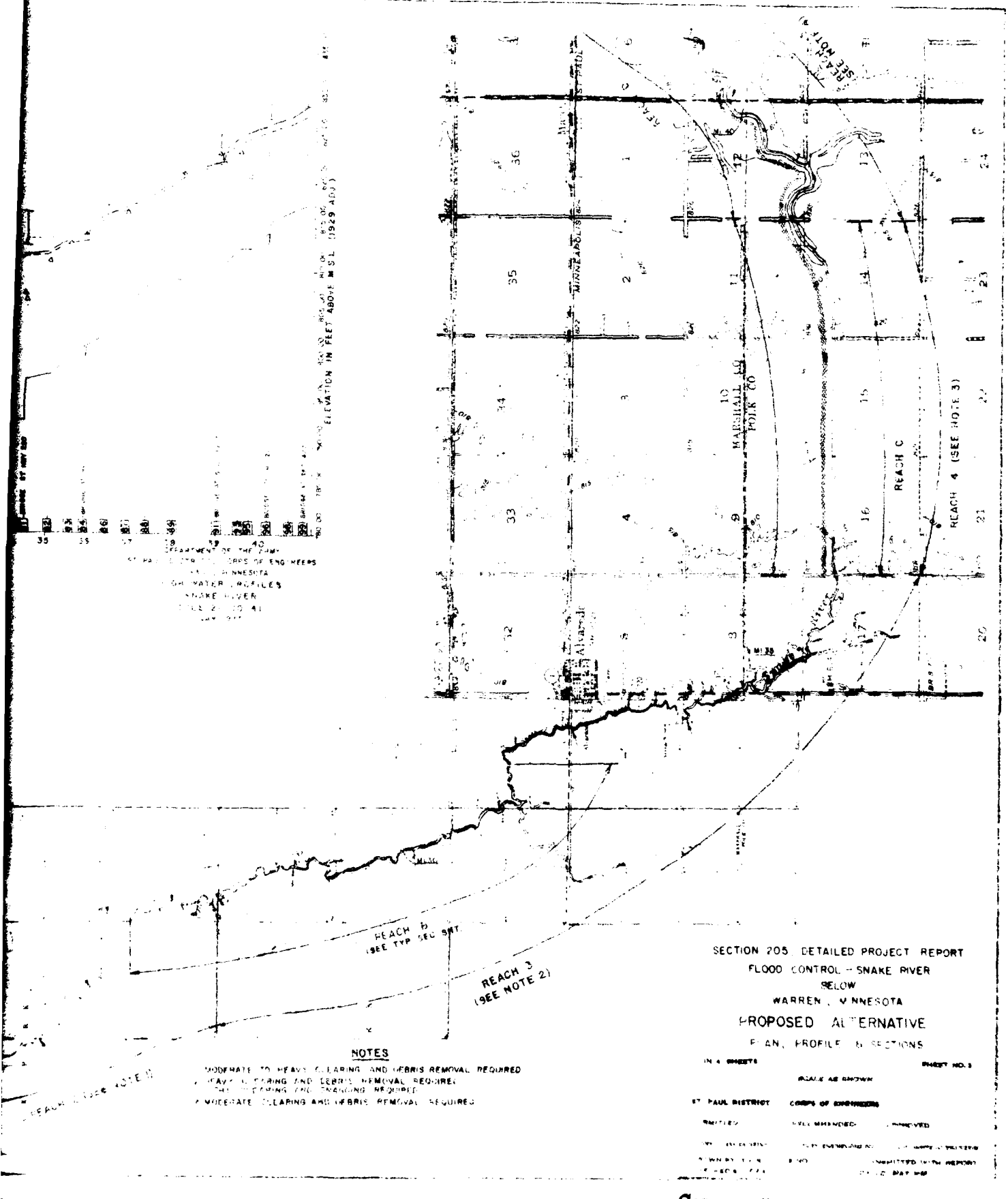

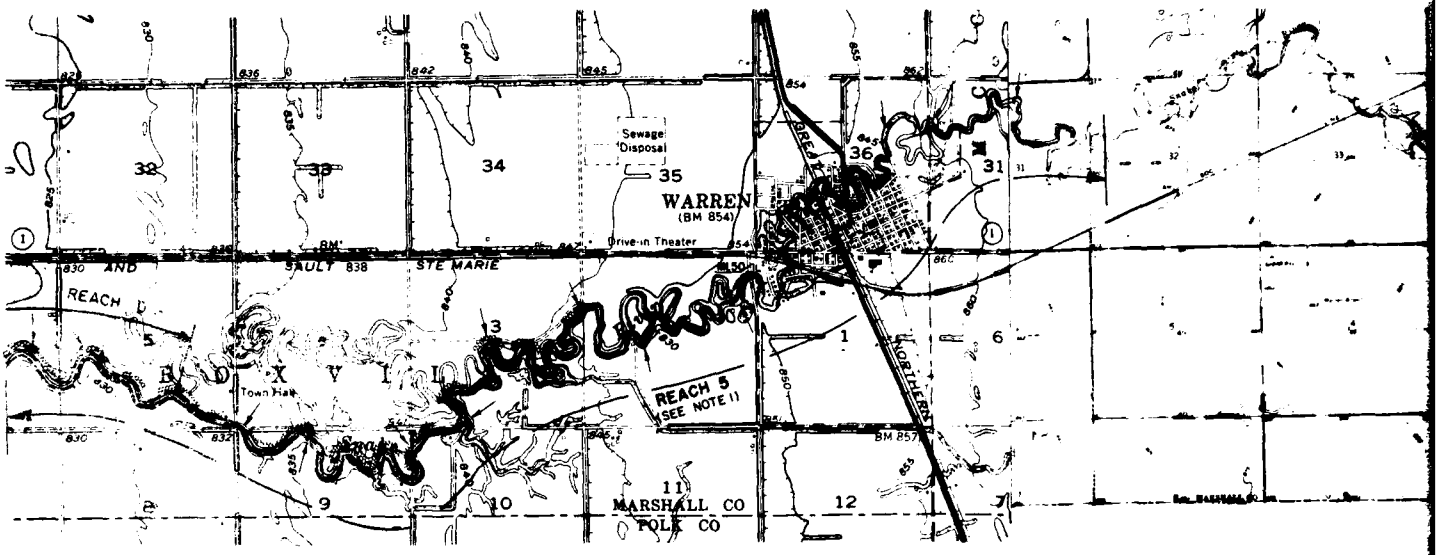

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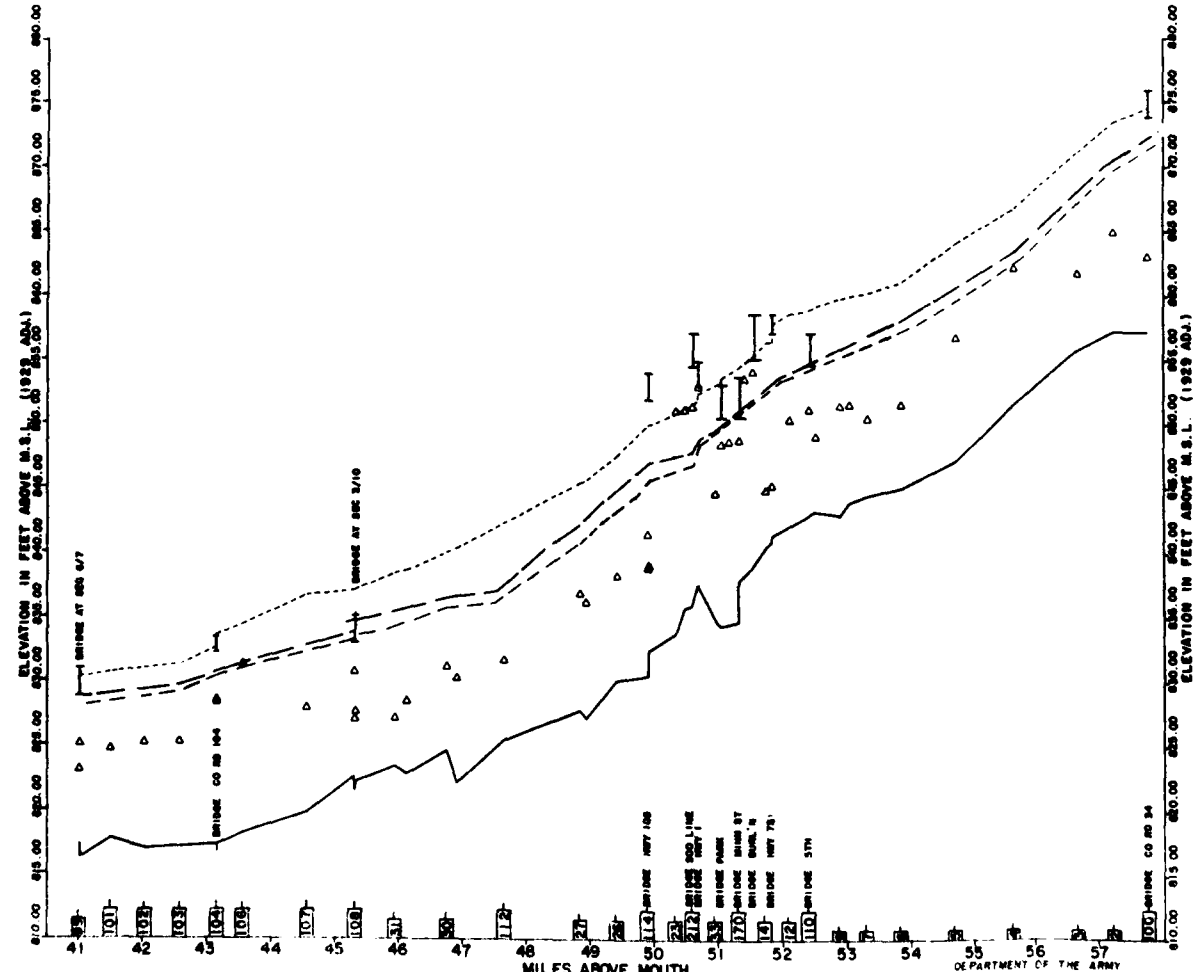
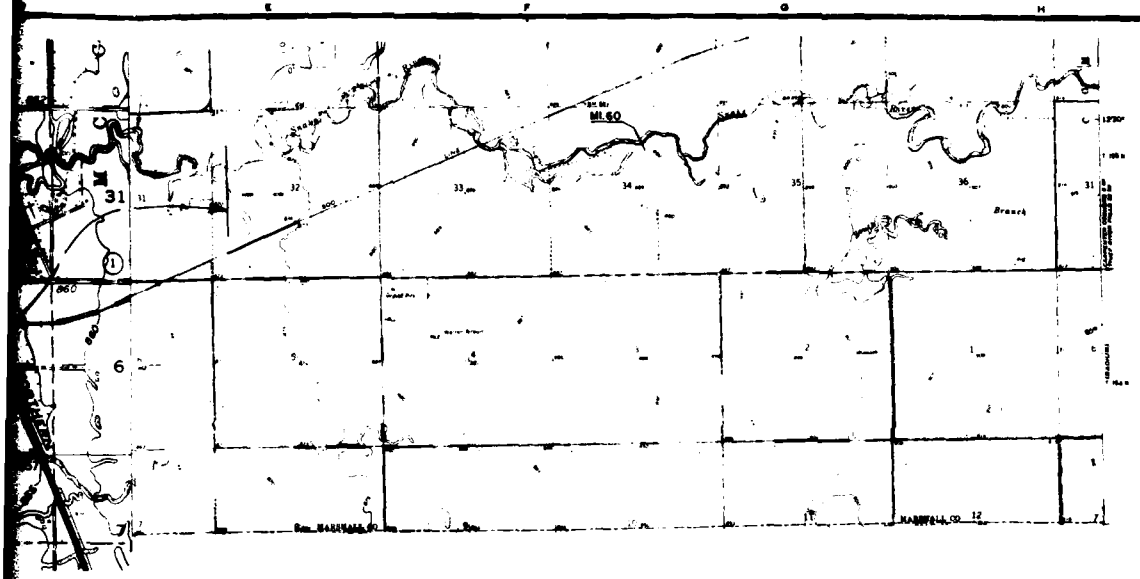
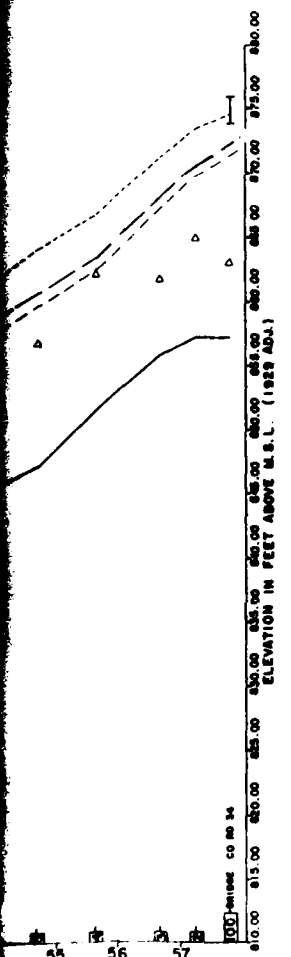


LEGEND

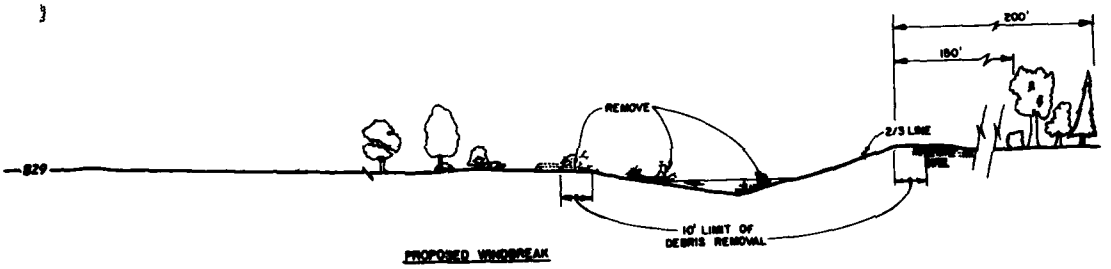
DEPARTMENT OF THE ARMY
ST PAUL DISTRICT, CORPS OF ENGINEERS
ST PAUL, MINNESOTA
HIGH WATER PROFILES
SNAKE RIVER

1. MODERATE





DEPARTMENT OF THE ARMY
PAUL DISTRICT, CORPS OF ENGINEERS
ST PAUL, MINNESOTA
HIGH WATER PROFILES
SNAKE RIVER
MILE 41.0 TO 58



PROPOSED WINDBREAK
TYPICAL SECTION REACH D
SCALE: 1" = 20'

NOTES

1. MODERATE CLEARING AND DEBRIS REMOVAL REQUIRED.

SECTION 205, DETAILED PROJECT REPORT
FLOOD CONTROL - SNAKE RIVER
BELOW
WARREN, MINNESOTA
PROPOSED ALTERNATIVE
PLAN, PROFILE, & SECTIONS

IN 4 SHEETS SHEET NO. 4
SCALE AS SHOWN

ST. PAUL DISTRICT CORPS OF ENGINEERS

SUBMITTED: RECOMMENDED: APPROVED:

DRAWN BY T.A.H. TITLE NO. TRANSMITTED WITH REPORT
CHECKED BY T.A.H. DATED: MAY 1977

PLATE 4

APPENDIX 1

ECONOMIC BACKGROUND AND IMPACTS

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TABLES

TABLES (CONT)

FIGURE

PLATES

APPENDIX 1

ECONOMIC BACKGROUND AND IMPACTS

ECONOMIC BASE STUDY

POPULATION CHARACTERISTICS

The population of Marshall County, Minnesota, was 13,100 in 1980, representing an average density of 7 persons per square mile compared to 48 persons per square mile for the State of Minnesota. The communities of Warren and Alvarado, Minnesota, constituted 16 percent and 3 percent, respectively, of the 1979 Marshall County population. Warren, with a population of 2,120, is the largest community in the county. In 1970, the Marshall County population represented about 6 percent of the OBERS, BEA 092, Grand Forks economic area. Between 1980 and 2030, the populations of Warren and Alvarado are expected to increase 7 percent. The population of Marshall County is expected to decrease 15 percent while the population of the Grand Forks economic area is expected to decrease 15 percent. The above population projections and their indexes of growth are shown in the following table.

Historic and projected populations with growth indexes

Location	Year									
	1950	1960	1970	1980	1985	1990	2000	2010	2020	2030
Warren										
Population	1,779[1]	2,007[1]	1,999[1]	2,120[1]	2,100[2]	2,120[2]	2,150[2]	2,190[2]	3,230[2]	2,270[2]
Index				1.00	0.99	1.00	1.01	1.03	1.05	1.07
Alvarado										
Population	317[1]	282[1]	302[1]	387[1]	378[2]	372[2]	374[2]	386[2]	400[2]	414[2]
Index				1.00	0.98	0.96	0.97	1.00	1.03	1.07
Marshall County										
Population	16,125[1]	14,262[1]	13,100[1]	13,100[1]	13,000[2]	12,900[3]	12,800[3]	12,800[2]	12,800[2]	12,700[2]
Index				1.00	0.98	0.99	0.97	0.97	0.97	0.96
BEA 092, Grand Forks										
Population	230,175[4]	227,200[2]	220,919[4]	205,400[4]	202,700	200,000[4]	192,400[4]	188,900[2]	185,400[4]	181,900[2]
Index				1.00	0.96	0.94	0.90	0.89	0.87	0.85

(1) Bureau of Census data.
(2) Extrapolation or interpolation.
(3) Minnesota Population Projections 1970-2000, Minnesota State Planning Agency.
(4) 1972 OBERS Series E projections.

EMPLOYMENT, EDUCATION, AND INCOME

In 1970, 3,923 persons were employed in Marshall County, a reduction of 1,890 persons since 1950. Agricultural employment declined by 2,508 persons; this decline was partially offset by gains in employment in manufacturing, services, and government. Employment declined somewhat in the economic area, but at a lesser rate than for Marshall County. Future employment in the Grand Forks economic area is expected to decrease slightly between 1970 and 2030. During this period, the participation rate (employment ÷ population) is projected to increase from 0.39 to 0.44. Thus, total employment in the economic area is expected to increase in relation to population.

The median number of school years completed in Marshall County for persons 25 years and older is 9.9, somewhat less than the State average of 12.2. About 4 percent of the persons 25 years or older in Marshall County are college graduates compared to about 11 percent for the State of Minnesota.

In 1970, per capita income in the Grand Forks economic area was $2,905 compared to an average of $3,476 for the United States. OBERS projections indicate that per capita income will increase at a faster rate in the economic area than for the United States, but will remain below the average for the United States through the year 2030. Data on employment, education, and income are shown in the following tables.

Employment by industry, Marshall County, 1950-1970

Industry	1950 Number	1950 Percent of total	1960 Number	1960 Percent of total	1970 Number	1970 Percent of total
Agriculture, forestry and fisheries	3,705	63.74	2,853	55.48	1,197	30.51
Mining	2	0.03	8	0.16	0	0
Construction	235	4.04	267	5.19	251	6.40
Manufacturing	94	1.62	149	2.90	418	10.66
Transportation, communications, and utilities	244	4.20	202	3.93	185	4.72
Wholesale and retail trade	746	12.83	738	14.35	753	19.19
Finance, insurance and real estate	54	0.93	62	1.21	62	1.58
Services	559	9.62	680	13.22	899	22.92
Government (public administration)	119	2.05	128	2.49	158	4.02
Industry not reported	54	0.93	52	1.01	0	0
Armed forces	1	0.01	3	0.06	0	0
Total	5,813	100.00	5,142	100.00	3,923	100.00

SOURCE: Minnesota Socio-Economic Characteristics, 1950, 1960, 1970.

