US Army Corps
of Engineers®
St. Paul District

WATER CONTROL MANUAL

FLOOD CONTROL – MINNESOTA RIVER
MINNESOTA AND SOUTH DAKOTA

HIGHWAY 75 DAM AND RESERVOIR

BIG STONE LAKE – WHETSTONE RIVER PROJECT

UPDATED MARCH 2005

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U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
ST. PAUL, MINNESOTA

MARCH 2005

Updated from
Highway 75 Dam Reservoir Regulation Manual, October 1979

Highway 75 Dam - Service Spillway

Highway 75 Dam - Low Flow Outlet

NOTICE TO USERS OF THIS MANUAL

This Water Control Manual complies with the latest US Army Corps of Engineers guidelines regarding management of water control systems and preparation of water control manuals. The manual is published in loose-leaf form to facilitate modifications. In the future, only those sections, or parts thereof, requiring changes will be revised and replaced.

EMERGENCY REGULATION ASSISTANCE PROCEDURES

In the event that unusual conditions arise during normal business (duty) hours, contact can be made to Water Control by telephone at 651-290-5619 or fax at 651-290-5841. During non-duty hours, assistance can be obtained by contacting one of the following persons, in the order listed below.

Water Control Regulation Assistance		
Ferris W. Chamberlin	Hydraulic Engineer **ferris.w.chamberlin@usace.army.mil**	Duty: 651-290-5619 [redacted]
Jodi L. Kormanik	Hydraulic Engineer **jodell.l.kormanik@usace.army.mil**	Duty: 651-290-5646 [redacted]
Farley R. Haase	Civil Engineering Technician **farley.r.haase@usace.army.mil**	Duty: 651-290-5633 [redacted]
Robert G. Engelstad	Chief, Water Control Section **robert.g.engelstad@usace.army.mil**	Duty: 651-290-5610 [redacted]
Michael R. Knoff	Chief, Hydraulics & Hydrology Branch **michael.r.knoff@usace.army.mil**	Duty: 651-290-5602 [redacted]
John J. Bailen	Chief, Engineering Division **john.j.bailen@usace.army.mil**	Duty: 651-290-5303 [redacted]

Highway 75 Dam and Reservoir

U.S. Army Corps of Engineers
St. Paul District March 2005

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Location: The impoundment created by the Highway 75 Dam is located on the Minnesota River below Ortonville, Minnesota in Big Stone and Lac qui Parle Counties. The dam site is about 9 miles downstream from Big Stone Lake and is located near Odessa, Minnesota just upstream of US Highway 75.

Drainage Area: 1,890 square miles – Total

Datum: 1929 NGVD

Dam:

Type:	Compacted Impervious Earth Fill
Total Length	16,250 feet
Crest of Earth Dam	Elevation 964.5 feet
Top Width of Earth Dam	20 feet
Max Height of Earth Dam	25 feet
Freeboard	3.1 ft above Standard Project Flood

Control Structure:

Service Spillway	
Type	Reinforced Concrete
Length	65 feet
Gate	1 Bascule Leaf Gate
Gate Sill	Elevation 947.3 feet
Emergency Spillway	
Type	Uncontrolled grass-lined
Length	715 feet
Crest	Elevation 956.5 feet
Notch Invert	Elevation 955.5 feet
Low Flow Outlet	
Type	42-inch reinforced concrete conduit
Control	Square Sluice Gate
Intake invert	Elevation 940.0 feet
Discharge invert	Elevation 939.0 feet

Reservoir:	Elevation (feet)	Capacity (ac-ft)	Area (acres)
Top of Dam	964.5		
Spillway Design Pool (Standard Project Flood)	961.4	87,000	7,900
Reservoir Design Pool (Emergency Spillway Crest)	956.5	37,000	6,100
Raised Bascule Leaf Gate	952.3	12,000	2,800
Lowered Bascule Leaf Gate	947.3	3,000	950

I INTRODUCTION

1-01. Authorization for Preparation of this Manual. Authority to prepare "Reservoir Regulation Manuals" for flood control structures regulated by the Corps of Engineers was granted by Engineering Regulation (ER) 1110-2-240, *Reservoir Regulation*, 1958. While the ER has been updated and amended numerous times sine the date of issuance, the document continues to provide the Corps of Engineers with the authority to prepare what became known as "Water Control Manuals" by ER 1110-2-240, *Water Control Management*, 1982. This manual was prepared for the regulation of Highway 75 Dam and Reservoir. It is an update to *Reservoir Regulation Manual, Highway 75 Dam and Reservoir* dated October 1979. This updated manual gave full consideration to Environmental Operating Principals (ER 200-1-5) and was prepared in compliance with the guidelines presented in:

a. Engineering Regulation ER 1110-2-240, *Water Control Management,* 8 October 1982, amended 30 April 1987 and 1 March 1994.
b. Engineering Manual EM 1110-2-3600, *Management of Water Control System*, 30 November 1987.
c. Division Regulation, DIVR 1110-2-204, *Water Control Management, Reporting Current Conditions*, 5 August 1992.
d. Engineering Regulation 1110-2-8156, *Preparation of Water Control Manuals*, 31 August 1995.

1-02. Purpose and Scope. The purpose of this manual is to provide guidance and instruction for project personnel and to serve as a reference source for others who may be involved with the regulation of this project. The manual is for daily use in Water Control Section activities for most foreseeable conditions and occurrences. The manual covers all water control management activities as they relate to the hydraulic and hydrologic aspects of the project.

1-03. Related Manuals and Reports. Prior reports on flood control and improved navigation for the region date from 1849. Some of the information is included in annual reports of the Chief of Engineers. The following is a list of related reports and manuals in chronological order. Additional reports are listed in **Appendix B**.

a. *Diversion of Floodwaters of Little Minnesota River into Lake Traverse*, US Engineer Office, St. Paul, Minnesota, 17 September 1945.
b. *Report on Survey of Minnesota River, Minnesota, For Flood Control and Allied Purposes*, Corps of Engineers, US Army Office of the District Engineer, St. Paul, Minnesota, 3 January 1950.
c. *Interim Reservoir Regulation Manual*, *Lac qui Parle Dam and Reservoir*, Corps of Engineers, US Army, Office of the District Engineer, St. Paul, Minnesota, November 1956.
d. *Interim Report on Survey of Big Stone Lake-Whetstone River Project, Project Modifications*, *Minnesota and North Dakota*, US Army Engineer District, St. Paul, Minnesota, Corps of Engineers, 2 reports dated 30 January 1959 and 24 June 1960.
e. *General Design Memorandum, Minnesota River, Minnesota, In the Interest of Navigation and Related Purposes*, US Army Engineer District, St. Paul, Corps of Engineers, St. Paul, Minnesota, February 1961.
f. *Phase 1 Report for Flood Control and Related Purposes, Minnesota River Basin*, *Minnesota and South Dakota*, Department of the Army, St. Paul District, Corps of Engineers, St. Paul, Minnesota, March 1966.
g. *Lac qui Parle Reservoir and Minnesota River, Channel Improvement, Reservoir Regulation Manual*, US Army Engineer District, St. Paul, Minnesota, Corps of Engineers, July 1966.
h. *Flood Control, Big Stone Lake-Whetstone River, Minnesota and South Dakota, Design Memorandum No. 2, Real Estate, Dam Site and Reservoir Area*, St. Paul District, Corps of Engineers, December 1967.
i. *Water Supply and Water Quality Control Study, Minnesota River Basin Reservoirs, Minnesota, South Dakota, Iowa*, US Department of the Interior, Federal Water Pollution Control Administration, July 1969.
j. *Flood Control, Big Stone Lake-Whetstone River, Minnesota and South Dakota, Design Memorandum No. 1, General,* St. Paul District, Corps of Engineers, August 1969.
k. *Interim Survey Report, 9-Foot Navigation Channel Above Mile 14.7, Minnesota River, Minnesota*, Department of the Army, St. Paul District, Corps of Engineers, St. Paul, Minnesota, 30 January 1970.
l. *Report on Probable Maximum Floods and Standard Project Floods, Minnesota River Basin, Minnesota*, Department of the Army, St. Paul District, Corps of Engineers, St. Paul, Minnesota, June 1971.
m. *Final Environmental Impact Statement, Big Stone Lake-Whetstone River, Big Stone and Lac qui Parle Counties, Minnesota and Grant County, South Dakota,* US Army Corps of Engineers, St. Paul District, December 1971.
n. *Flood Control, Big Stone Lake-Whetstone River, Minnesota-South Dakota, Design Memorandum No. 3*, *Upstream Works on the Minnesota River*, Department of the Army, St. Paul District, Corps of Engineers, St. Paul, Minnesota, June 1973.
o. *Flood Control, Big Stone Lake-Whetstone River, Minnesota-South Dakota, Design Memorandum No. 4*, *Master Plan For Resource Management*,