Location	Employment projections[1]								
	1950	1960	1970	1980	1990	2000	2010	2020	2030[2]
BEA economic area 092, Grand Forks, N.Dak.	81,515	76,506	77,337	79,000	78,300	79,100	78,200	77,300	76,400
Participation rate	0.35	0.34	0.35	0.38	0.39	0.41	0.43	0.42	0.42
United States	57,474,912	66,372,649	79,306,527	96,114,000	106,388,000	117,891,000	128,018,000	130,534,000	133,050,000
Participation rate	0.38	0.37	0.39	0.43	0.43	0.45	0.45	0.44	0.44

(1) OBERS Series E, 1972.
(2) 2030 projections determined by extrapolation.

Location	Sex	Number of persons 25 years and older, 1970	Completed 4 years high school only	Completed 1-3 years college	Completed 4 years or more college	Median school years completed	Percent high school graduates or more	Percent college graduates (4 years or more)
		Educational characteristics						
Marshall County, Minnesota	Male	3,782	734	206	171	8.8	29.4	4.5
	Female	3,505	957	515	157	11.1	46.5	4.5
	Total	7,287	1,691	721	328	9.9	37.6	4.5
State of Minnesota	Male	957,251	289,130	99,688	132,120	12.1	54.4	13.8
	Female	1,033,116	389,112	138,440	88,812	12.3	60.5	8.6
	Total	1,990,367	678,242	238,128	220,932	12.2	57.0	11.1

SOURCE: Minnesota Socio-Economic Characteristics, 1970.

Projections of per capita income (1967 dollars)

Location	Year									
	1950	1960	1970	1975	1980	1990	2000	2010	2020	2030
BEA 092										
Grand Forks	$1,557	$1,926	$2,905	$3,427	$3,800	$5,100	$6,900	$ 9,300	$11,700	$15,000(1)
United States	2,065	2,488	3,476	4,120	4,700	6,100	8,100	10,650	13,200	15,750(1)
Index										
BEA 092										
Grand Forks				1.00	1.11	1.49	2.01	2.71	3.41	4.38
United States				1.00	1.14	1.48	2.00	2.58	3.20	3.82

Source: OBERS Projections Series E, Vol. 2, 1972
(1) Extrapolated.

DEVELOPMENT AND ECONOMY

In 1878, the railroad reached Warren, and settlers came into the area to farm the rich fertile lands of the former Lake Agassiz floodplain. Marshall County was organized in 1879, and the county seat was located at Warren in 1881. Warren and Alvarado are trading centers for the surrounding agricultural area.

The Snake River, with a total drainage area at Warren of 260 square miles, is a tributary of the Red River of the North. The Snake River starts northeast of Warren and flows in a horseshoe-shaped fashion toward the south, west through Warren, and finally enters the Red River northwest of Alvarado. The river has an average gradient of about 3 feet per mile in the study area and, like most tributaries in the Red River Valley, has an extremely broad floodplain. Seventy-five percent of Warren was flooded in 1969; almost the entire town would be flooded by the intermediate regional flood.

EXISTING AND FUTURE LAND USE

Residential properties represent about 43 percent of the area in Warren; commercial use represents about 15 percent of the total area. Warren is located on both banks of the Snake River. Vacant land in the city and agricultural land outside the city limits are available for expansion. However, because the 100-year floodplain is so broad, most new development must be flood proofed in accordance with the provisions of Public Law 93-234 (Flood Disaster Protection Act of 1973) and State of Minnesota zoning regulations. Data on existing land use are shown in the following table.

Existing land use - Warren

Category	Acres	Percent of total
Residential	185	43.0
Commercial	65	15.1
Public	10	2.3
Streets and railroad	80	18.6
Woods	40	9.3
Vacant	35	8.2
Water	15	3.5
Total	430	100.0

TRANSPORTATION

Warren is served by U.S. Highway 75, a north-south highway, and Minnesota 1, an east-west highway. The Burlington Northern and Soo Line Railroads also serve the city. Alvarado is served by Minnesota Highways 1 and 220 and the Soo Line Railroad. A commercial airport is located at Grand Forks, North Dakota, about 30 miles from Warren.

COMMUNITY DAMAGES AND BENEFITS

DESCRIPTION OF DAMAGE AREA

The damage area includes the nonurban communities of Warren and Alvarado. Floods occur on the Snake River in the spring following snowmelt and in the summer following intense storms.

The first sign of flooding in Warren is sewer backup. Then overbank water flows through the city causing some flooding and rejoins the main stem below the city. Alvarado suffers damage mainly during large floods. Damages at Warren and Alvarado are estimated to begin at discharges of about 1,400 and 3,000 cfs (cubic feet per second), respectively.

FLOOD DAMAGE SURVEYS

Flood damage surveys were conducted at Warren for actual damages sustained in 1950 and 1969. These surveys were updated to October 1980 price levels. Theoretical 1969 damages at Alvarado were obtained by field survey; theoretical 1966 damages were derived from the 1969 survey. The community flood damages for various floods are shown in the following table. The elevation-damage curve is compared to the discharges and frequencies to give the frequency-damage curves shown on plates 1-1 and 1-2.

Community flood damages (October 1980 prices)

Location	Flood	Flood elevation at reference point	Reference point	Community flood damages					
				Residential	Commercial	Public	Lost wages and profits	Emergency costs	Total
Warren	1950	853.4	Minnesota	$485,400	$67,700	$49,000	0	$15,000	$617,100
	1969	854.3	Street	467,300	227,700	6,300	$167,000	14,800	883,000
	500-year	857.1	Bridge	-	-	-	-	-	2,023,500
Alvarado	1969	810.3	100 feet up-	1,000,600	114,800	310,100	0	0	1,425,500
	1966	810.8	stream of	1,141,300	382,400	369,800	0	0	1,893,500
	500-year	811.5	railroad bridge	-	-	-	-	-	2,150,000

FLOOD DAMAGE CLASSIFICATION

Present flood damage figures include monetary losses only. Monetary losses include inundation damage to residential, commercial, and public structures and contents; damage to transportation facilities; flood fighting costs; postflood cleanup costs; business losses; lost wages; and increased expenses for normal operating and living during a flood. Losses not quantified in dollar terms include threat of injury or loss of life, human misery during a flood, disruption of normal community activities, and potential health hazards from contaminated water supplies.

FLOOD DAMAGE EVALUATION

Residential Structures and Contents

The market value of existing residential structures and contents in the floodplain is shown in the following tables. About 335 residential structures at Warren and about 89 residential structures in Alvarado are located in the floodplain. The total value of residential structures in the floodplain in Warren and Alvarado is about $5.0 million and $2.7 million, respectively.

The value of the contents is expected to increase as the affluence factor increases. Contents are now valued at 25 percent of the structures' value. By regulation, the value of contents can increase to 75 percent of the structures' value (a factor of 3; $\frac{75 \text{ percent}}{25 \text{ percent}} = 3$).

Value of structures and contents

City	Number of structures	Value of structures	Value of contents	75 percent of structure value
Warren	335	$5,000,000	$1,250,000	$3,750,000
Alvarado	89	2,700,000	675,000	2,025,000

The value of contents is expected to increase as the income of the Grand Forks BEA area increases. The per capita income for the area was $3,700 in 1980. It is projected to increase to $15,000 by 2030 (from OBERS Series E projections). The factor of increase in income would be 4.054 in 50 years or a yearly compound growth rate of 2 13/16 percent.

Because value of contents can only increase from 25 to 75 percent of the value of the structure, the growth rate will remain steady after it reaches a factor of 3. The value of contents will increase to the maximum value in 40 years at a growth rate of 2 13/16 percent (see the following table).

Year	Growth rate from 1980 to 2030 Interval (years)	Amount of 1
1980	0	1.00
1990	10	1.32
2000	20	1.74
2010	30	2.30
2020	40	3.00
2030	50	3.00

The average market value per residential structure is about $14,000 for Warren and $28,000 for Alvarado. The average value of contents is about $3,500 and $7,000, respectively. Without the project, no new nonflood-proofed residential structures are expected in the floodplain because of the zoning requirements of Public Law 93-234 (Flood Disaster Protection Act of 1973) and State of Minnesota zoning regulations. No significant changes in land use are anticipated with the project. The projected rate of increase in the value of flood-susceptible household contents was used to increase the future unit flood damage to household contents.

Commercial Damages

Commercial damages are assumed to remain constant over the life of the project because new structures and improvements to existing structures in the floodplain are expected to be flood proofed.

Public Damages

Future public damages are unrelated to changes in income; i.e., more affluence. Instead, growth in public damages is considered to be a function of physical improvements in city plant facilities and public use by a larger population. Public damages were increased by the projected population growth rate for Warren and Alvarado.

The estimated numbers of all types of floodplain structures are shown in the following table.

Estimated number of structures in floodplain

Property type	Existing	Year 1980	1990	2000	2010	2020	2030	2080
Warren								
Residential	335	335	335	335	335	335	335	335
Commercial	73	73	73	73	73	73	73	73
Industrial	0	0	0	0	0	0	0	0
Public	1	1	1	1	1	1	1	1
Semipublic	0	0	0	0	0	0	0	0
Alvarado								
Residential	89	89	89	89	89	89	89	89
Commercial	9	9	9	9	9	9	9	9
Industrial	0	0	0	0	0	0	0	0
Public	1	1	1	1	1	1	1	1
Semipublic	2	2	2	2	2	2	2	2

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DETAILED PROJECT REPORT FOR FLOOD CONTROL, SNAKE RIVER BELOW WA--ETC(U)
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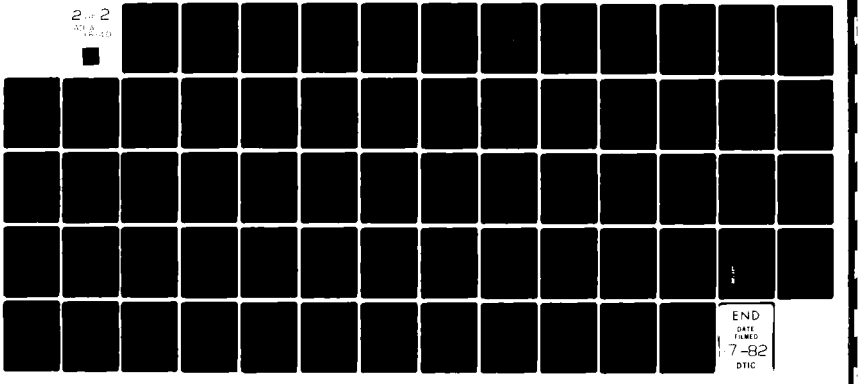

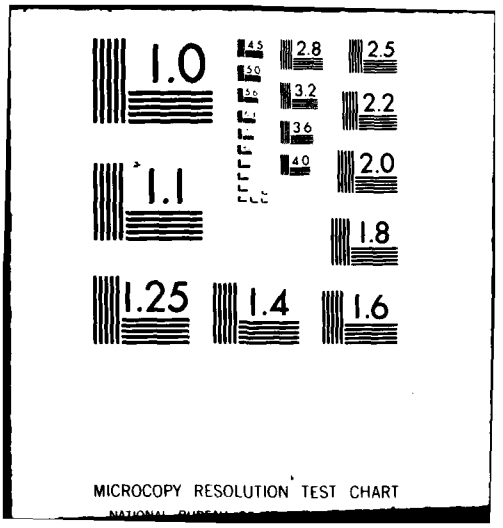
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MICROCOPY RESOLUTION TEST CHART

Summary of Community Flood Damages

Average annual existing residential unit damages for the two communities are shown in the following table. The number of structures in the floodplain for existing and future conditions is expected to be the same. Average annual structural and content unit damages for Warren are estimated to be $66 and $44, respectively. In Alvarado, the corresponding values are $116 and $76, respectively. Since no new residential structures are expected to be constructed without the project, no future increase in residential unit damages is contemplated without application of the affluence factor.

Average annual residential unit damages

Location	Category	Average annual damages	Estimated number of structures in floodplain	Average annual damages per unit
Warren	Residential structure	$22,100	335	$66
	Contents	14,800	335	44
	Total	36,900		110
Alvarado	Residential structure	10,300	89	116
	Contents	6,800	89	76
	Total	17,100		192

In the following table, the affluence factor is applied to unit average annual residential contents for each reach. Structural damages are assumed to remain constant over the life of the project.

Residential flood damages per unit with adjustment for the affluence factor

Location	Residential property type	Year 1980	1990	2000	2010	2020	2030
Warren	Structure	$66	$66	$66	$66	$66	$66
	Contents	44	58	77	101	132	132
	Total	110	124	143	167	198	198
Alvarado	Structure	116	116	116	116	116	116
	Contents	76	100	132	175	228	228
	Total	192	216	248	291	344	344
Content value increase		1.00	1.32	1.74	2.30	3.00	3.00
Total increase		1.00	1.13	1.30	1.52	1.79	1.79

Future flood damages include the effects of the affluence factor on residential contents and population growth applied to public damages. Average annual damages for Warren and Alvarado over the life of the project are estimated to be $79,400 and $28,200, respectively (see the following table).

Existing and future average annual urban flood damages including effects of the affluence factor

Typical flood losses by property type	Projected total future flood damages						Increase 1980-2030	Average annual equivalent increase[1]	Total average annual damages
	1980	1990	2000	2010	2020	2030			
Warren									
Residential	$36,900	$41,700	$48,000	$56,100	$66,100	$66,100	$29,200	$8,300[2]	$45,200
Commercial	18,500	18,500	18,500	18,500	18,500	18,500			18,500
Public[3]	800	800	700	900	900	900	100	0[2]	800
Business	6,400	6,400	6,400	6,400	6,400	6,400			6,400
Emergency costs	8,500	8,500	8,500	8,500	8,500	8,500			8,500
Total damages	71,100	75,900	82,100	90,400	100,400	100,400		8,300	79,400
Composite index	1.00	1.07	1.15	1.27	1.41	1.41			
Alvarado									
Residential	17,100	19,300	22,200	26,000	30,600	30,600	13,500	3,800[2]	20,900
Commercial	1,900	1,900	1,900	1,900	1,900	1,900			1,900
Public[3]	5,400	5,400	5,400	5,400	5,400	5,400			5,400
Total damages	24,400	26,600	29,500	33,300	37,900	37,900		3,800	28,200
Composite index	1.00	1.09	1.21	1.36	1.55	1.55			
Total average annual damages	95,500	102,500	111,600	123,700	138,300	138,300		12,100	107,600

(1) Rounded to the nearest 100.
(2) Average annual equivalent compound interest factor for 40 years of 50-year economic life at 7 3/8 percent = 0.285.
(3) Population indexes were used to project public flood losses.

COMMUNITY FLOOD CONTROL BENEFITS

A composite index was derived from the projections of total flood damages. The composite included the effects of the affluence factor on residential contents and the effects of population growth on public damages. Commercial damages were held constant over the life of the project. Total average annual flood control benefits are evaluated to be $15,500 for Warren and $9,800 for Alvarado at 7 3/8 percent over the life of the project. Residual average annual damages are estimated to be $63,900 for Warren and $18,400 for Alvarado as shown in the following table.

Existing and future average annual flood control benefits and residual damages

Location	1980	1990	2000	2010	2020	2030	Increase 1980-2030	Average annual equivalent of increase[1]	Total average annual benefits
Warren									
Benefits	$13,900	$14,800	$16,000	$17,700	$19,600	$19,600	$5,700	$1,600[2]	$15,500
Index	1.00	1.06	1.15	1.27	1.41	1.41			
Residual damages	57,200	61,100	66,200	72,700	80,800	80,800	23,600	6,700[2]	63,900
Alvarado									
Benefits	8,500	9,300	10,300	11,600	13,200	13,200	4,700	1,300[2]	9,800
Index	1.00	1.09	1.21	1.36	1.55	1.55			
Residual damages	15,900	17,300	19,200	21,700	24,700	24,700	8,800	2,500[2]	18,400
Total urban benefits	22,400	24,100	26,300	29,300	32,800	32,800	10,400	2,900	25,300

(1) Rounded to the nearest 100.
(2) Average annual equivalent compound interest factor for 40 years of a 50-year economic life at 7 3/8-percent interest = 0.285.

AGRICULTURAL AND OTHER AGRICULTURAL DAMAGES AND BENEFITS

AGRICULTURAL FLOOD DAMAGES

General

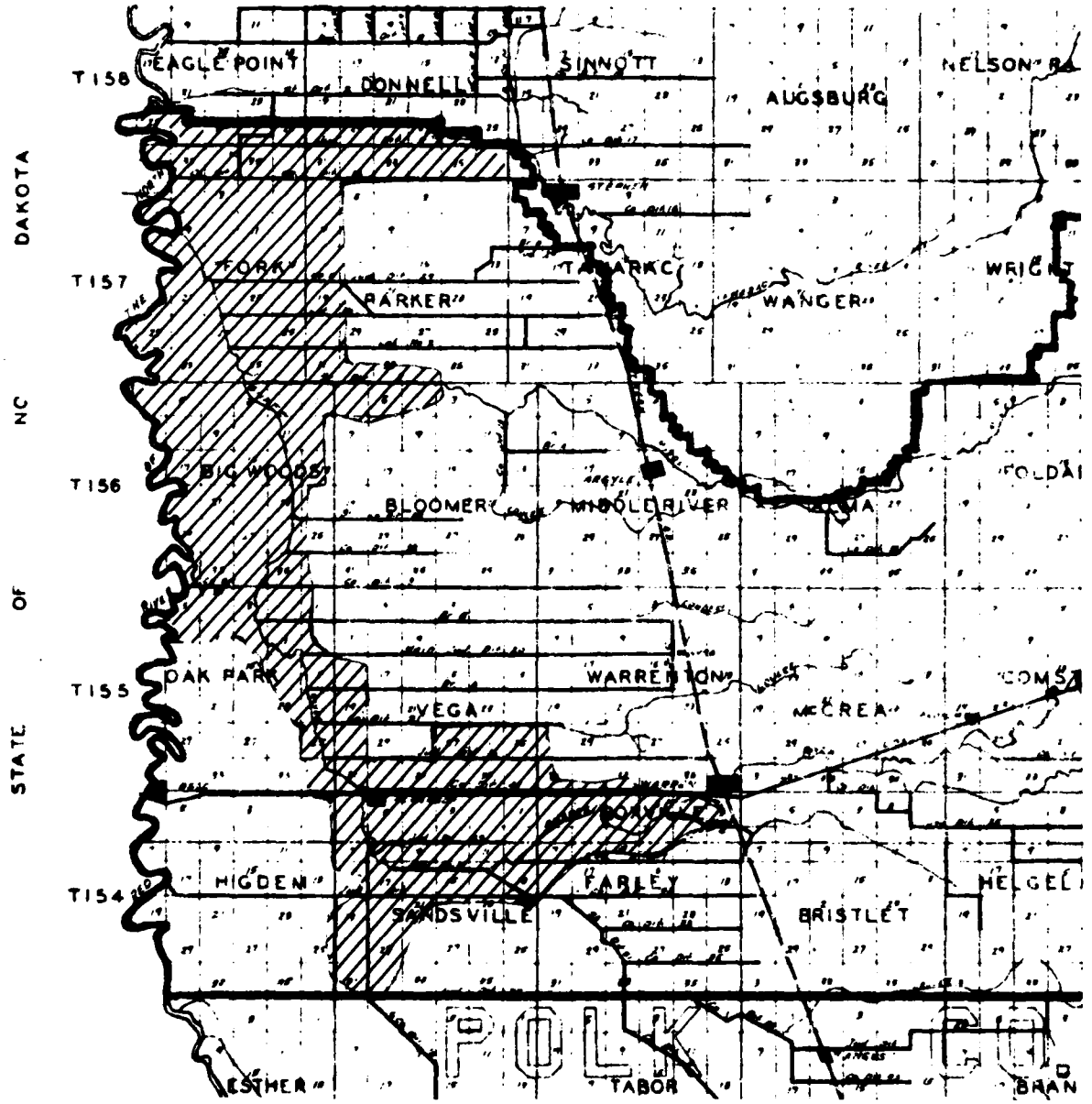
Crop losses caused by flooding have been evaluated by analyzing net losses sustained by farmers in their crop raising programs. All major crops grown were considered to determine the total potential loss from floods occurring at any time during the growing season. The evaluation takes into account the reduction in yield caused by late planting following a spring flood, replanting costs when reseeding would be possible, a partial or complete loss of crop occasioned by a flood during the growing or harvesting periods, and net increases or decreases in farm operating costs incurred as a result of flooding. The 1969 agricultural area flooded is shown on page 1-20.