Department of the Army, St. Paul District, Corps of Engineers, St. Paul, Minnesota, June 1973.

p. *Flood Control, Big Stone Lake-Whetstone River, Minnesota-South Dakota, Design Memorandum No. 5, Upstream Works on the Minnesota River*, Department of the Army, St. Paul District, Corps of Engineers, St. Paul, Minnesota, December 1973.

q. *Forecasting Rainfall and Snowmelt Runoff on Floods on Upper Midwest Watersheds*, St. Anthony Falls Hydraulic Laboratory, University of Minnesota, Lab Report No. 151, June 1974.

r. *Feasibility Report, Silt Reduction Pollution Control, Big Stone Lake, Minnesota and South Dakota,* US Army, Corps of Engineers, St. Paul District, June 1975.

s. *Minnesota River Basin Report*, Southern Minnesota Rivers Basin Commission, February 1977.

t. *Highway 75 Dam and Reservoir, Reservoir Regulation Manual*, Big Stone Lake-Whetstone River Project, Appendix B, Department of the Army, St. Paul District, Corps of Engineers, St. Paul, Minnesota, October 1979.

u. *Upper Mississippi River Subbasins Study, Stage I, Report Alternatives*, Public Law 87-639, US Department of Agriculture, Soil Conservation Service, and Department of the Army, St. Paul District, Corps of Engineers, January 1980.

v. *An Archaeological Reconnaissance Survey of the Proposed Channel Realignment Area at Big Stone Whetstone Flood Control Project, Big Stone and Lac qui Parle Counties, Minnesota,* Kathleen A. Roetzel, Impact Services Incorporated, Mankato, Minnesota, August 1980.

w. *Computer Simulation of Low Flow Conditions, Minnesota River*, Barr Engineering for US Army Corps of Engineers, St. Paul District, 1980.

x. *Final Supplement, Environmental Impact Statement, Modification Project, Big Stone Lake Whetstone River*, Department of the Army, St. Paul District, Corps of Engineers, 1980.

y. *Flood Control, Big Stone Lake-Whetstone River, Minnesota-South Dakota, Supplement To Master Plan For Resource Management*, Department of the Army, St. Paul District, Corps of Engineers, January 1982.

z. *Environmental Assessment, Highway 75 Dam, Low Flow Outlet Riprap Repair, Minnesota River, Lac qui Parle County, Minnesota*, US Army Corps of Engineers, St. Paul District, June 1985.

aa. *Environmental Assessment, Debris Barrier, Whetstone River, Ortonville, Minnesota,* US Army Corps of Engineers, St. Paul District, November 1986.

bb. *Big Stone National Wildlife Refuge Master Plan and Environmental Assessment,* US Department of Interior, Fish and Wildlife Service, 1986.

cc. *Dam Failure Planning Report, Highway 75 Dam*, Minnesota River, Minnesota, US Army Corps of Engineers, St. Paul District, July 1987.

dd. *Operation and Maintenance Manual, Big Stone Lake-Whetstone River Flood Control, Upstream Works Minnesota River, Big Stone County, Minnesota*, US Army Corps of Engineers, St. Paul District, March 1987.

ee. *Sedimentation Rates and Changing Water Quality - Pomme de Terre River Watershed*, West Central Minnesota, Geology Department, University of Minnesota, Morris, Minnesota, Dr. James Van Alstine, March 1987.

ff. *Dam Failure Planning Report, Marsh Lake Dam*, *Minnesota River, Minnesota*, US Army Corps of Engineers, St. Paul District, August 1987.

gg. *Problem Appraisal Report, Operation Plan Evaluation for Highway 75-Lac qui Parle Reservoir*, US Army Corps of Engineers, St. Paul District, September 1987.

hh. *Dam Failure Planning Report, Chippewa Dam, Chippewa River, Minnesota*, US Army Corps of Engineers, St. Paul District, September 1987.

ii. *Emergency Action Plan, Lac qui Parle Flood Control Project*, Corps of Engineers, St. Paul District, October 1988.

jj. *Report On Possible Design Deficiency, Flood Control Project, Big Stone Lake Whetstone River, Big Stone County, Minnesota,* US Army Corps of Engineers, St. Paul District, March 1989.

kk. *Reservoir Operation Plan Evaluation for Highway 75-Lac qui Parle Reservoirs*, *Minnesota River, Minnesota*, Draft Report, US Army Corps of Engineers, St. Paul District, September 1989.

ll. *Drought Contingency Plan, Big Stone Lake-Whetstone River, Highway 75 Dam, Lac qui Parle Reservoir and Minnesota River - Channel Improvement, Reservoir Regulation Manual*, Appendix, Draft Report, US Army Corps of Engineers, St. Paul District, September 1992.

mm. *Minnesota River Assessment Project Report, Report to the Legislative Commission on Minnesota Resources*, Minnesota Pollution Control Agency, January 1994.

nn. *Big Stone Lake Whetstone River Project, Minnesota River, Minnesota, Highway 75 Dam, Periodic Inspection No. 10*, St. Paul District, Corps of Engineers, July 1994.

oo. *The Great Flood of 1993*, *Post-Flood Report, Upper Mississippi River and Lower Missouri River Basins*, US Army Corps of Engineers, North Central Division, Main Report, September 1994.

pp. *Economic Analysis, Agricultural Flood Damages, Lac qui Parle Flood Control Project*, Gulf Engineers and Consultants, Incorporated, Project No. 22302401, Baton Rouge, Louisiana, Volume I: Main Report, Volume II: CACFDAS Output Data, Revised Draft Report, September 1994.

qq. *After Action Report, Spring 1997 Flood in the Red River of the North Basin, Minnesota River Basin and Mississippi River Basin*, US Army Corps of Engineers, St. Paul District, April 1998.

rr. *Big Stone Lake Whetstone River Project, Minnesota and South Dakota, Assessment of the 1997 Flood and Problem Identification Report*, St. Paul District, Corps of Engineers.

ss. *Highway 75 Dam on the Minnesota River near Odessa, Minnesota, Periodic Inspection Report No. 11 for Highway 75 Dam, Bigstone/Whetstone Flood Control Project*, US Army Corps of Engineers, St. Paul District, July 1999.

tt. *After Action Report, Spring 2001 Flood in the Red River of the North, Minnesota River and Mississippi River Basins*, US Army Corps of Engineers, St. Paul District.

uu. *Policy for Implementation and Integrated Application of the US Army Corps of Engineers (USACE) Environmental Operating Principals (EOP) and Doctrine,* Engineering Regulation (ER) 200-1-5, US Army Corps of Engineers, 30 October 2003.

1-04. Project Owner. The United States Government is the owner of the Highway 75 Dam and Reservoir project. The US Army Corps of Engineers owns approximately 254 acres encompassing the embankment, main service spillway, emergency spillway, and low flow outlet works. Also, included in this acreage is a 150-foot wide trans-basin channel within the reservoir that extends from the Minnesota River channel, transects the former Yellow Bank River channel and ends just upstream of the service spillway area. The Corps of Engineers also has acquired about 105 acres of easements within the reservoir that includes right of access to the trans-basin channel. The US Fish and Wildlife Service owns and manages approximately 10,540 acres of project lands and water just upstream of Highway 75 Dam.

1-05. Operating Agency. The Highway 75 Dam and appurtenant structures are operated and maintained by the St. Paul District, Corps of Engineers. Operation and maintenance of the project is the responsibility of Operations Division, Western Flood Control Project Office. The Project Resource Manager and staff are located at the Lac qui Parle Project Office which is located about 40 miles southeast of Highway 75 Dam. Personnel from the Lac qui Parle Project Office perform project maintenance as well as gate adjustments at the Highway 75 Dam as directed by Water Control. The Area Resource Manager's office is in Fargo, North Dakota. **Table 1-1** provides the names, addresses and telephone numbers for personnel associated with the Highway 75 Dam and Reservoir Project.