Damage Area and Property Affected

The principal area subject to flooding lies between Warren and the mouth of the Snake River. Flooding occurs in both spring and summer and as a result of overflow from the main channel, overflow from the adjacent Middle River, and high stages on the Red River of the North.

Floods from the meandering Snake River adversely affect agriculture, physically damaging crops, livestock, fences, buildings, and lands (through erosion and sedimentation). Rural roads and bridges are damaged through loss of surface material at road grades, washouts at bridge and culvert approaches, and bridge structural damage attributable to ice and scour.

For this analysis, the Snake River floodplain areas have been divided into two agricultural reaches: Reach 1 - Alvarado to mouth of the Snake River, Reach 2 - Warren to Alvarado. Damages begin at discharges of about 800 and 600 cfs, respectively. The average annual area flooded in these two reaches is shown on plates I-3 and I-4.



////// FLOODED AREA

SECTION 205 - DETAILED PROJECT REPORT
FLOOD CONTROL - SNAKE RIVER
BELOW WARREN, MINNESOTA

AREA FLOODED IN 1969

ST. PAUL, MINN. DISTRICT
FILE No.

Discharge-Area Inundated Relationships

Flooded overbank areas were computed for existing and modified two-thirds bank snagging and clearing conditions for both agricultural reaches. The 5-, 10-, and 25-year flood frequencies were considered. These relations and an evaluation of channel capacities for the two reaches served as a basis for developing discharge-area flooded curves. Frequency-area flooded curves for each of the reaches were obtained by relating the frequency-discharge relations to discharge-area flooded curves. The discharge-area flooded curves are relationships developed from the 1969 area flooded.

		Agricultural area flooded	
Reach	Flood frequency (year)	Existing conditions (acres)	Snagging and clearing two-thirds bank (acres)
1	5	8,200	5,700
	10	11,100	8,800
	25	13,400	12,000
2	5	3,500	2,000
	10	5,000	4,200
	25	6,500	6,000

Land Use

The basic land use pattern for the watershed was obtained from records of the Agricultural Stabilization and Conservation Service. Yields per acre, land use percentages, and current Minnesota normalized crop prices used to determine flood damages are shown in the following table.

Weighted income per acre

Crop	Land use in percent Reach 1	Land use in percent Reach 2	Weighted crop yield per acre Reach 1	Weighted crop yield per acre Reach 2	Minnesota normalized prices	Weighted average income per acre of flooded area Reach 1	Weighted average income per acre of flooded area Reach 2
Wheat	43	45	50 bu	45 bu	$3.16	$67.94	$63.99
Barley	22	23	60 bu	60 bu	1.97	26.00	27.19
Sunflowers	6	5	15 cwt	15 cwt	10.51	9.46	7.88
Sugar beets	7	8	15 ton	15 ton	22.86	24.00	27.43
Dry beans	2	0	16 cwt	16 cwt	17.05	5.46	0
Potatoes	2	1	190 cwt	190 cwt	2.84	10.79	5.40
Other	18	18				2.17	3.13
Total	100	100				145.82	135.02

Crop Yields

Crop yield data were obtained from farmers in the adjoining Middle River basin and from the Marshall County Agricultural Stabilization and Conservation Service.

Crop Prices

Unit crop prices reflect estimated Minnesota normalized prices based on current normalized United States prices. Agricultural normalized prices are provided each year by the Water Resources Council for use in agricultural water resource projects.

Weighted Crop Income

The weighted average income per acre is determined by multiplying the percentage of land use by the yield per acre and the price per unit. The total weighted income per acre for the nine major crops shown in the Snake River floodplain is $145.82 for reach 1 and $135.02 for reach 2.

Crop Production Costs

Crop production costs consist of fixed and variable costs. Fixed production costs consist of taxes, interest, amortization costs, and overhead costs and are not appreciably affected by flooding because these costs accrue regardless of whether a farmer raises and harvests a crop. Variable production costs, which include seed, soil preparation, planting, weed control, cultivation, harvesting, and transporting to market, are affected by floods and are included in the analysis. Variable semi-monthly production costs are shown in the following table.

Seasonal variable crop production costs - October 1980 prices (per acre)

Seasonal period	Wheat	Barley	Sun-flowers	Sugar beets	Potatoes	Dry beans
To 31 Mar	$16.94	$3.44	-	-	$5.57	$16.68
1-15 Apr	-	-	$12.30	$3.92	11.00	-
16-30 Apr	1.27	1.97	17.47	11.16	79.80	-
1-15 May	7.66	7.90	7.17	20.07	92.94	13.60
16-31 May	11.93	17.52	7.01	26.02	22.38	18.80
1-15 June	8.11	15.54	1.36	22.21	5.12	12.54
16-30 June	3.44	3.44	5.97	17.27	9.33	-
1-15 July	-	-	5.04	17.30	41.55	-
16-31 July	-	0.27	4.81	3.68	2.78	-
1-15 Aug	-	1.53	0.65	3.68	10.94	-
16-31 Aug	1.95	2.09	0.65	1.18	23.44	-
1-15 Sept	3.64	3.36	5.48	2.70	52.18	2.51
16-30 Sept	1.69	1.68	6.53	7.75	34.12	5.65
1-15 Oct	1.69	-	2.39	7.75	-	1.10
Total	58.32	58.74	76.83	144.69	391.15	70.88

Crop Flood Damage Analysis

Floods on the Snake River occur in the spring following snowmelt and from rainfall in the summer. Following an early spring flood, a farmer would rework the land and replant the same or a substitute crop in an

effort to minimize his loss. Some additional variable costs would be incurred for a second planting and yields could be expected to be reduced because of the shortened growing season. Also, income from substitute crops is usually less than from the original crop. The total crop damages per acre amount to the expected net income without a flood minus the actual net income with a flood. Excluding fixed costs, the expected net income without a flood is simply the difference between the expected gross crop revenue and the expected total variable production costs. The actual net income, exclusive of fixed costs, with an early spring flood is the gross revenue realized from a replanted crop minus the sum of variable production investment for the original crop to the date of the flood occurrence. For a flood occurring too late in the year to permit replanting, the damages can be represented as the reduction of gross crop income caused by the flooding minus the difference between the forgone remaining production cost without the flood and the remaining production cost with a flood. Production investments to 1 June each year are based on about 25 percent of the accumulated variable costs. After replanting time, only cultivation, harvesting, and transportation costs remain. After 1 June, a flood mainly reduces income with small expected net savings in forgone versus actual variable costs. Loss of crop income for both reaches is shown in the following tables.

Loss of gross crop income - Alvarado to mouth of Snake River (reach 1)

Crop	Weighted income per acre, 1979 normalized prices	16-31 Mar	1-15 Apr	16-30 Apr	1-15 May	16-31 May	1-15 June	16-30 June	1-15 July	16-31 July	1-15 Aug	16-31 Aug	1-15 Sept	16-30 Sept	1-15 Oct	16-31 Oct
Barley	$26.00	5% $1.30	20% $5.20	35% $9.10	46% $11.96	53% $13.78	65% $16.90	80% $20.80	67% $17.42	56% $14.56	43% $11.18	30% $7.80	0	0	0	0
Wheat	67.94	7% $4.76	33% $22.42	45% $30.57	47% $31.93	50% $33.97	67% $45.52	80% $54.35	71% $48.24	64% $43.48	52% $35.33	42% $28.53	32% $21.74	22% $14.95	0	0
Oats	0.91	5% $0.05	25% $0.23	40% $0.36	48% $0.44	53% $0.48	64% $0.58	75% $0.68	66% $0.60	56% $0.51	47% $0.43	40% $0.36	0	0	0	0
Flax	0.42	3% $0.01	19% $0.08	32% $0.13	46% $0.19	55% $0.23	65% $0.27	75% $0.32	67% $0.28	57% $0.24	47% $0.20	40% $0.17	0	0	0	0
Sugar beets	24.00	3% $0.72	9% $2.16	15% $3.60	25% $6.00	40% $9.60	60% $14.40	80% $19.20	77% $18.48	75% $18.00	73% $17.52	68% $16.32	54% $12.96	30% $7.20	0	0
Sunflowers	9.46	3% $0.28	19% $1.80	32% $3.03	46% $4.35	55% $5.20	65% $6.15	75% $7.10	67% $6.34	57% $5.39	47% $4.45	40% $3.78	0	0	0	0
Dry beans	5.46	3% $0.16	6% $0.33	16% $0.87	26% $1.42	46% $2.51	66% $3.60	75% $4.10	53% $2.89	53% $2.89	53% $2.89	42% $2.29	32% $1.75	0	0	0
Soybeans	0.84	3% $0.03	6% $0.05	16% $0.13	26% $0.22	46% $0.39	66% $0.55	75% $0.63	53% $0.45	53% $0.45	53% $0.45	42% $0.35	32% $0.27	0	0	0
Potatoes	10.79	7% $0.76	8% $0.86	10% $1.08	20% $2.16	30% $3.24	75% $8.09	77% $8.31	77% $8.31	75% $8.09	73% $7.88	68% $7.34	54% $5.83	50% $5.40	40% $4.32	24% $2.59
Total income loss per acre	145.82	8.07	33.13	48.87	58.67	69.40	96.06	115.49	103.01	93.61	80.33	66.94	42.55	27.55	4.32	2.59

(1) ...reduction losses from the Soil Conservation Service.

Loss of gross crop income - Alvarado to Warren (reach 2)

Crop	Weighted income per acre, 1979 normalized prices	16-31 Mar	1-15 Apr	16-30 Apr	1-15 May	16-31 May	1-15 June	16-30 June	1-15 July	16-31 July	1-15 Aug	16-31 Aug	1-15 Sept	16-31 Sept	1-15 Oct	16-31 Oct
Barley	$27.19	5%(1) $1.36	20% $5.44	35% $9.52	46% $12.51	53% $14.41	65% $17.67	80% $21.75	67% $18.22	56% $15.23	43% $11.69	30% $8.16	0	0	0	0
Wheat	63.99	7% $4.48	33% $21.12	45% $28.80	47% $30.08	50% $32.00	67% $42.87	80% $51.19	71% $45.43	64% $40.95	52% $33.27	42% $26.88	32% $20.48	22% $14.08	0	0
Oats	1.36	5% $0.07	25% $0.34	40% $0.54	48% $0.65	53% $0.72	64% $0.87	75% $1.02	66% $0.90	56% $0.7(	47% $0.64	40% $0.54	0	0	0	0
Sugar beets	27.43	3% $0.82	9% $2.47	15% $4.11	25% $6.86	40% $10.97	60% $16.46	80% $21.94	77% $21.12	75% $20.57	73% $20.02	68% $18.65	54% $14.81	30% $8.23	0	0
Sunflowers	7.88	3% $0.24	19% $1.50	32% $2.52	46% $3.62	55% $4.33	65% $5.12	75% $5.91	67% $5.28	57% $4.49	47% $3.70	40% $3.15	0	0	0	0
Soybeans	1.77	3% $0.05	6% $0.11	16% $0.28	26% $0.46	46% $0.81	66% $1.17	75% $1.33	53% $0.94	53% $0.94	53% $0.94	42% $0.74	32% $0.57	0	0	0
Potatoes	5.40	7% $0.38	8% $0.43	10% $0.54	20% $1.08	30% $1.62	75% $4.05	77% $4.16	77% $4.16	75% $4.05	73% $3.94	68% $3.67	54% $2.92	50% $2.70	40% $2.16	24% $1.30
Total income loss per acre	135.02	7.40	31.41	46.31	55.26	64.86	88.21	107.30	96.05	86.99	74.20	61.79	38.78	25.01	2.16	1.30

(1) Percentage reduction losses from the Soil Conservation Service.

Seasonal Crop Damage Curve

The semimonthly seasonal crop damages consist of the weighted production investment loss plus the loss of income per acre. Seasonal crop damages per acre for reaches 1 and 2 are shown in the following table and on plates 1-5 and 1-6.

Snake River seasonal crop damage per acre (October 1980 prices)

Seasonal period	Loss of gross crop income	Spring replant and invested cost loss	Forgone harvest costs	Seasonal crop damage
		Reach 1		
To 31 Mar	$8.07	$0.13	$1.30	$6.90
1-15 Apr	33.13	0.80	5.49	28.44
16-30 Apr	48.87	4.79	7.82	45.85
1-15 May	58.67	12.20	8.45	56.48
16-31 May	69.40	22.69	10.62	82.16
1-15 June	96.06	28.87	14.62	110.31
16-30 June	115.49		14.68	100.81
1-15 July	103.01		15.42	87.59
16-31 July	93.61		13.77	82.02
1-15 Aug	80.33		11.47	68.86
16-31 Aug	66.94		9.27	57.67
1-15 Sept	42.55		5.26	37.29
16-30 Sept	27.55		3.79	24.76
1-15 Oct	4.32		0.94	3.38
16-31 Oct	2.59			2.59
		Reach 2		
To 31 Mar	7.40	0.02	1.26	6.16
1-15 Apr	31.41	0.90	5.37	26.94
16-30 Apr	46.31	3.37	7.98	41.70
1-15 May	55.26	10.86	9.35	56.77
16-31 May	64.86	21.09	10.26	75.69
1-15 June	88.21	27.41	14.17	101.45
16-30 June	107.30		16.08	91.22
1-15 July	96.05		15.03	80.02
16-31 July	86.99		13.34	73.65
1-15 Aug	74.20		10.98	63.22
16-31 Aug	61.79		8.75	53.04
1-15 Sept	38.78		4.83	33.96
16-30 Sept	25.01		3.28	21.73
1-15 Oct	2.16		0.47	1.69
16-31 Oct	1.30			1.30

Weighted Average Crop Damages per Acre

The amount of crop damage per acre depends on the time of the flood. A historical crop damage per acre was established by multiplying acres flooded by crop damages per acre. A weighted crop damage per acre was obtained by dividing total historical crop damages by total acres flooded. The weighted damage per acre using current Minnesota normalized crop prices is $59 for reach 1 and $51 for reach 2 as shown in the following table.

Snake River weighted average crop damage per acre - current normalized prices

Date	Frequency	Discharge at Warren (cfs)	Area flooded acres	Damage per acre-seasonal crop damage curve	Total damage per flood
Reach 1 - Alvarado to mouth of Snake River					
25 Apr 1950	4.0	3,600	13,800	$48	$662,000
12 June 1962	11.4	2,300	10,400	118	1,227,000
12 Apr 1965	4.0	3,600	13,800	34	469,000
3 Apr 1966	9.7	2,500	11,200	20	224,000
23 Apr 1967	17.8	1,800	8,400	46	386,000
11 Apr 1969	2.2	4,600	14,450	32	462,000
19 June 1970	6.5	2,900	12,200	104	1,269,000
22 Apr 1974	7.4	2,770	11,900	45	536,000
5 July 1975	13.7	2,100	9,900	105	1,040,000
Total			106,050		6,275,000
Weighted crop damage per acre: $59					
Reach 2 - Alvarado to Warren					
25 Apr 1950	3.2	3,260	6,600	43	284,000
12 June 1962	11.3	2,020	4,800	97	466,000
12 Apr 1965	3.3	3,240	6,600	28	185,000
3 Apr 1966	8.6	2,280	5,200	18	94,000
23 Apr 1967	17.0	1,650	3,900	41	160,000
11 Apr 1969	1.6	4,300	7,300	28	204,000
19 June 1970	5.8	2,690	5,900	97	572,000
22 Apr 1974	7.7	2,400	5,450	41	223,000
5 July 1975	15.4	1,750	4,000	83	332,000
Total			49,750		2,520,000
Weighted crop damage per acre: $51					

OTHER AGRICULTURAL FLOOD DAMAGES

Other agricultural flood damages include fence damage, erosion and siltation, loss of livestock, building and machinery damages, loss of stored grain and hay, damage to private roads and ditches, additional miles of travel because of floods, and associated business losses. Average annual other agricultural flood damages per acre are estimated to be $17.77 for the two reaches. Other agricultural damages were derived from the Phse I GDM on the Wild Rice River and adapted to the Snake River area.

AVERAGE ANNUAL AGRICULTURAL AND OTHER AGRICULTURAL DAMAGES AND BENEFITS

From the mean daily discharge-frequency and discharge-area flooded relationships, the average annual area flooded was obtained for the two reaches. The weighted average damages and benefits per acre multiplied by the average annual acres flooded gives the 1980 agricultural and other agricultural damages and benefits as shown in the following table.

Item	Average annual acres flooded	Weighted damage per acre	Average annual agricultural damages and benefits								
			Year								
			1980	1990	2000	2010	2020	2030			
			Index(1)								
			1.00	1.10	1.19	1.30	1.42	1.50	Increase 1980-2030	Average annual equivalent increase(2)	Total damages and benefits
Crop											
Reach 1											
Existing damages	3,620	$59	$213,600	$235,000	$254,200	$277,700	$303,300	$320,400	$106,800	$28,000	$241,600
Residual damages	2,880	59	169,900	186,900	202,200	220,900	241,300	254,800	85,000	22,300	192,200
Benefits	740	59	43,700	48,100	52,000	56,800	62,000	65,600	21,800	5,700	49,400
Reach 2											
Existing damages	1,680	51	85,700	94,300	102,000	111,400	121,700	128,600	42,900	11,200	96,900
Residual damages	990	51	50,500	55,600	60,100	65,600	71,700	75,800	25,300	6,600	57,100
Benefits	690	51	35,200	38,700	41,900	45,800	50,000	52,800	17,600	4,600	39,800
Other agricultural											
Reach 1											
Existing damages	3,620	17.77	64,300	70,700	76,500	83,600	91,300	96,400	32,100	8,400	72,700
Residual damages	2,880	17.77	51,200	56,300	60,900	66,600	72,700	76,800	25,600	6,700	57,900
Benefits	740	17.77	13,100	14,400	15,600	17,000	18,600	19,600	6,500	1,700	14,800
Reach 2											
Existing damages	1,680	17.77	29,900	32,900	35,600	38,900	42,500	44,800	14,900	3,900	33,800
Residual damages	990	17.77	17,600	19,400	20,900	22,900	25,000	26,400	8,800	2,300	19,900
Benefits	690	17.77	12,300	13,500	14,600	16,000	17,500	18,400	6,100	1,600	13,900

(1) Index computed from Souris-Red-Rainy River Comprehensive Study, Volume 2, 1972, page A 149.
(2) Average annual increase over 50-year project life straight lined at 7 3/8 percent equals 0.2619.

EVALUATION OF FLOOD DAMAGES AND BENEFITS - FUTURE CONDITIONS

AGRICULTURAL AND OTHER AGRICULTURAL

The recommended snagging and clearing plan is designed for a 50-year project life. A composite index of yield increases was determined and applied to existing damages and benefits (see previous table). Total average annual crop damages for reach 1 and reach 2 are $241,600 and $96,900, respectively. Total average annual benefits for the respective reaches are $49,400 and $39,800.

Other agricultural damages for reaches 1 and 2 equal $72,700 and $33,400, respectively. The total other agricultural benefits for the two reaches equal $14,800 and $13,900, respectively. Other agricultural damages and benefits are projected to increase as managerial ability, storage capacity, farm size, value of land and buildings, and crop yields increase. All these changes have been taking place and are expected to continue.

TRANSPORTATION

Historical transportation damages were obtained from the Marshall County Highway Department. On an average annual basis, the damages and benefits were $6,000 and $2,100, respectively. Damages and benefits are assumed to remain constant over the life of the project. Average annual transportation damages are based on the frequency-discharge relationship shown in plates 1-7 and 1-8.