1-06. Regulating Agency. Regulation of the Highway 75 Dam and Reservoir Project is under the supervision of the Water Control and Hydrology Section, within the

Hydraulics and Hydrology Branch, Engineering and Construction Division of the St. Paul District, Corps of Engineers. A Cooperative Agreement (**Appendix C,** Exhibit 1) between the US Department of the Army and the US Department of the Interior, allows for an annual operating plan to be prepared by the Corps of Engineers and the US Fish and Wildlife Service with particular consideration given to the reservoir water levels desired for waterfowl production and enhancement at various times of the year.

Table 1-1
Project Office Points of Contact

Names and Addresses	Telephone Numbers
Randy Melby, Project Resource Manager Lac qui Parle Flood Control Project 9055 1st Street West PO Box 177 Watson, Minnesota 56295-0177	Duty: 320-269-6303 Non Duty: 320-269-5909 Cellular: 320-226-3299
Project Fax Number, Lac qui Parle Dam	320-269-5858
Tim Bertschi, Operations Project Manager Western Flood Control Project Office Federal Building 15 South 21st Street, Suite 103 Fargo, North Dakota 58103	Duty: 701-232-1894 Non Duty: 701-232-5967 Cellular: 701-238-1680 Fax 701-232-1789

II DESCRIPTION OF PROJECT

2-01. Location. The impoundment created by the Highway 75 Dam is part of the Big Stone Lake-Whetstone River Flood Control Project. **Plates 2-1** and **2-2** show the location of project features. The main project features are the modifications to the silt barrier on the Whetstone River, increased flow capacity at the Big Stone Lake Outlet, channel improvements downstream of the Big Stone Lake Outlet, and creation of the Highway 75 Reservoir. Highway 75 Reservoir is located on the Minnesota River in western Minnesota near the South Dakota state line just downstream of Odessa, Minnesota and within the counties of Big Stone and Lac qui Parle. The dam site is about 9 miles downstream from Big Stone Lake and is, by its name, just upstream of US Highway 75. Highway 75 Dam is located just upstream of Marsh Lake, which is part of the Lac qui Parle Flood Control Project. While actions at Highway 75 Dam have a direct impact on operations at Lac qui Parle Reservoir, the Lac qui Parle Flood Control Project is operated independent of the Big Stone Lake-Whetstone River Project.

2-02. Purpose. In 1960 the Corps of Engineers investigated flood problems on Big Stone Lake and the immediate vicinity. The recommended plan included (1) erosion control and siltation improvements on the Whetstone River, (2) channel improvements downstream of Big Stone Lake (4) increased capacity of the Big Stone Lake outlet, and (5) construction of the Highway 75 Dam as mitigation for the increased outlet capacity. The dam was to provide storage for the increased outflow such that there was no increase in flood damages downstream. A dry reservoir was considered but was not economically justified. Therefore, the project was designed to be multipurpose in that it not only provides flood control, but also provides a means for the enhancement of migratory wildlife. Thus, the Highway 75 Reservoir was born. The authorized purposes and those derived from general Congressional acts along with the relevant public laws are provided in **Table 2-1**.

Table 2-1
Authorized Project Purposes Assigned by Congress

Authorized Purpose	Public Law	Name
Flood Control	PL 74-738	Flood Control Act of 1936
Surplus Water, Recreation	PL 89-72	Flood Control Act of 1944
Fish and Wildlife	PL 85-624	Fish and Wildlife Coordination Act of 1958
Water Supply	PL 92-500	Water Supply Act of 1958
Recreation	PL 78-534	Federal Water Project Recreation Act of 1965
Flood Control	PL 89-298	Flood Control Act of 1965
Water Quality	PL 92-500	Federal Water Pollution Control Act of 1972
Fish and Wildlife	PL 93-205	Conservation, Protection and Propagation of Endangered Species Law of 1973

2-03. Physical Components.

a. Embankment. The Highway 75 Dam consists of two sections of compacted impervious earth fill (including a pervious sand toe drain), separated by about 2,000 feet of high ground, as shown on **Plate 2-3**. The embankment is approximately 16,250 feet long (including spillway sections) and has a maximum height of about 25 feet. It has a top width of 20 feet and side slopes of 1V:3H on the downstream face and 1V:2.5H on the upstream face. The crest elevation is 964.5 feet. The embankment provides 12.2 feet of freeboard above the conservation pool elevation of 952.3 feet, 8.0 feet of freeboard above the emergency spillway crest elevation of 956.5 feet, and 3.1 feet of freeboard above the standard project flood elevation of 961.4 feet.

The upstream face of the embankment is protected by 18 inches of riprap overlying 9 inches of bedding material. The top of the dam consists of a 6-inch layer of stabilized aggregate to facilitate the use of the dam as a roadway for maintenance and observation purposes for operating personnel. Turnouts to provide parking space for wildlife observation are located at intervals along the upstream side of the dam. The downstream face of the dam is covered with 6

inches of topsoil and seeded except where a layer of riprap and bedding sand are placed on the exit face of the underdrain to inhibit the growth of vegetation and maintain the free exit and inspection of seepage water. Typical embankment sections are shown on **Plate 2-4**.

b. Service Spillway. Flood flows are discharged by means of a reinforced concrete gravity weir that is located near the south end of the dam (**Figure 2-1**). The service spillway has a crest elevation of 947.3 feet and a width of 65 feet. Mounted to the crest is an electrically operated Bascule leaf gate that can be raised to elevation 952.3 feet. A reinforced concrete stilling basin is provided at the toe of the spillway chute. The stilling basin is 68 feet long and has a concrete slab with a floor elevation of 934.0 feet. There are five baffle blocks 4.6 feet in height. The end sill has a top elevation of 936.9 feet. A 0.5-mile long discharge channel with a bottom width of 55 feet and lV:3H side slopes connects the service spillway with the Minnesota River. The service spillway plan and profile are shown on **Plate 2-5**.

Figure 2-1. Highway 75 Dam Service Spillway

c. Emergency Spillway. The emergency spillway consists of a 715-foot long grass-lined section that was excavated through a wide section of existing high ground. It can be seen in **Figure 2-2** to the left of the low flow outlet. The plan and profile are presented in **Plate 2-6**. The crest of the spillway is at elevation 956.5 feet and is 50-feet wide. A one-foot deep v-notch ditch is located at the center of the spillway with side slopes of 1V:10H. The purpose is to concentrate flow to the center of the spillway and keep the flow away from the training dikes. Training dikes with side slopes of 1V:3H provide a channel for the flow. They are riprap lined to resist erosion and safely direct the spillway discharges away from the earth dam embankment and into the Minnesota River.

Figure 2-2. Emergency Spillway and Low Flow Outlet.

d. Low Flow Outlet Works. The low flow outlet works consist of a 42-inch diameter reinforced concrete pipe that extends through the embankment near the north end of the dam as shown on **Plate 2-3**. The outlet was constructed in the dry. When completed, an approach channel about 1,000 feet long, with a bottom width of 6 feet and side slopes of 1V:3H, was excavated to connect the intake of

the conduit with the Minnesota River. The approach channel is still evident (**Figure 2-3**). Flow through the conduit is controlled by a sluice gate. An emergency sluice gate is also provided for use in the event of failure of the main sluice gate. At the inlet there is a trash rack and a stop -log bay for dewatering the conduit for inspection or repair of the sluice gates. The sluice gate that controls flow is square whereas the conduit is round; therefore, flow area is not linear with gate opening. The intake and discharge inverts of the conduit are at elevations 940.0 feet and 939.0 feet, respectively. The culvert installation includes seepage diaphragms at 20-foot intervals and an energy dissipater at the outlet. An excavated discharge channel about 400 feet long with a bottom width of 12 feet and side slopes of 1V:3H connects the outlet of the conduit with the Minnesota River. The low-flow outlet plan and profile are shown on **Plate 2-7**. To aid in computing low-flows, a weir was constructed in the discharge channel as shown on **Figure 5-5** and **Plate 2-8**.

Figure 2-3. Low Flow Channel - Looking Upstream.

e. Reservoir. Highway 75 Reservoir is normally operated between pool elevation 947.3 feet (service spillway crest) and elevation of 952.3 feet (Bascule leaf gate fully raised). The dam provides a pool of about 950 acres at elevation 947.3 feet and 2,800 acres at elevation of 952.3 feet. The normally flat pool extends upstream about 7.5 miles, but is not continuous over the entire distance since areas of high ground above elevation 952.3 feet are located within this reach. The shoreline of the reservoir, including that of the islands created by the high ground, is estimated to be 23 miles in length.