LOCAL EMPLOYMENT BENEFITS

Warren is qualified under Title IV of the Public Works and Economic Development Act of 1965 because of "substantial and persistent unemployment". Total construction costs equal $674,200. Approximately 40 percent or $258,900 is labor costs; 56 percent of the labor cost is skilled labor and 44 percent is unskilled labor.

According to "NED Benefit Evaluation Procedures: Unemployed and Underemployed Resources," 30 percent of the skilled labor cost and 47 percent of the unskilled labor cost equal the local employment benefits.

	Total costs		Local share		Employment benefits
Skilled labor cost	$145,000	X	30%	=	$43,500
Unskilled labor cost	113,900	X	47%	=	53,500
Total labor cost	258,900				97,000

In Marshall County, it is estimated that there will be $43,500 in skilled labor benefits and $53,500 in unskilled labor benefits, totaling $97,000. Local labor benefits ($97,000) X the interest and amortization factor (0.07591) = $7,400 in local employment benefits.

SHELTERBELT BENEFITS

Shelterbelt benefits on the Snake River are derived from reduction of spring overland flooding. The shelterbelts reduce flooding by keeping snow from drifting into the channel. Without the shelterbelts, the snow fills in the channel and reduces channel capacity to near zero, resulting in overland flows. On the basis of local experience and observation of existing shelterbelts on the Snake River, the watershed engineer has conservatively estimated that 1,000 acres will benefit each spring from shelterbelt protection. On the basis of this estimate, the assumption of spring breakup around 15 April, and the seasonal crop damage curve, average annual benefits from the shelterbelts are about $34,000. These benefits are calculated in addition to agricultural benefits because shelterbelts would prevent flooding over and above that which is prevented by snagging and clearing. Shelterbelt benefits also demonstrate capacity for environmental enhancement.

LOCATION BENEFITS

Little or no change in land use is contemplated with the partial protection provided by the recommended snagging and clearing. Thus, insignificant or no location benefits are expected to accrue as a result of the project.

INTENSIFICATION BENEFITS

No increase in the intensity of any land use activity is expected to result from the project.

PROJECT EFFECTS

Total average annual existing damages including urban, agricultural, other agricultural, and transportation categories are about $495,000 over the life of the project. Total average annual existing benefits to these categories are about $162,800 with the shelterbelts and $128,800 without the shelterbelts. The remaining average annual damages are $332,200 with the shelterbelts and $366,200 without the shelterbelts as shown in the following table.

Project effects - damages and benefits

Item	Existing damages	Residual damages	Benefits
Crop			
Reach 1	$213,600	$169,900	$43,700
Reach 2	85,700	50,500	35,200
Other agricultural			
Reach 1	64,300	51,200	13,100
Reach 2	29,900	17,600	12,300
Urban			
Warren	71,100	57,200	13,900
Alvarado	24,400	15,900	8,500
Transportation	6,000	3,900	2,100
Total	495,000	366,200	128,800
Shelterbelt benefits	0	-34,000	34,000
Total with shelterbelts	495,000	332,200	162,800

BENEFIT-COST RATIO

EXISTING CONDITION BENEFIT-COST RATIO

Existing condition (1980) flood control benefits are $162,800 with shelterbelts and $128,800 without. At a 7 3/8-percent interest rate and October 1980 prices, the annual charges are $67,700 with the shelterbelt protection and $64,100 without shelterbelt protection. The existing condition benefit-cost ratios are 2.4 and 2.0 with and without shelterbelt protection, respectively.

BENEFIT-COST RATIO INCLUDING FUTURE GROWTH

Total average annual benefits of all types, including future growth, are $186,700 with shelterbelts and $152,700 without. The benefit-cost ratio is 2.8 for the project with the shelterbelts and 2.4 without.

BENEFIT SUMMARY

Benefits computed for this analysis include urban, agricultural, other agricultural, transportation, local employment, and shelterbelt protection. Total benefits of $186,700 with shelterbelts and $152,700 without are shown in the following benefit summary table.

Benefit summary (including future growth)

Urban	
Warren	$15,500
Alvarado	9,800
Rural	
Agricultural	
Reach 1	49,400
Reach 2	39,800
Other agricultural	
Reach 1	14,800
Reach 2	13,900
Transportation	2,100
Other	
Local employment	7,400
Total	152,700
Shelterbelt benefits	34,000
Total with shelterbelts	186,700

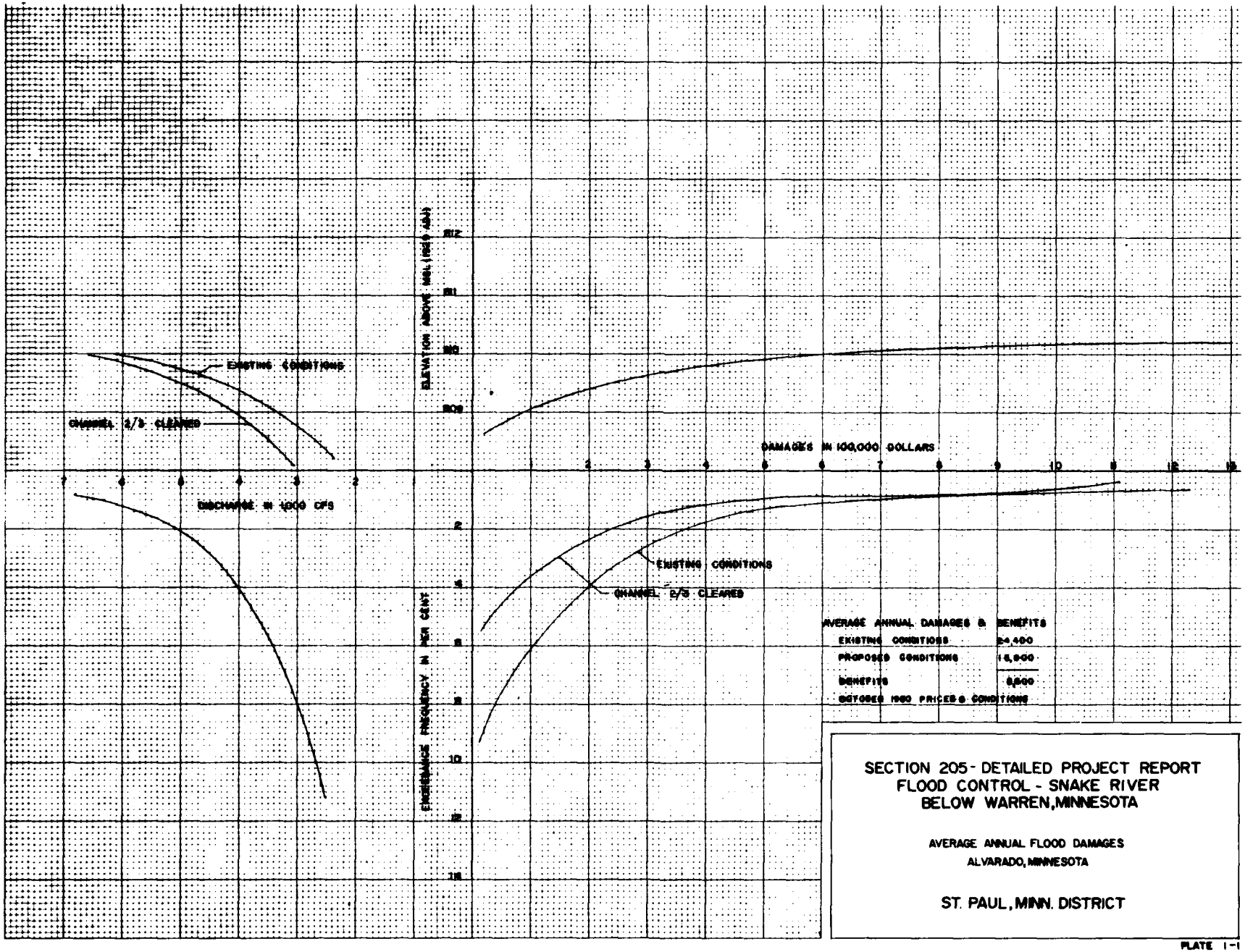
SENSITIVITY ANALYSIS

BREAK EVEN YEARS (7 3/8-PERCENT INTEREST)

The recommended plan for the Snake River is justified under present (1980) flood control conditions.

INTERNAL RATE OF RETURN

The internal rate of return (the rate at which benefits equal costs over the period of analysis) is approximately equal to 17 percent.

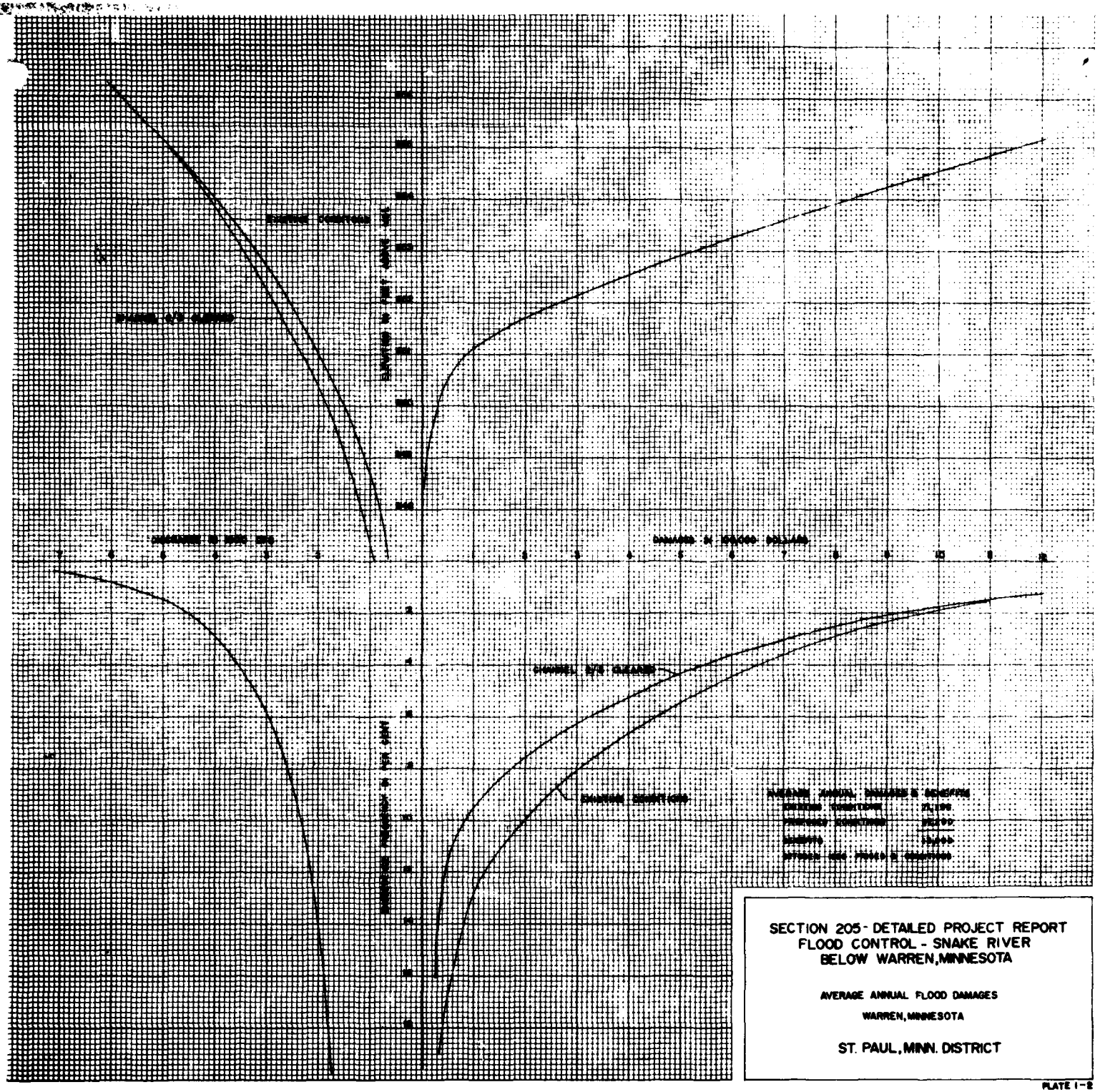


SECTION 205 - DETAILED PROJECT REPORT
FLOOD CONTROL - SNAKE RIVER
BELOW WARREN, MINNESOTA

AVERAGE ANNUAL FLOOD DAMAGES
ALVARADO, MINNESOTA

ST. PAUL, MINN. DISTRICT

PLATE 1-1



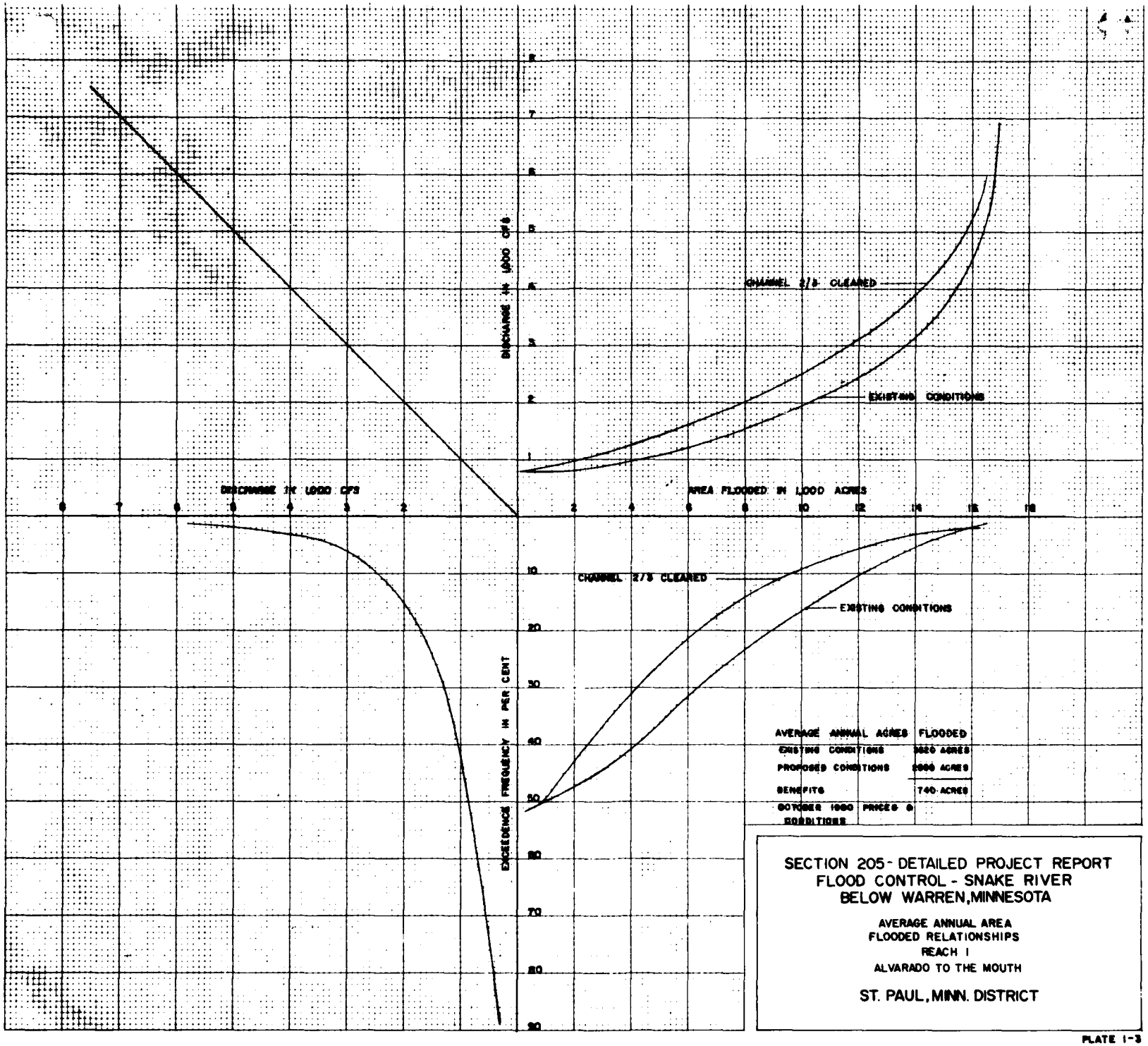
SECTION 205 - DETAILED PROJECT REPORT
FLOOD CONTROL - SNAKE RIVER
BELOW WARREN, MINNESOTA

AVERAGE ANNUAL FLOOD DAMAGES

WARREN, MINNESOTA

ST. PAUL, MINN. DISTRICT

PLATE 1-2

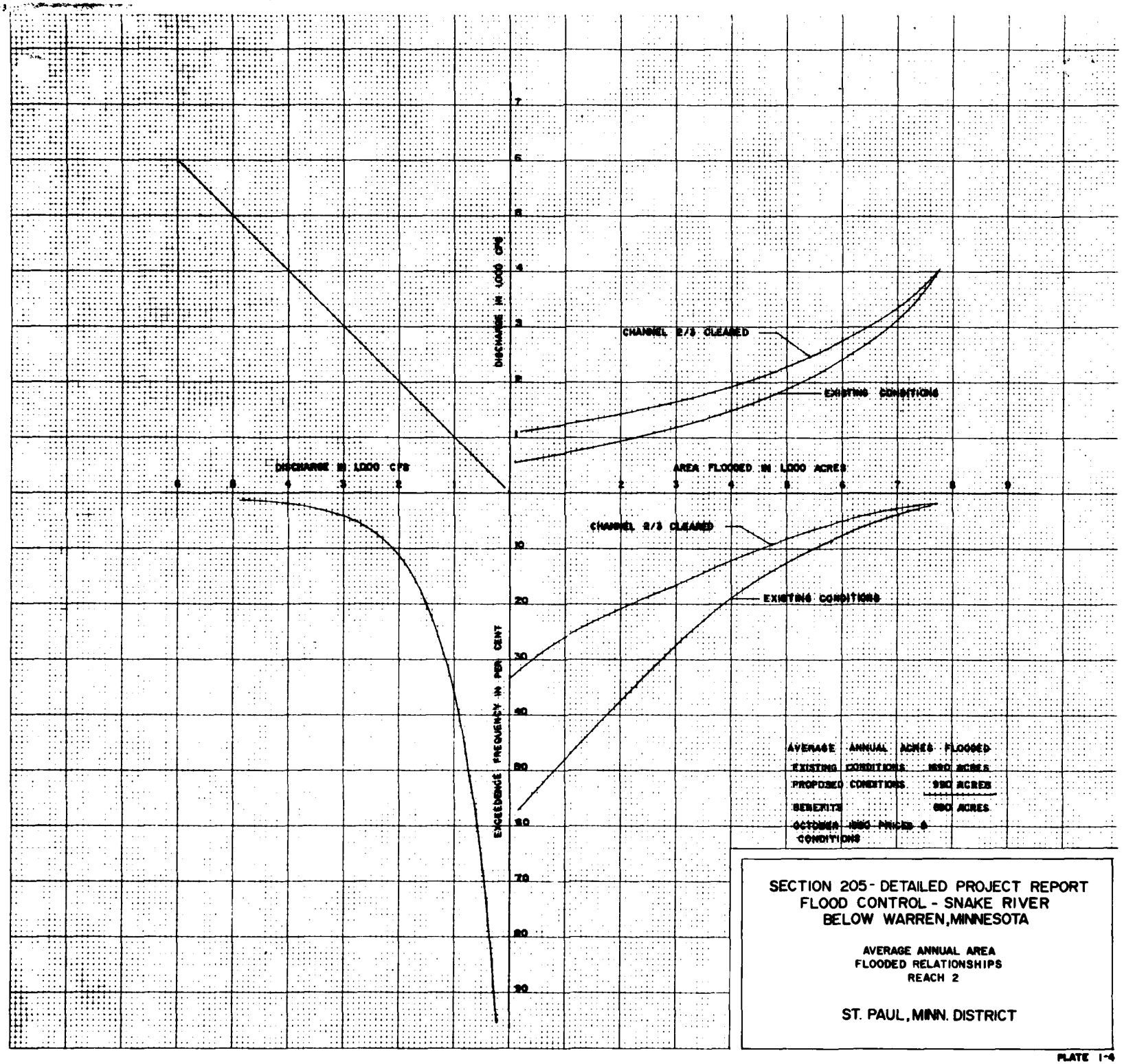


SECTION 205 - DETAILED PROJECT REPORT
FLOOD CONTROL - SNAKE RIVER
BELOW WARREN, MINNESOTA

AVERAGE ANNUAL AREA
FLOODED RELATIONSHIPS
REACH I
ALVARADO TO THE MOUTH

ST. PAUL, MINN. DISTRICT

PLATE I-3

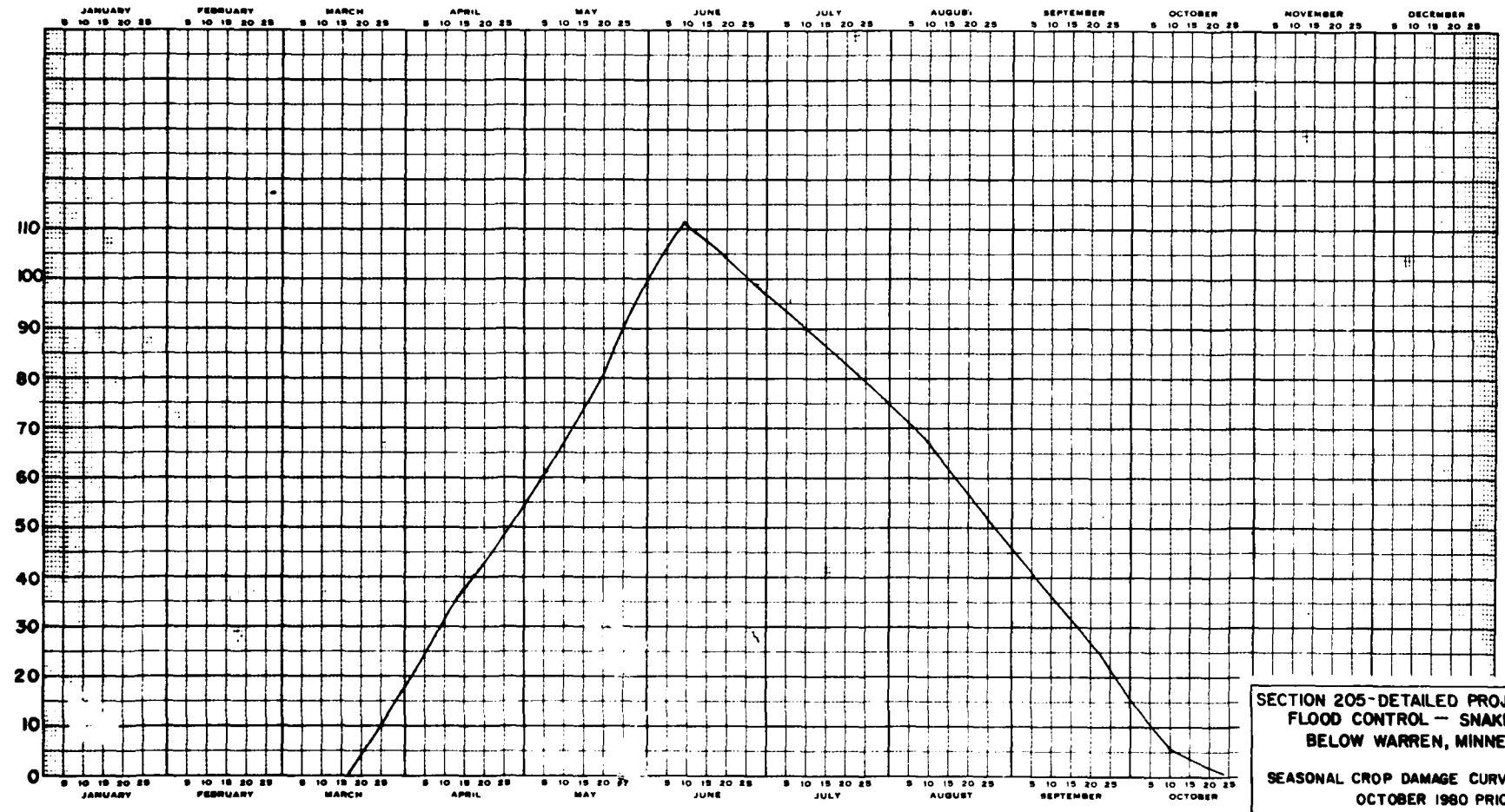


SECTION 205 - DETAILED PROJECT REPORT
FLOOD CONTROL - SNAKE RIVER
BELOW WARREN, MINNESOTA

AVERAGE ANNUAL AREA
FLOODED RELATIONSHIPS
REACH 2

ST. PAUL, MINN. DISTRICT

PLATE 1-4

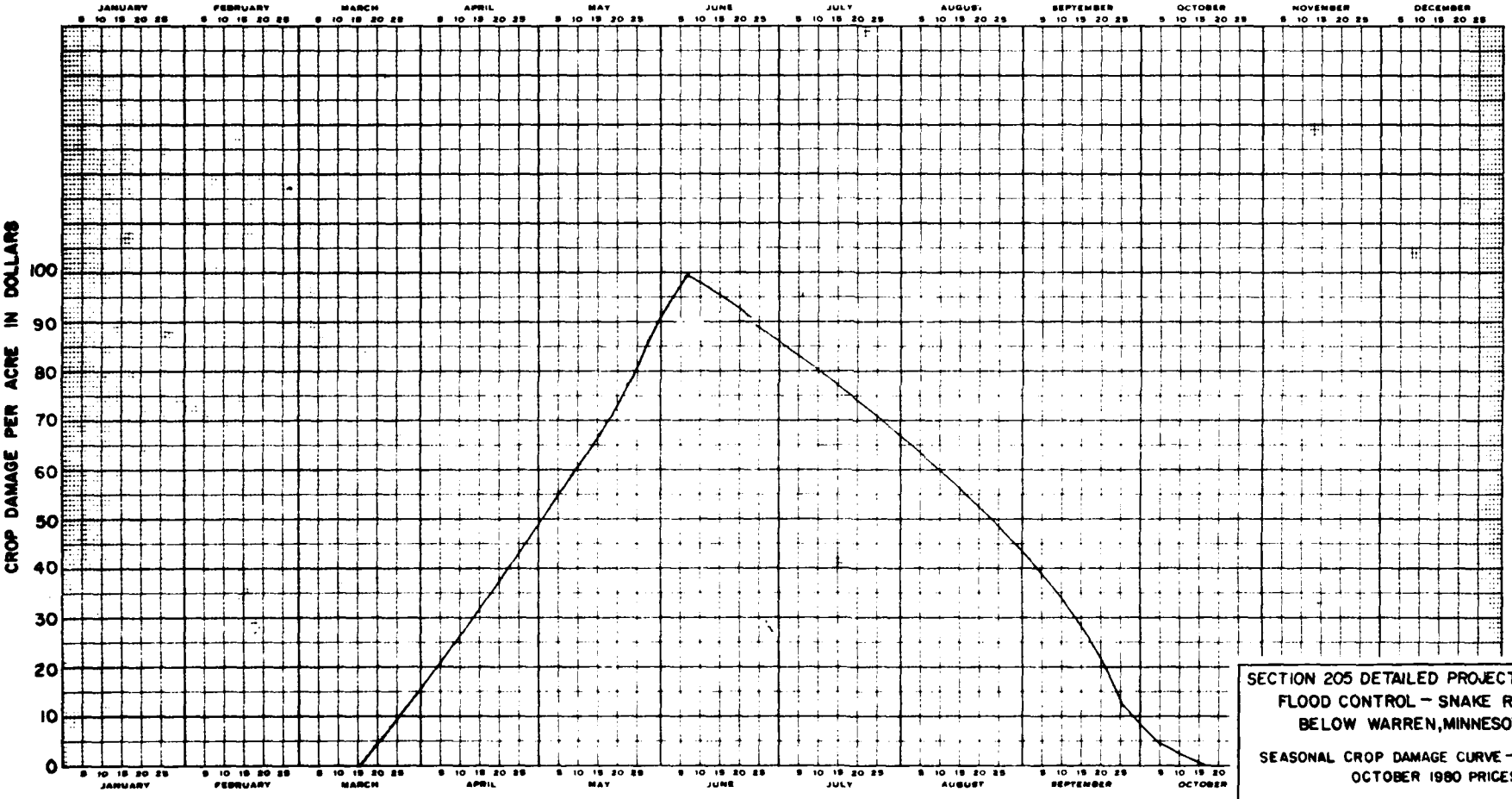


SECTION 205-DETAILED PROJECT REPORT
FLOOD CONTROL — SNAKE RIVER
BELOW WARREN, MINNESOTA

SEASONAL CROP DAMAGE CURVE- REACH I
OCTOBER 1980 PRICES

ST. PAUL, MINN. DISTRICT

PLATE I-5

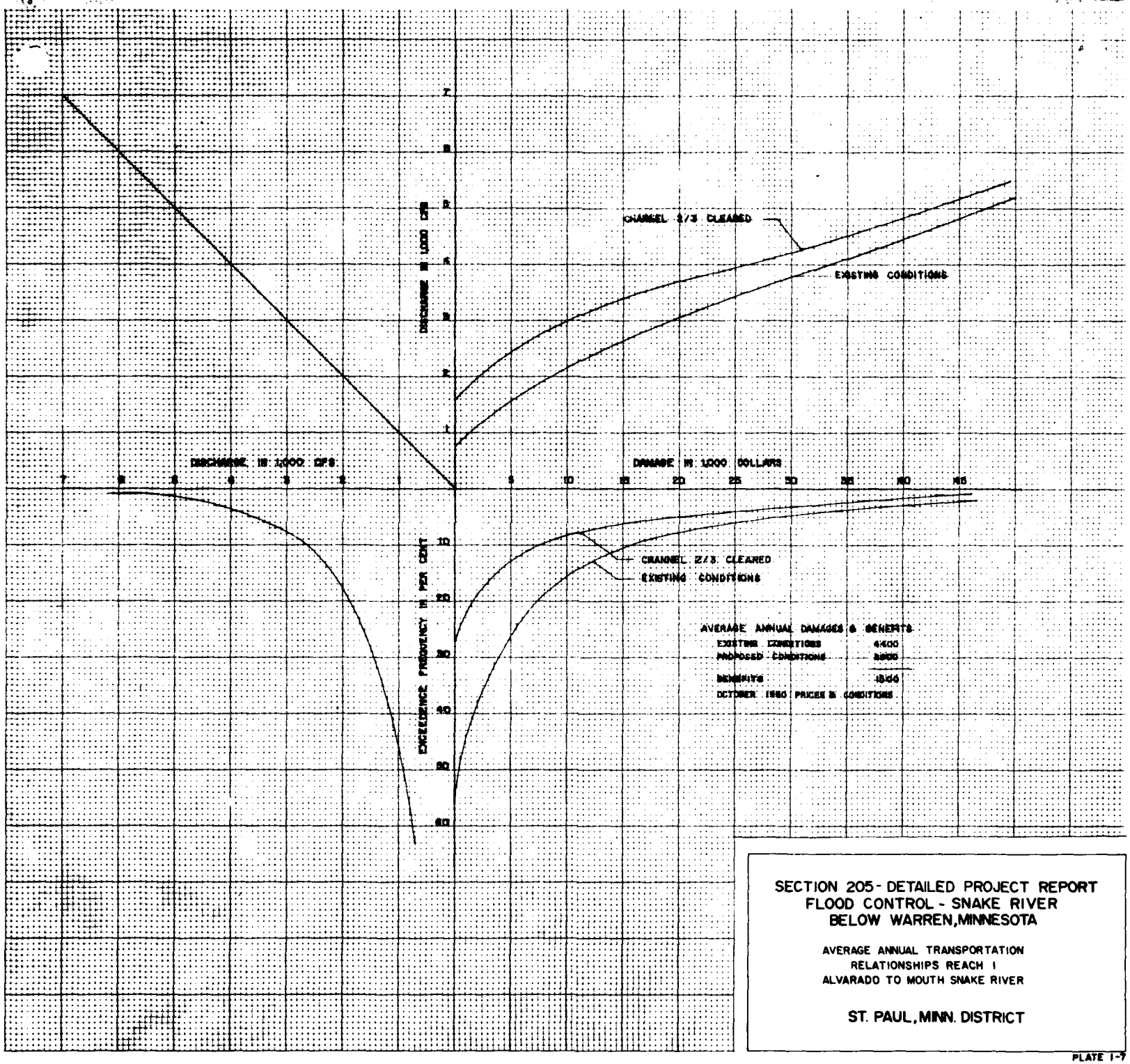


SECTION 205 DETAILED PROJECT REPORT
FLOOD CONTROL – SNAKE RIVER
BELOW WARREN, MINNESOTA

SEASONAL CROP DAMAGE CURVE – REACH 2
OCTOBER 1980 PRICES

ST. PAUL, MINN. DISTRICT

PLATE 1-6

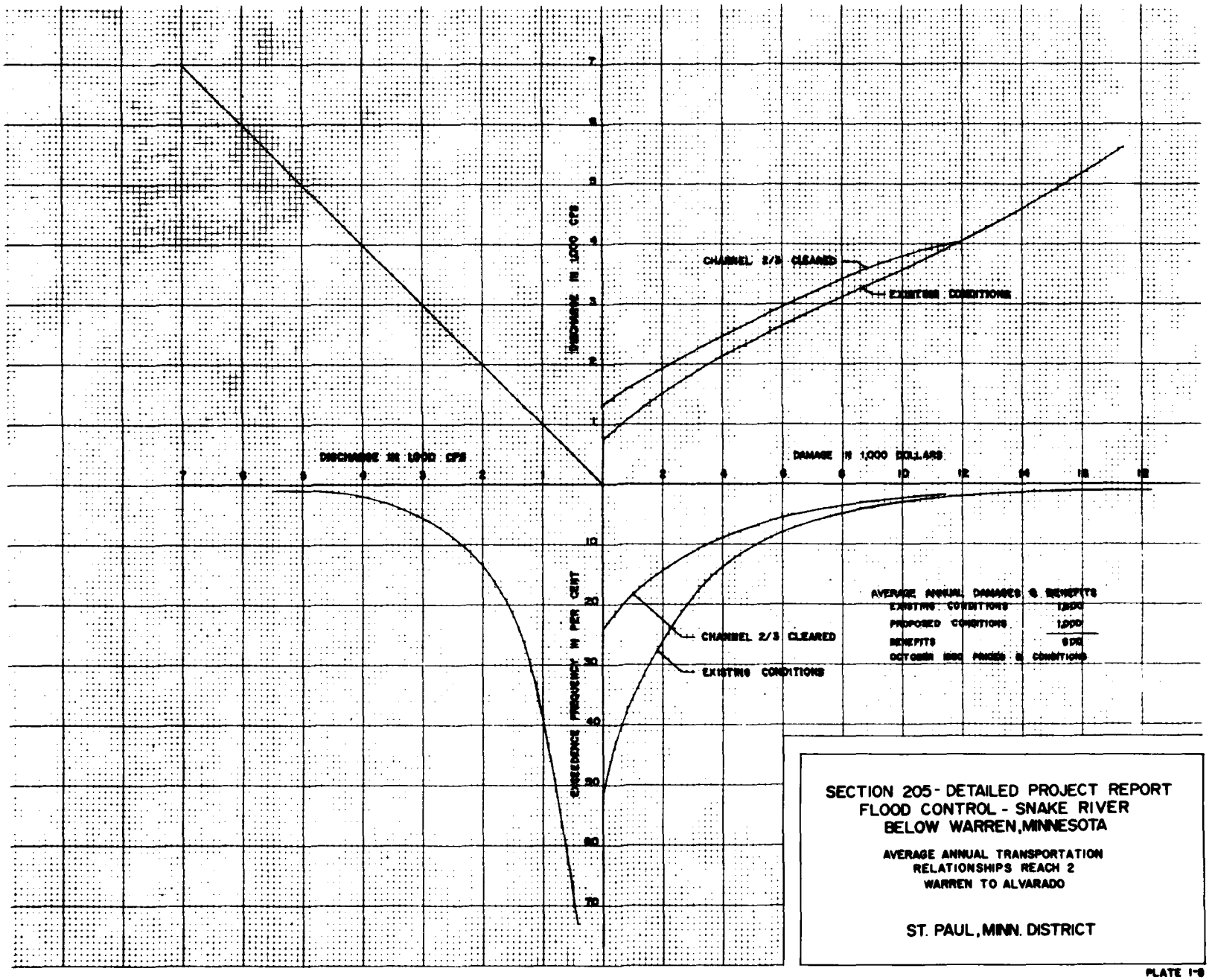


SECTION 205 - DETAILED PROJECT REPORT
FLOOD CONTROL - SNAKE RIVER
BELOW WARREN, MINNESOTA

AVERAGE ANNUAL TRANSPORTATION
RELATIONSHIPS REACH I
ALVARADO TO MOUTH SNAKE RIVER

ST. PAUL, MINN. DISTRICT

PLATE I-7



SECTION 205 - DETAILED PROJECT REPORT
FLOOD CONTROL - SNAKE RIVER
BELOW WARREN, MINNESOTA

AVERAGE ANNUAL TRANSPORTATION
RELATIONSHIPS REACH 2
WARREN TO ALVARADO

ST. PAUL, MINN. DISTRICT

PLATE I-8

APPENDIX 2

DESIGN CONSIDERATIONS
AND
DETAILED COST ESTIMATES

TABLE OF CONTENTS

TABLES

TABLE (CONT)

PLATES

NUMBER

APPENDIX 2

DESIGN CONSIDERATIONS AND DETAILED COST ESTIMATES

GENERAL

This section presents a detailed discussion of the base data used to prepare the flood damage reduction alternatives considered. Included are discussions of the hydrologic and hydraulic studies and the detailed estimate of first and annual costs for the selected plan. The geologic, soils, and groundwater data described in the main report were used for the preliminary assessments of the structural plans considered.

HYDROLOGY

CLIMATE

Weather data are available for Warren, Minnesota, only for the years 1912-1922. Therefore, information on the climate is based on records from nearby stations. The nearest weather stations are at Angus, Minnesota, 9 miles south of Warren, with 72 years of records, and Argyle, Minnesota, 10 miles north of Warren, with 59 years of records through 1974. Other nearby stations with long periods of record are at Crookston, Minnesota, and Grand Forks, North Dakota.

The climate in the area around Warren is characterized by wide temperature fluctuations and moderate precipitation. The high and low mean temperatures for Warren in July are 82° F and 57° F, respectively. In January, the coldest month, the mean maximum temperature is 13° F, and the mean minimum temperature is -8° F. The average annual temperature for Warren is approximately 39° F. The last spring frost usually occurs about 23 May, and the earliest fall frost occurs about 18 September, for an average growing season of 118 days for Warren compared to 160 days in southeastern Minnesota.

Normal annual precipitation is approximately 20 inches. Annual precipitation has ranged from a high of 32.87 inches at Crookston in 1941 to a low of 7.81 inches at Angus in 1936. Normal monthly precipitation varies from 0.5 inch in February to 3.5 inches in June. Although total precipitation is important, its distribution during the growing season is even more significant. Approximately 70 percent of the annual precipitation normally falls during the growing season (May through September). Annual snowfall averages 35 inches and amounts to about 18 percent of the annual precipitation at Warren.

The area is characterized by local thunderstorms occurring in cyclonic areas moving eastward across the basin. The storms are most numerous during the summer. Blizzards occur frequently during the winter and often seriously interfere with communications and transportation. Major storms have been rare in the area. The most notable recorded storms occurred in 1897, 1901, and 1909. The largest 24-hour rainfalls recorded in the region are 8.97 inches on 19 July 1909 at the Fosston Power Plant and 10.75 inches on 20 July 1909 at Beaulieu, Minnesota, located approximately 68 miles and 77 miles, respectively, southeast of Warren. A 24-hour rainfall of 7.50 inches occurred on 29 May 1949 at Thief River Falls, Minnesota, 29 miles east of Warren. In a recent large storm, 4.72 inches of rain fell in a 24-hour period on 1 and 2 July 1975 at Argyle. During this storm, 14 inches of rain fell in several days in Clay County, Minnesota, 90 miles south of Warren.

RUNOFF

Winter streamflow in the Snake River is very small or nonexistent. The continual cold weather during winter precludes direct surface runoff, and the flow is limited to that from lakes, swamps, and groundwater. Streamflow generally starts to increase between the middle of March and early April as a result of spring snowmelt, sometimes accompanied by spring rains. A large portion of annual runoff ordinarily occurs from April through June; the year's maximum flow is usually in April.

Streamflow often remains high through May and June as a result of heavy rainstorms. During the summer, the flow recedes slowly except following heavy rainstorms. In the fall, the streamflow usually continues to recede until it reaches a low discharge or no flow. The river rises and falls slowly because of the flat land and stream slopes.

The study area has State, judicial, and county ditches along with many miles of on-farm ditches. Little thought has been given to proper outlets. Culverts and bridges in road and railroad systems, which were designed to handle the volume of water in the given system at the time they were built, are now inadequate. Bank slides and lush summer vegetation in ditch channels impede excessive flows of water.

FLOODS OF RECORD

Floods that caused significant damages in Warren occurred in 1896, 1897, 1901, 1941, 1950, 1965, 1966, 1969, 1975 and 1979. The largest flood of record occurred in 1969. A flood in 1897 probably exceeded the 1969 flood but no official data are available.

During the record spring flood of 1969, about 75 percent of the city of Warren was flooded to shallow depths. A record peak discharge of 4,350 cfs (cubic feet per second), compared with the existing channel capacity of only about 1,400 cfs, occurred on 10 April 1969. Flooding in Warren was first caused by storm sewer backup, then by the river overtopping the channel banks in the northeast area of the city. For about 3 days, the business district lacked water and sewer service, and most basements were flooded.

Records have been kept for a relatively short period of time at Warren. Discharge records have been obtained by the U.S. Geological Survey for the Snake River at Warren only from March to September 1945 and October 1953 to September 1956. Flood data are presented in the following table.

Flood crest elevations, Snake River at Warren, Minnesota
Minnesota Street Bridge

Date of crest	Estimated peak Discharge (cfs)[1]	Stage[2]	Elevation[3]
4-6 May 1950	3,510	18.4	853.4
April 1965	3,250	17.9	852.9
3 April 1966	3,410	18.4	853.4
10 April 1969	4,350	19.4	854.4
3 July 1975	2,080[4]	17.73	852.73
19 April 1979	3,560[5]	19.56	854.56
100-year flood	5,500		855.7
Standard Project Flood	10,500		

(1) From elevation-discharge rating curve for old U.S. Geological Survey gage. Updated through 1978.
(2) From high-water marks.
(3) Feet, mean sea level, 1929 adj. Elevations are based on a gage height of 835.0 feet.
(4) This peak discharge and stage would have been higher had it not been for an internal overflow on the Snake River headwaters which caused a large portion of this flood to bypass Warren.
(5) Flow at peak measured by SCS engineers, downstream of Warren at CSAH # 105. Flow at USGS gage in Warren was affected by ice and debris.

FLOOD FREQUENCIES

Because of the short period of discharge records available for the Snake River at Warren and Alvarado, Minnesota, records from a nearby basin were analyzed and compared. Studies of peak discharges and frequency curves in this area indicate that the long period of record for the adjacent Middle River at Argyle (drainage area = 248 square miles) correlates well with the Snake River at Warren (drainage area = 175 sq.mi.). Studies of peak flows at Argyle and Warren indicate that the peaks vary about as the 0.65 power of the drainage area ratio. The Argyle frequency curve was transferred to the Snake River at Warren and Alvarado.

DURATION OF FLOODS

Based on flow records for the Middle River at Argyle and miscellaneous records of flow data at Warren and Alvarado, the duration of floods exceeding channel capacity in the study area is usually 3 or more days.

Middle River at Argyle

Discharge-frequency curves for the Middle River at Argyle were derived from a study of the 29 years of record (1945 and 1950-1977). During this period, five peak flows were much lower than the others and were considered as low outliers. The five lowest peaks are shown with the ten lowest peak flows in the following table:

Ten lowest peak flows, Middle River at Argyle

Rank	Water year	Flow (cfs)
20	1972	729
21	1976	631
22	1952	612
23	1959	570
24	1955	527
25	1961	135
26	1954	128
27	1953	112
28	1973	93
29	1977	80

Several different discharge-frequency curves were developed using guidelines and procedures outlined in the Water Resources Council Bulletin No. 17A. Low flows were omitted, and the resulting frequency

curves were plotted and studied. These frequency curves are based on annual series with log Pearson type III distribution. A generalized skew value of -0.2 was used in accordance with the St. Paul District Skew Map (17 February 1977). The best discharge-frequency curve from this study was derived when the three lowest flows were omitted. Selection of the best frequency curve was based on visual fit of the curve to the plotting points. This frequency curve with 0.05 and 0.95 confidence limits is shown on Plate 2-1 . Because these data are being used for flood design studies, the results are plotted using "expected probability P_N" and Weibull's plotting positions in accordance with NCDR 1110-2-22.

The partial duration series instantaneous peak discharge-frequency curve for the Middle River at Argyle was developed graphically from the 29 years of record (1945 and 1950-1977) using Weibull's plotting positions. This curve ties into the annual instantaneous curve at the upper end. This curve with plotting points is shown on Plate 2-2.

To derive the mean daily peak discharge-frequency curve for the Middle River at Argyle, the relationship between instantaneous and mean daily peaks was studied. The mean daily peaks are 91 percent of the instantaneous peaks. This same relationship of 0.91 was used to develop mean daily discharge-frequency curves for the Snake River at Warren and Alvarado.

Snake River at Warren

The Argyle frequency curves were transferred to the Snake River at Warren using a factor of 0.8, which is the 0.65 power of the drainage area ratio. To check the derivation of the discharge-frequency curve for Warren, the three largest known peak flows in 50 years were plotted using Weibull's plotting points. (Largest = 2% = 4,350 cfs 1969 flood; 2nd largest = 3.9% = 3,560 cfs 1979 flood; 3rd largest 5.9% - 3,510 cfs 1950 flood.) The resultant curve seems to fit the three largest known flood

peaks well. These frequency curves, with additional remarks, are shown on Plate 2-3. The frequency curves were developed to be used on design studies and should not be used for flood insurance studies.

The suspected overflow (at high stages) from the Middle River to the Snake River headwaters, which was considered in previous studies, does not exist. This conclusion was field-checked by the Soil Conservation Service and Corps of Engineers. No overflow was observed from the Middle River during the record flood, which was 4,260 cfs on 3 July 1975.

The record flood for the Middle River at Argyle on 3 July 1975 was not the largest observed flood peak at Warren for two reasons:

a. The 1-2 July 1975 storm centered on the headwaters of the Middle River basin and covered only a small portion of the Snake River headwaters.

b. An internal overflow on the Snake River headwaters caused a large portion of this flood to bypass Warren. This overflow area has been diked and will not exist during future floods.

The three largest known peak flows, which were used to verify the derivation of the discharge-frequency curve, had no significant overflows that left or bypassed Warren. The 3 July 1975 flood was the only event involving a major breakout. The peak discharge for the 3 July 1975 flood was 2,080 cfs with gage height of 17.73. Since the rainfall of the 3 July 1975 flood was not uniform on the Middle River and on the Snake River, it is impossible to estimate the peak flow at Warren in 1975 without the internal overflow.

Snake River at Alvarado

The discharge-frequency curves for the Snake River at Alvarado (drainage area = 220 square miles) are also based on records for the Middle River at Argyle. The Argyle frequency curves were transferred to

the Snake River at Alvarado using a factor of 0.92, which is the 0.65 power of the drainage area ratio. The Alvarado discharge-frequency curves are shown on Plate 2-4. The curves were plotted using "expected probability P_N" and Weibull's plotting positions. These frequency curves were developed for use in design studies and should not be used for flood insurance studies.

The following data for the 1979 flood are from SCS engineers for the Middle River-Snake River Watershed District:

MIDDLE RIVER-SNAKE RIVER WATERSHED DISTRICT
1979 SUMMARY OF STREAMGAGING FOR THE SNAKE RIVER

LOCATION	TIME-DATE	GAGE READING	ELEVATION(MSL)	FLOW RATE (cfs)	AVERAGE VELOCITY(fps)	COMMENTS
TH #1 at Alvarado 0.00=700.30	2 PM 4-18-79	15.23	805.5	584	0.86	-----
	2 PM 4-19-79	19.99	810.3	3,130	2.69	
	4 PM 4-20-79	20.18	810.5	3,720	3.14	
	1 PM 4-21-79	19.96	810.3	3,170	2.72	
	12 N 4-25-79	18.44	808.7	1,010	1.02	
	3 PM 4-26-79	18.20	808.5	1,260	1.29	
	3 PM 4-27-79	18.0	808.3	1,320	1.38	
	11 AM 5-7-79	8.88	799.2	122	0.48	
CSAH #105 W. of Warren	10 AM 4-19-79	NA	848.06	3,560	3.51	No Gage at CSAH #150 flow measurement affected
	11 AM 4-20-79	NA	846.07	2,250	2.84	by debris and brush in channel (approx. only ≠ 20%)
Bridge St. in Warren (1)	1 PM 4-17-79	48.59	848.7	1,560	2.66	Does not include flow around the bridge
0.00=800.1	9 AM 4-19-79	51.15	851.2	3,000	3.44	
	9 AM 4-25-79	47.25	847.3	1,680	3.71	
	2 PM 4-26-79	45.79	845.8	1,180	3.67	
	2 PM 4-27-79	43.65	843.7	760	3.98	
	10 AM 5-7-79	40.02	840.0	111	2.71	
CSAH #34	2 PM 4-17-79	8.75	873.4	2,220	4.27	
0.00=864.64	12 N 4-21-79	4.96	869.6	1,210	3.14	
	1 PM 4-24-79	4.34	869.0	1,090	3.02	
	9 AM 4-25-79	7.45	872.1	2,020	4.26	
	1 PM 4-26-79	4.34	869.0	1,080	2.98	
	1 PM 4-27-79	2.73	867.4	601	1.99	
CSAH #14	11 AM 4-17-79	6.40	985.9	870	2.46	

(1) Corps of Engineers' gage at Minnesota Highway No. 1 bridge. This gage is used by National Weather Service for forecasting.

DURATION OF FLOODS

The impact of the project on peak flow magnitudes due to the reduction of overland storage would be minimal or negligible. Since the duration of floods is usually 3 or more days as can be seem from the study of the 1979 summary of stream gaging data for the Snake River at Warren and Alvarado. The duration of flooding due to the project would be shorter and the flooded area would be less than without the project.

Comparing data from HEC-2 backwater computations for the existing conditions and for the two-thirds clearing and snagging alternative, the channel carries approximately 80 percent of the 10-year discharge with existing conditions. This value would increase about 7 percent with the proposed project. With such a large portion of the discharge in the channel, it is questionable whether or not a loss of overland storage would have much effect. Through the project area, valley storage would be reduced approximately 25 percent for the 10-year flood with the project in place. If the entire reach from the mouth to the upstream end of the project is considered, the reduction in valley storage is approximately 10 percent.

The following table compares the 100-year (Corps of Engineers) design discharge data and the 100-year intermediate regional or regulatory flood peaks used for flood insurance studies.

Comparison of data for design studies and flood insurance studies

Site	Drainage Area (square miles)	100-year (1-percent) frequency flood peaks (cfs)	
		Design studies	Flood insurance studies
Middle River at Argyle	248	6,860	5,940
Snake River at Alvarado	220	6,310	5,460
Snake River at Warren	175	5,490	4,750

A coincidental frequency analysis for the Snake River at Alvarado and the Red River of the North has not been developed for this study because records are not available. In addition, there is a serious question as to the independence of events on the Snake River and Red River. Profile data for the Red River of the North at Oslo, Minnesota, (6 miles west of Alvarado) indicate that flows such as the 100-year (1-percent frequency) peak and greater on the Red River of the North main stem would definitely cause flooding at Alvarado. Therefore, it can be assumed that the 500-year peak stage, as determined for this study, would occur more often and that the 500-year (0.2-percent frequency) profile would be somewhat higher than the computed for no backwater from the Red River. This same coincidental backwater condition could also affect the other profiles.

HYDRAULIC ANALYSIS

GENERAL

The hydraulic effects of all three snagging and clearing alternatives, which include clearing of the lower two-thirds of the riverbank, clearing to the top of the riverbank, and clearing to 10 feet beyond the top of the riverbank, were studied. Significant hydraulic factors analyzed include water surface profiles, Manning's "n" values, discharge rating curves, limiting channel capacities, flooded overbank areas, and the previously discussed flood frequency curves. For existing conditions on the Snake River, the limiting channel capacities were computed to be 1,400 cfs from the mouth to river mile 21.2, 700 cfs from river mile 21.2 to Warren, and 600 cfs upstream of Warren. After the proposed snagging and clearing of the lower two-thirds of the riverbank, the limiting channel capacity would be 900 cfs from river mile 21.2 to Warren, making the project reach equal in limiting flood capacity to that of the previously cleared reach of the Snake River.

RATING CURVES AND WATER SURFACE PROFILES

Discharge rating curves for the Snake River at Warren and Alvarado for existing conditions and the two-thirds riverbank clearing alternative are shown on plates 2-5 and 2-6. Rating curves for the two other clearing alternatives are not shown because only small differences in river stage existed between all alternatives (less than 0.1 foot). The rating curves shown were based on HEC-2 Backwater Program computations and gaging data at Warren and Alvarado to directly prepare the rating curves for existing Snake River conditions. The rating curve site at Warren was the upstream side of the Minnesota Street Bridge; the rating curve site at Alvarado was located 100 feet upstream of the Soo Line railroad bridge.

The rating curves for Alvarado and Warren are based on discharge measurements and backwater computations. A stage of 854.4 at the Minnesota Street Bridge was recorded in 1969; the discharge is estimated at 4,350 cfs. Using this value as the peak 1969 flood discharge at Warren, the existing conditions roughness coefficients required to match the profile computed by HEC-2 to the 1969 recorded high-water marks were determined (see the following table). These roughness coefficients were used to compute the existing conditions water surface profiles for a number of flood frequency discharges. The slope-area method was used to determine the starting water surface elevation on the Snake River. The energy slope used for all cases was 0.000057 ft./ft., the approximate energy grade line slope for highwater on the Red River of the North at the confluence with the Snake River. Rating curves for the proposed clearing alternatives were obtained from HEC-2 backwater computations.

Roughness coefficients - existing conditions as determined from 1969 flood high-water marks

Reach of river (miles)	Roughness coefficients		
	Left overbank	Channel	Right overbank
0.0			
	0.155	0.040	0.155
18.9			
	0.080	0.035	0.080
21.2			
	0.060	0.035	0.060
22.9			
	0.100	0.050	0.100
31.1			
	0.080	0.040	0.080
32.3			
49.9			
	0.100	0.060	0.100
50.5			
	0.100	0.040	0.100
50.8			
	0.085	0.035	0.085
51.0			
	0.090	0.040	0.090
52.4			

The profiles for the snagging and clearing alternative were computed using a channel roughness coefficient of 0.035. No plugging of bridges was assumed for existing or proposed conditions.

The computed water surface profiles are shown on Plates 2 through 4 in the main report. Plotted profiles are for existing conditions and the lower two-thirds of the riverbank cleared and the channel snagged. For existing conditions, the 1969 and 10-year frequency flood profiles are plotted from the mouth of the Snake River to river mile 77.7. The computed 10-year frequency flood profile, assuming the lower two-thirds of the riverbank is cleared, is plotted from the County Road 18 bridge at river mile 21.2 to the County Road 34 bridge at river mile 57.8. These portions of the river include the reaches containing the most snags and debris. No analysis was done to determine the sensitivity of water surface elevations on the Snake River to backwater from the Red River of the North. The majority of the project area is too far upstream to be affected by backwater from the Red River of the North for more frequent floods. Looking at the 1969 flood water surface profile, the water surface appears to reach normal depth below Alvarado. The 1969 flood was approximately a 4% chance flood on the Red River of the North and approximately a 2% chance flood on the Snake River. These data suggest that, for 10- and 25-year floods on the Snake River, the flood water elevations in the project area would not be sensitive to backwater effects from the Red River of the North for discharges up to the 4% chance flood on that river.

EFFECT OF FUTURE AGRICULTURAL DRAINAGE

In recent years, on-farm agricultural drainage has been intensive in the Red River Valley area. Farm drains consist mostly of wide, shallow surface ditches excavated by tractor-drawn carry-all scrapers of limited capacity. County and judicial outlet ditches have been cleaned out and improved only to a limited extent because of a lack of adequate major

outlets. The Middle River-Snake River Watershed District has studied needed improvements in the watershed. The suggested improvements are expected to be installed as the main channels of the Middle and Snake Rivers are improved.

EFFECT OF ICE AND SNOW IN CHANNEL

The channel is often filled with ice and snow. (The reduction in channel capacity causes problems, especially during smaller floods.) This problem is more severe in years with heavy precipitation in the fall. The river water surface is high when it freezes, and the channel will virtually freeze solid due to little winter inflow. The following spring the channel will be blocked much longer than if it were only filled with snow.

Once the project is complete the problem of snow in the channel should be reduced considerably due to the placement of a shelterbelt on the right overbank (north side of the channel) in reaches C and D. The shelterbelt will reduce the amount of snow drifting into the channel since the majority of winds come out of the north-northwest in the winter months. The normal snowfall is not great enough to cause a problem without the effects of the wind.

A survey of USGS records for the Middle River at Argyle, Minnesota, (10 miles north of Warren) for 1951-1979 shows that, on the average, the ice went out by 12 April, and the peak discharge occurred on 11 April. Therefore, the high water was affected somewhat by backwater due to ice in the channel.

For larger floods the effects of ice and snow in the channel are small compared to the problems brought on by overland flow and backwater from the Red River of the North.

VELOCITIES

Flow velocities along the Snake River for improved conditions are shown in the following table. The channel velocities for the 10-year flood range from about 1.3 fps (feet per second) at river mile 19.8 to about 5.2 fps at river mile 28.8. The flow velocities for improved conditions are not significantly higher than those computed for existing conditions. In general, average channel velocity increases less than 16 percent. Therefore, project-induced erosion is not expected to be a problem.

Velocities for project conditions on Snake River for 10-year flood conditions

Cross section	River mile	Discharge, 10-year flood (cfs)	Average velocities		
			Left overbank (fps)	Channel (fps)	Right overbank (fps)
8	3.8	6,430	0.3	2.3	0.2
15	8.7	6,160	0.3	2.6	0.3
25	16.1	4,190	0.2	2.0	0.2
38	19.8	4,010	0.2	1.3	0.2
44	21.4	3,560	0.2	1.5	0.2
55	26.2	3,350	0.2	1.3	0.2
62	28.8	2,965	0.0	5.2	0.0
109	45.7	2,460	0.6	2.9	0.6
111	47.5	2,375	0.7	2.8	0.7
125	51.1	2,350	0.3	3.2	0.6

BRIDGE CLEARANCES

Numerous bridges cross the Snake River in the area proposed for snagging and clearing. The low-beam elevations of the bridges are shown with the plotted water surface profiles on plates 2 through 4 in the main report. Despite the low elevations of most of these bridges, the magnitude of the resultant channel capacities under the proposed plan would not warrant any bridge alterations. Many of the bridges in the project reach have multiple piers which have caused large accumulations of debris during past floods. However, debris clearance to a point 20 feet from the top of the primary bank has been included in the selected plan as a preventive measure and could reduce future flood stages and maintenance costs.

DETAILED COST ESTIMATE

BASIS FOR ESTIMATE

Cost estimates were based on field survey information obtained from sample sections within the various reaches of the river. These cost estimates were adjusted to reflect the average bid prices received for similar work within the St. Paul District. Because of the nature of the work and the difficulties involved in determining quantities and construction methods, an allowance of 20 percent for contingencies is included.

FIRST COSTS

The detailed estimate of first costs for work recommended in this report is given in the following table. Detailed costs are based on October 1980 price levels.

Item	Unit	First costs Quantity	Unit cost	Total cost
Federal first costs				
Snagging and clearing				
Reach 1	Mile	21.0	$3,500	$73,500
Reach 2	Mile	6.0	6,000	36,000
Reach 3	Mile	9.0	12,000	108,000
Reach 4	Mile	2.5	1,000	2,500
Reach 5	Mile	12.5	15,000	187,500
Planting of shelterbelt	-	Job	Sum	53,000
Contingencies				92,100
Total Federal construction cost				552,600
Engineering and design				55,300
Supervision and administration				
Supervision and inspection				24,900
Overhead				14,400
Total supervision and administration				39,300
Non-Federal first costs				
Lands, easements, and rights-of-way				50,000
Total first costs				697,200

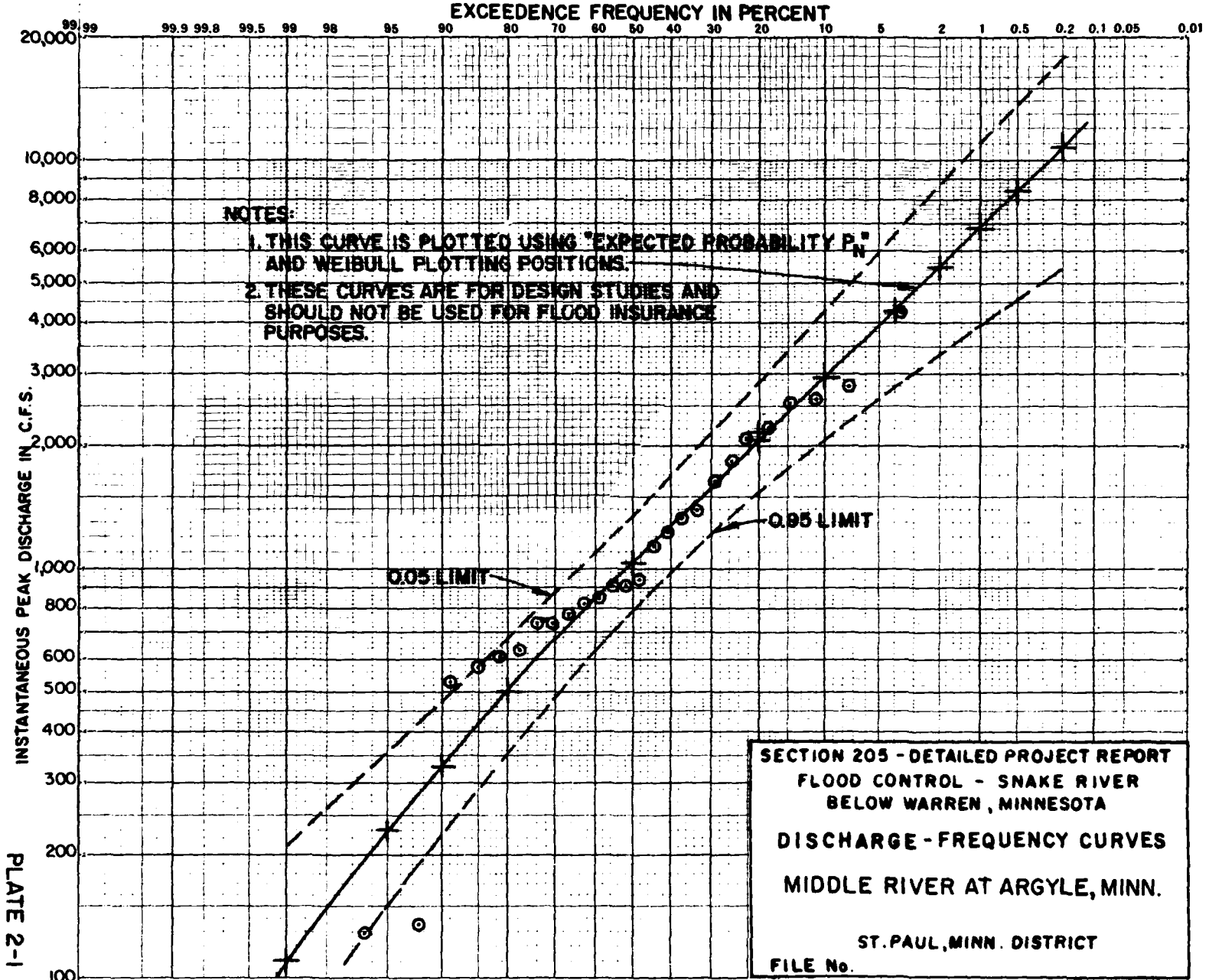
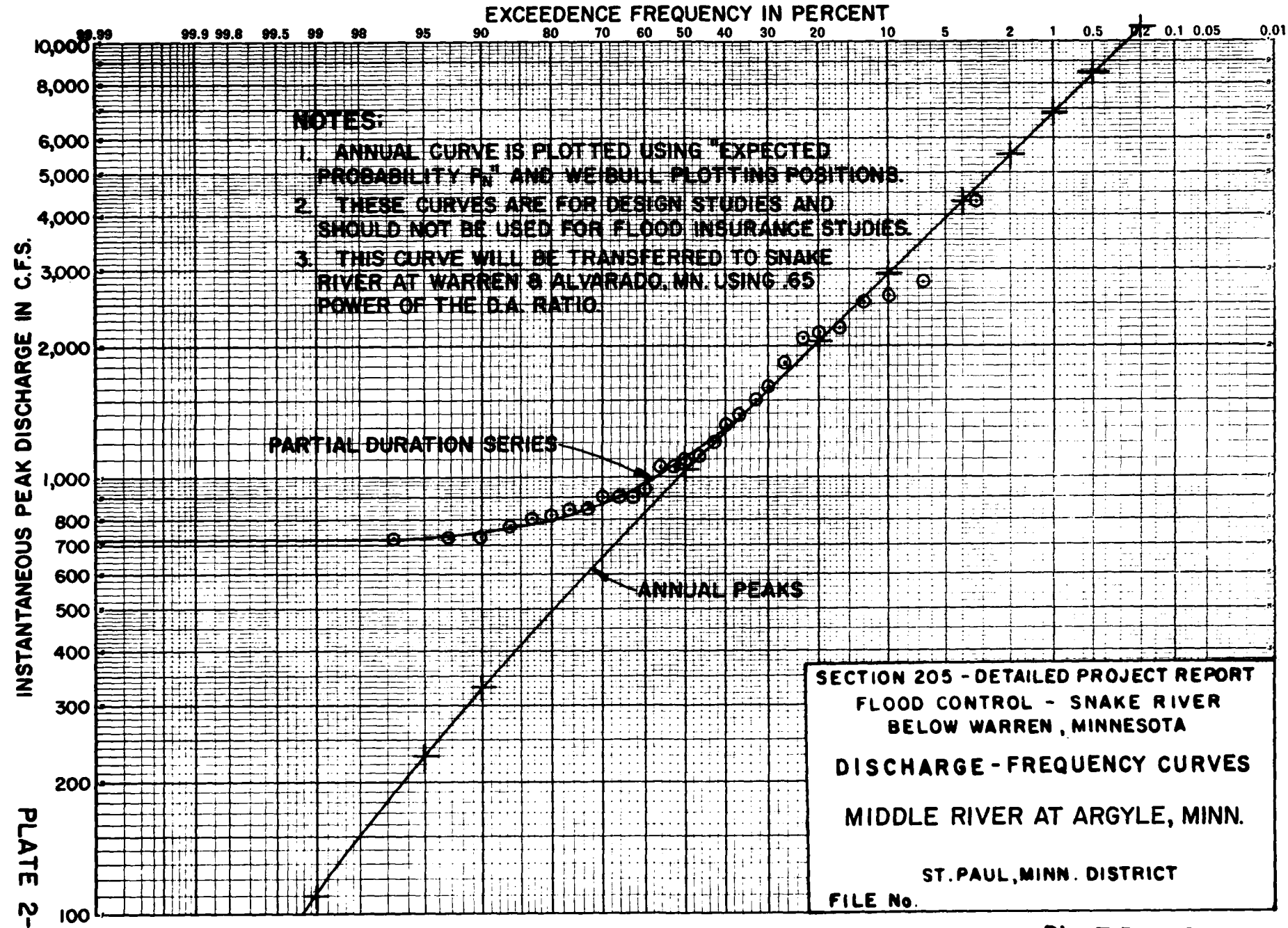


PLATE 2-1

PLATE 2-1


EXCEEDENCE FREQUENCY IN PERCENT
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99.8
99.5
99
98
95
90
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70
60
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40
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2
1
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0.1
0.05
0.01
INSTANTANEOUS PEAK DISCHARGE IN C.F.S.
10,000
8,000
6,000
5,000
4,000
3,000
2,000
1,000
800
700
600
500
400
300
200
100
NOTES:
1. ANNUAL CURVE IS PLOTTED USING "EXPECTED PROBABILITY P_N" AND WEIBULL PLOTTING POSITIONS.
2. THESE CURVES ARE FOR DESIGN STUDIES AND SHOULD NOT BE USED FOR FLOOD INSURANCE STUDIES.
3. THIS CURVE WILL BE TRANSFERRED TO SNAKE RIVER AT WARREN & ALVARADO, MN. USING .65 POWER OF THE D.A. RATIO.
PARTIAL DURATION SERIES
ANNUAL PEAKS
SECTION 205 - DETAILED PROJECT REPORT
FLOOD CONTROL - SNAKE RIVER
BELOW WARREN, MINNESOTA
DISCHARGE - FREQUENCY CURVES
MIDDLE RIVER AT ARGYLE, MINN.
ST. PAUL, MINN. DISTRICT
FILE No.
PLATE 2-2

PLATE 2-2

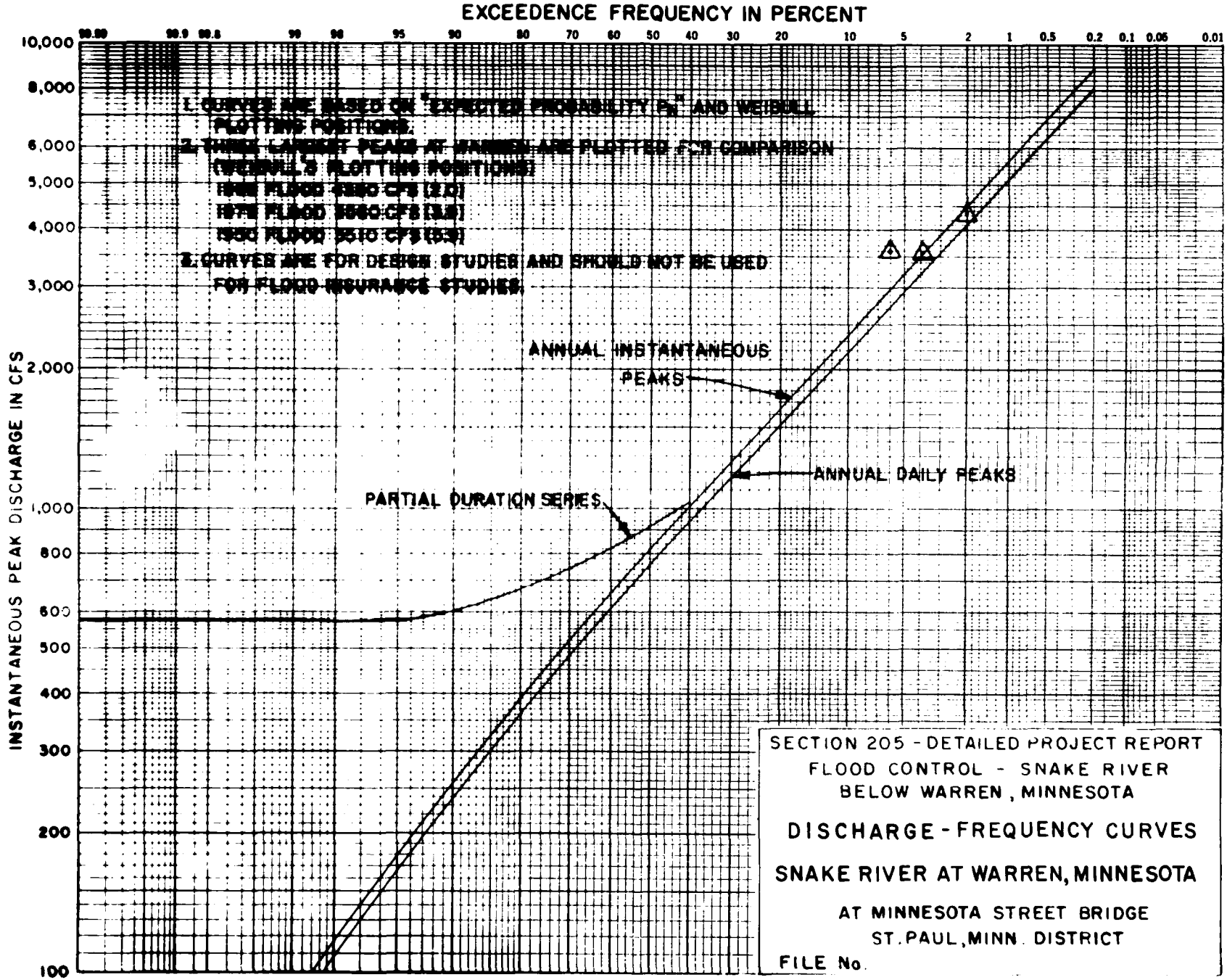


PLATE 2-3

PLATE 2-3

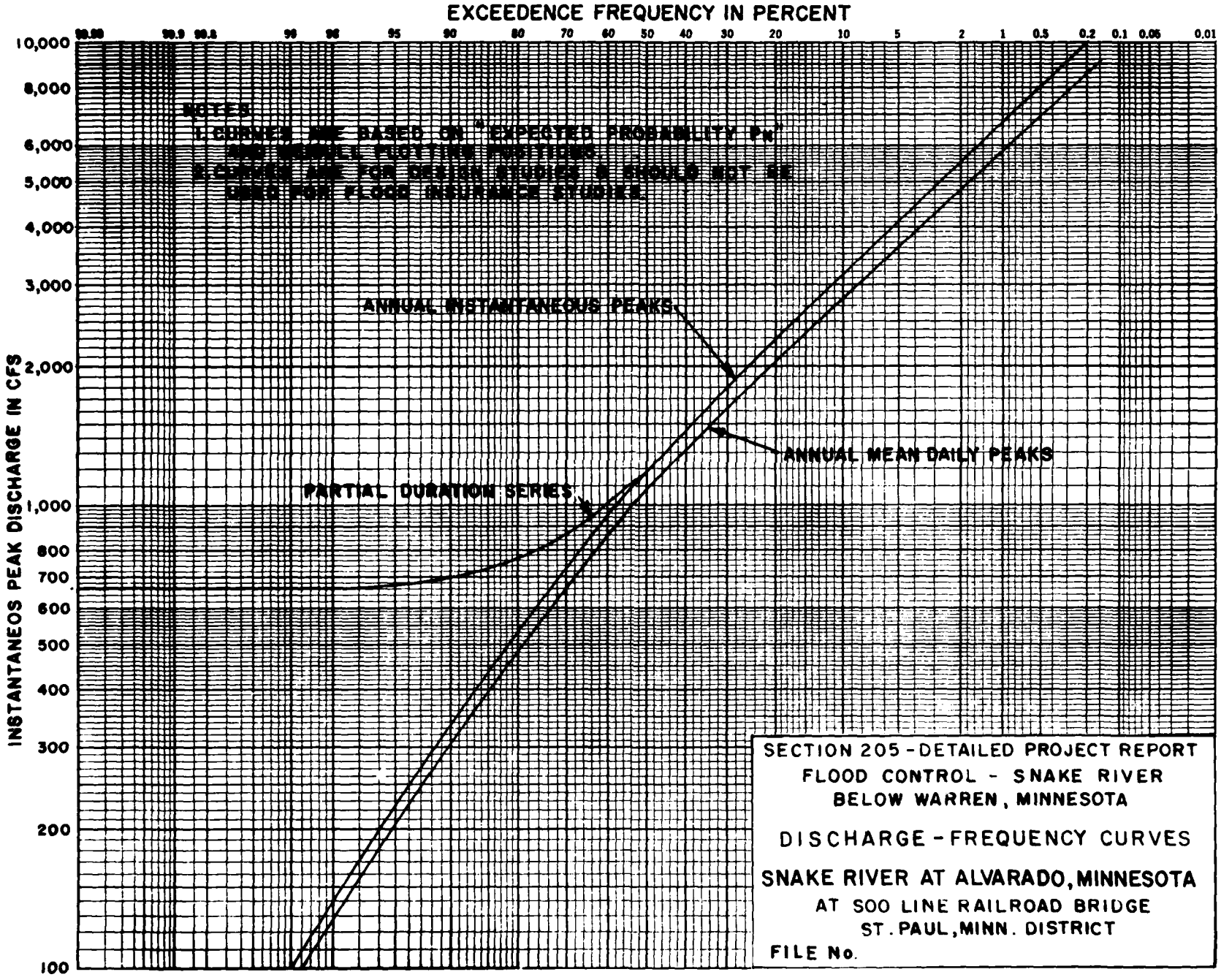


PLATE 2-4

PLATE 2-4

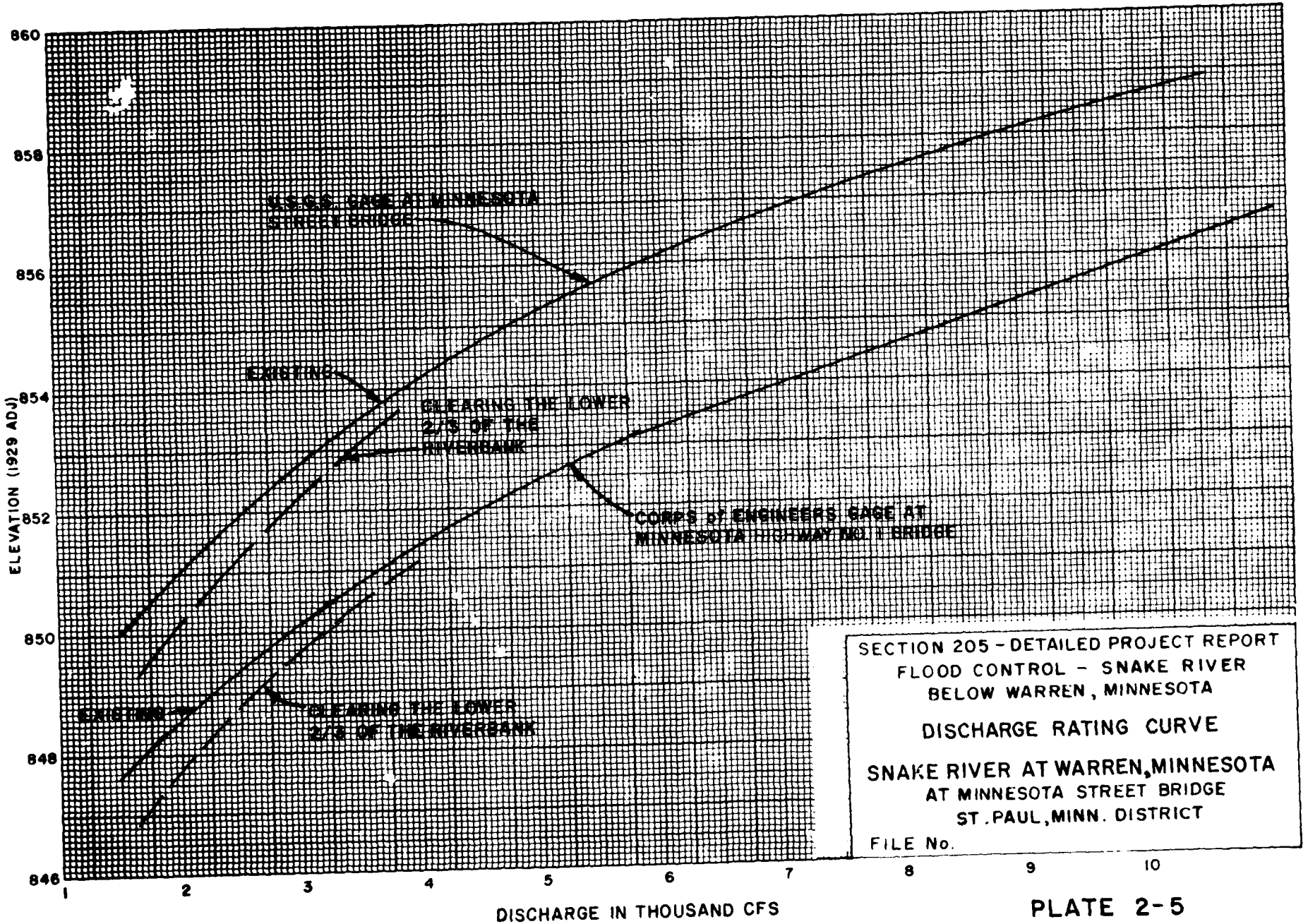
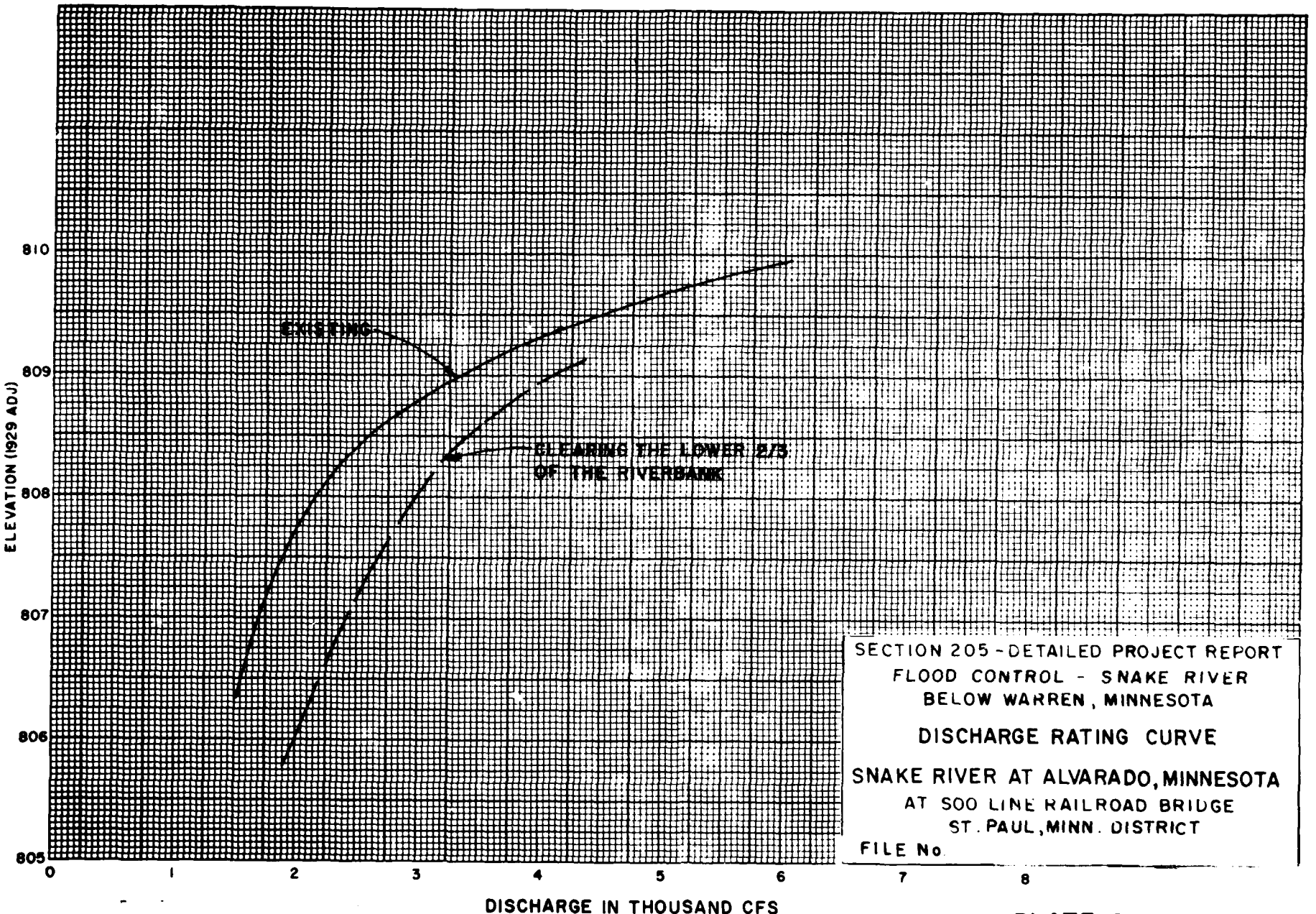

860
858
856
854
852
850
848
846
ELEVATION (1929 ADJ)
1
2
3
4
5
6
7
8
9
10
DISCHARGE IN THOUSAND CFS
U.S.C.E. GAGE AT MINNESOTA STREET BRIDGE
EXISTING
CLEARING THE LOWER 2/3 OF THE RIVERBANK
CORPS of ENGINEERS GAGE AT MINNESOTA HIGHWAY NO. 1 BRIDGE
EXISTING
CLEARING THE LOWER 2/3 OF THE RIVERBANK
SECTION 205 - DETAILED PROJECT REPORT
FLOOD CONTROL - SNAKE RIVER
BELOW WARREN, MINNESOTA
DISCHARGE RATING CURVE
SNAKE RIVER AT WARREN, MINNESOTA
AT MINNESOTA STREET BRIDGE
ST. PAUL, MINN. DISTRICT
FILE No.

PLATE 2-5



SECTION 205 - DETAILED PROJECT REPORT
FLOOD CONTROL - SNAKE RIVER
BELOW WARREN, MINNESOTA

DISCHARGE RATING CURVE

SNAKE RIVER AT ALVARADO, MINNESOTA
AT SOO LINE RAILROAD BRIDGE
ST. PAUL, MINN. DISTRICT

FILE No.

PLATE 2-6

APPENDIX 3

LETTERS OF COMMENT

TABLE OF CONTENTS

United States Department of Agriculture
Forest Service
Northeastern Area State and Private Forestry
370 Reed Road — Broomall, PA 19008
(215) 596-1672

1950
September 25, 1979

Colonel William D. Badger
Department of the Army
St. Paul District, Corps of Engineers
135 U.S. Post Office & Custom House
St. Paul, MN 55101

Refer to: NCSED-ER
Draft Environmental Statement
Flood Control, Snake River, MN

Dear Colonel Badger:

We feel that any complete or large scale removal of trees and shrubs from the riverbank should be avoided. Woody vegetation reduces erosion of the banks more effectively than grass alone; since erosion is reduced, sedimentation downstream including the Red River, is reduced as well. If flooding should occur after clearing of these trees and before establishment of grasses, bank erosion could be severe. Streamside plants, combined with higher-growing plants, have water-holding capacity that tends to reduce run-off.

3-1

Thank you for the opportunity to review this Statement.

Sincerely,

DALE O. VANDERPOOL
Draft Director
Environmental Quality Evaluation

CORPS RESPONSE TO U.S. DEPARTMENT OF AGRICULTURE - FOREST SERVICE

There will not be complete or large scale removal of trees and shrubs from the riverbank. (Refer to Section 1.00.)

United States Department of the Interior

ER-79/810

September 24, 1979

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

Dear Colonel Badger:

We have reviewed the draft environmental statement (DES) and draft detailed project report for flood control on the Snake River, Marshall, Polk, and Pennington Counties, Minnesota. The following comments are provided for your consideration:

General Comments

Mineral production in Marshall, Pennington, and Polk Counties is limited to lime and sand and gravel. We do not believe the proposed project would adversely affect mineral production in those counties.

3-2

No effects of the project upon units of the National Park System or involving the jurisdiction or expertise of the National Park Service have been identified during project review. The area under National Park Service administration nearest the site is Voyageurs National Park, 125 airline miles to the east.

We believe that the project will provide flood damage reduction benefits and yet be undertaken in a manner that should not create significant adverse impacts to fish and wildlife or fish and wildlife habitat along this 50-mile reach of the Snake River. We also believe that the 3-row shelterbelts (30-feet wide) also proposed along the various unprotected sections of the riverbank are an excellent project feature and the Corps should be commended for this effort. These shelterbelts should not only help to reduce snow accumulations and erosion and sedimentation in these areas but also provide food, cover, and a migrational corridor for wildlife. This is an area of Minnesota where agricultural clearing has eliminated or significantly reduced most of the natural wildlife habitat.

The primary impact of the project on fish and wildlife resources would be due to the loss of floodplain vegetation within the wetted portion and along the lower two-thirds of the primary bank. Clearing of the channel likely will result in increased snowmobile activity within the channel and adversely impact some wildlife species along this reach of the Snake River. In our opinion, however, the project should not have a degrading effect on this riverine floodplain area or have more than a minimal adverse impact on fish and wildlife in these area. Because of this, the project would comply with Executive Order 11988.

We suggest that one additional statement be included in the Final Environmental Impact Statement as follows: "The construction features and measures proposed should be adequately documented in the construction contract and fully understood and undertaken by the contractor(s)." The proposed construction techniques and equipment used (hand axes, snowmobiles, etc.) should also be addressed in the FEIS.

Specific Comments

Page 40, paragraph 4.38. The draft environmental statement (DES) states that there are nine sites which may be eligible for listing in the National Register. We urge the Corps to complete testing at these sites and request formal determinations of eligibility from the keeper of the National Register. We also recommend that the effects the project will have on these sites be more thoroughly analyzed and discussed. If the sites are determined eligible for the National Register and the impacts on them are adverse, the Corps should work with the Advisory Council on Historic Preservation (ACHP) and State Historic Preservation Officer (SHPO) to provide acceptable mitigation measures. 3-3

We also suggest the Corps contact the Interagency Archeological Service, Heritage Conservation and Recreation Service, Midcontinent Region, P.O. Box 25387, Denver Federal Center, Denver, Colorado 80225, for assistance in discussing acceptable mitigation measures for any site to be affected by the project. The final environmental statement should contain any memorandums of agreement prepared in consultation with the SHPO and ACHP.

Sincerely yours,

David L. Jarvis
Regional Environmental Officer

CORPS RESPONSE TO THE U.S. DEPARTMENT OF THE INTERIOR

The nine sites which were recommended for further testing will not receive any further testing. It has been determined that all these sites can be avoided during clearing and snagging operations. Protective measures such as in-field site boundary identification will be undertaken to insure avoidance of these sites. This project will therefore have no adverse impact upon any of the 32 sites located during the 1975 cultural resources survey.

SEP 10 1979

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

Attention: NCSED-ER

Re: Environmental Impact Statement and Detail Project Report for Flood Control on the Snake River
Warren, Minnesota

Dear Colonel Badger:

We have reviewed the referenced documents which you submitted to the Minnesota Pollution Control Agency under cover letter dated August 6, 1979 and we have the following comments regarding our position on your proposals.

1. You are well aware that the State of Minnesota and North Dakota have been involved in a series of negotiations regarding flood control in the Red River Valley. Flood impacts on the Red River should be extensively discussed before any action is taken. The project should only be undertaken in such a manner to as not to cause increased flood stages on the Red River of the North. We also feel that any action taken in the Red River watershed which may affect the State of North Dakota should be coordinated with that state.

2. The MPCA regulates the disposal of trees, stumps, and other such waste. Therefore, approval for the disposal of these materials must be obtained from the MPCA, Division of Solid Waste. If burning of the debris will be used as a disposal method, a permit from the MPCA, Division of Air Quality must be obtained.

3. We are concerned that the potential water quality impacts of the project have not been discussed in sufficient detail. It appears that there will be temporary and long term effects on siltation from the clearing and grubbing activity due to initial erosion and the subsequent change in the regime of the river. Effects on the water temperature and the aesthetic impacts of the tree removal should also be discussed in more detail.

(612) 296-7225

CORPS RESPONSE TO THE MINNESOTA POLLUTION CONTROL AGENCY

1. Increased channel velocities would result in an earlier flood peak and a reduction in flood duration. This earlier Snake River peak would cause a minimal adverse impact on the Red River flooding downstream of the mouth of the Snake River.

2. Comment noted.

3. There would be a minimal, if not insignificant, impact on Water Quality. Shelter belts would reduce wind-blown channel siltation with a resultant effect of reduced turbidity. All grubbing activities would be limited to channel debris. Trees and stumps would either be left intact or cut flush with the ground. In all cases, channel stability would be of the highest priority. Some negative aesthetic impacts would result from tree removal, but these negative impacts would be offset by the positive effects of the shelterbelt plantings.

4. Maintenance of the project will be a local responsibility. The nature and extent of the maintenance should be carefully detailed to allow a careful evaluation of the total impacts of the project and to insure that local agencies understand their duties and responsibilities they will have under the proposed project. We are concerned whether the $15,000 annual maintenance cost reflects costs due to increased need for erosion protection or will that be an additional cost to local, State, or Federal agencies. We are also concerned that without proper maintenance the project will have a much shortened or nonexistent life expectancy.

If you have any questions regarding our position, please feel free to contact me or Mr. Louis Flynn of my staff at (612) 296-7225.

Yours truly,

Barry C. Schade
Acting Director
Division of Water Quality

BCS/LLF:cg

CORPS RESPONSE TO THE MINNESOTA POLLUTION CONTROL AGENCY (CONTINUED)

4. Project maintenance, as specified under the Sec. 205 authority, is a local responsibility and would be conducted under the same constraints as the initial project construction.

STATE OF MINNESOTA
DEPARTMENT OF NATURAL RESOURCES
CENTENNIAL OFFICE BUILDING • ST. PAUL, MINNESOTA • 55155

OFFICE OF THE COMMISSIONER
(612) 296-2549

November 2, 1979

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

Re: NCSED - ER, DEIS and DPR for Snake River Snagging and Clearing Proposal

Dear Colonel Badger:

The Department of Natural Resources has reviewed the Draft EIS and the Detailed Project Report (DPR) for the proposed Snake River snagging and clearing project and offers the following comments.

Our primary concern is that neither the DEIS or the DPR discuss the possible adverse effects of this project on downstream flood flows. There is a great deal of ongoing public and agency concern regarding activities which increase flood flows and result in damage to structures and agricultural land along the Red River.

The report states on page H-9 that the channel capacity from river mile 21.2 to Warren will increase from 600 cfs to 900 cfs or 50%. It is also stated on page H-12 that channel velocities will increase up to 16%, which is considered insignificant in terms of erosion potential. 3-6

The report also states on page H-12 that "County and judicial outlet ditches have been cleaned out and improved only to a limited extent because of a lack of adequate major outlets. The Middle River-Snake River Watershed District has made a study of needed improvements in the watershed and the improvements are expected to be installed as the main channels of the Middle and Snake Rivers are improved". Therefore, not only will this project have the potential for increasing flood flows downstream, it will have the added impact of encouraging the improvement of the existing drainage system since the main channel will now be able to handle it.

We request that the Corps look into these possible impacts and discuss them in the final documents, including an analysis of the downstream damages that could result and how this affects the benefit-cost ratio. Some of the benefits claimed are not true benefits if flood damages are merely transferred from one location to another.

We hope these comments will be useful in your preparation of the final EIS and report.

Yours truly,

Joseph N. Alexander
Commissioner

cc: C. Cohn, F. Fitch,

CORPS RESPONSE TO THE MINNESOTA DEPARTMENT OF NATURAL RESOURCES

Increased channel velocities would result in an earlier flood peak and a reduction in flood duration. This earlier Snake River peak would cause a minimal adverse impact in the Red River flooding downstream of the mouth of the Snake River.

Minnesota
Department of Transportation
Transportation Building
St. Paul, Minnesota 55155

CORPS RESPONSE TO MINNESOTA DEPARTMENT OF TRANSPORTATION

September 18, 1979

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

In Reply Refer To: 702
Snagging and clearing for flood control
Snake River, Minnesota
Draft Environmental Impact Statement

Dear Colonel Badger:

The Minnesota Department of Transportation has reviewed the draft environmental impact statement prepared by the Corps of Engineers for flood control on the Snake River in Minnesota. The proposed action is not anticipated to impact any existing or proposed facilities under the jurisdiction of our department. However, we wish you to note the proposed replacement of Bridge No. 6971 on Trunk Highway 210 over the Snake River, 1 mile south of Alvarado, Minnesota. The letting of the construction contract for this project is scheduled for November 1979.

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Comment noted.

Thank you for the opportunity to review this report. If you have any questions please contact Randy Halvorson, Office of Environmental Affairs, at (612)296-1636.

Sincerely,

Richard P. Braun
Commissioner

STATE OF MINNESOTA)
)ss
COUNTY OF MARSHALL)

EXCERPT FROM THE MINUTES OF THE MAY 18, 1981 MEETING OF THE
BOARD OF MANAGERS OF THE
MIDDLE RIVER-SNAKE RIVER WATERSHED DISTRICT

RESOLUTION OF INTENT TO PROCEED WITH FLOOD CONTROL PROJECT
ON THE SNAKE RIVER BELOW WARREN, MINNESOTA

WHEREAS: Local interests have been involved in the planning process for the proposed project, and have reviewed information contained in the draft detailed project report.

WHEREAS: The Watershed District supports the flood control measures recommended in the detailed project report, and has the legally constututed authority and financial capability to satisfy all requirements of local cooperation.

WHEREAS: We understand that the local cooperation requirements will be included in the final detailed project report and the local cooperation (Section 221) agreement. We also understand that construction of the project is contingent upon approval of the detailed project report, the availability of construction funds, and negotiation of the Section 221 agreement, which is the final legal constraint between the Watershed District and the Federal Government.

NOW, THEREFORE, BE IT RESOLVED that the Board of Managers of the Middle River-Snake River Watersehd District intends to:

a. Provide without cost to the United States all lands, easements, right-of-way, utility relocations and alerations, and highway or highway bridge construction and alterations necessary for project construction. The non-federal participation in non-structional measures shall not exceed 20 percent of the costs.

b. Hold and save the United States free from damages due to the construction works and adjust all claims concerning water rights, but not including damages during construction, operation and maintenance which are due to the fault or negligence of the United States or its contractors.

c. Maintain and operate the Project after completion without cost to the United States in accordance with regulations prescribed by the Secretary of the Army.

d. Assume full responsibility for all project costs in excess of the Federal cost limitation stated in the first paragraph of this information sheet.

e. Prevent future encroachment which might interfere with proper functioning of the project for flood control.

f. Provide a contribution toward construction costs where special local denefits will accrue in accordance with existing policies for regularly authorized projects.

g. Provide a cash contribution for project costs assigned to project features other than flood control.

h. Comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (Public Law 91-646) in acquiring lands, easements, and right-of-way for the project.

i. Comply with the provisions of Title VI of the Civil Rights Act of 1964 (Public Law 33-352).

I, Iner Quern, Secretary of the Middle River-Snake River Watershed District certify that the above is a correct and complete copy of the above resolution as adopted by the Board of Managers on May 18, 1981.

Subscribed and sworn to before me this 22nd day of May, 1981.

Iner Quern, Secretary

Notary Public

OLIVIA J. GUSTAFSON
NOTARY PUBLIC—MINNESOTA
MARSHALL COUNTY
My Commission Expires Aug. 9, 1986