In accordance with a request from the US Fish and Wildlife Service, no clearing was done except for construction purposes. For dam construction, all trees and other vegetation were cleared and grubbed for a distance of 100 feet on either side of the embankment centerline. Foundation areas for access roads to the dam and outlet channel spoil bank areas were cleared flush with the ground surface.

f. Oxidation Pond Dike Raise. The village of Odessa has installed sanitary sewers and a disposal system involving the use of sewage oxidation ponds. These ponds were placed near the left bank of the Minnesota River (as shown on **Plate 2-3**) and were formed by dikes surrounding the ponding area. Since the ponds were within the reservoir area of the Highway 75 Dam, construction of the project required raising the dikes about 3.5 feet from elevation 958.0 feet to 961.5 feet. The raise was accomplished by placing compacted impervious fill on the exterior face of the dikes where the existing side slope of 1V:4H on the south and east side of the ponds was maintained. Because of space limitations, the side slope on the north and west side of the ponds was changed to 1V:3H. The new dike construction was covered with 6 inches of topsoil and was seeded.

g. County State Aid Highway No. 15. Construction of the Highway 75 Dam required the raising of County State Aid Highway No. 15 which runs north and south across the reservoir about 2.5 miles west of the dam (see **Plate 2-3**). This roadway was raised to elevation 959.5 feet along the section extending from just

beyond the Yellow Bank River crossing north to a point just beyond the Minnesota River crossing for a total distance of 5,930 feet. As computed at that time, the raise was 3 feet above the one percent exceedence flood event. The roadway has a maximum height of 4.6 feet. Within the limits of the road raise, turnouts, each 90 feet long and spaced at intervals of 400 feet on alternate sides of the road, are provided to facilitate parking for wildlife observation. The roadway consists of a 5-inch thick stabilized aggregate base course with a 1.5-inch bituminous surface.

Also, authorized as part of the modifications was the raising of the Minnesota River bridge by 2-feet 5-inches. However, local officials felt the existing bridge was obsolete and requested a new bridge at this location. The counties of Big Stone and Lac qui Parle designed and constructed the new bridge with the Federal Government contributing the estimated cost of the bridge raise.

2-04. Related Control Facilities. Big Stone Lake Dam is owned and operated by the Upper Minnesota River Watershed District. There are two control structures located at the outlet of Big Stone Lake. The first is a silt barrier to prevent sediment from depositing in Big Stone Lake. All of the following elevations are in NGVD 1929. This structure is a weir with a top elevation of 964.7 feet and has a 30-inch low flow gate located near the shoreline. The other control structure is located at the confluence of the re-aligned Whetstone River and the outlet of Big Stone Lake. This structure consists of an ogee spillway with a crest elevation of 960.70 feet surmounted by eight slide gates that each measure 7 feet high by 10-feet 10-inches wide. There are also two low flow orifices. One is square (4 feet by 4 feet) and the other is round (18 inch diameter). Both inlet and discharge elevations are 961.4 feet and 961.2 feet respectively.

A debris deflection-collection structure was constructed across the Whetstone River. It consists of forty 12-inch steel pilings placed on a line running at a 30-degree angle to the shoreline. A wooden floating boom, attached to the upstream

side of the pilings, extends across the river. The boom is designed to intercept floating debris coming down the river and deflect it toward the right bank. From this point, the material is removed from the river by mechanical means. Riprap bank protection is placed along the right bank from the confluence to a point 200 feet upstream.

2-05. Real Estate Acquisition. The government purchased 10,794.63 acres in fee title land in the Highway 75 Reservoir at a cost of $2,110,314.50. This includes all lands below the taking-line guide-contour of elevation 959.5 feet that represents the static full pool elevation (reservoir design pool) plus 3 feet. In addition, the government has acquired easements on 104.84 acres at a cost of $4,750.00. A map showing project rights-of-way and the taking line contour are provided on **Plate 2-9**.

The Corps of Engineers owns approximately 254 acres encompassing the embankment, main service spillway, emergency spillway, and low flow outlet works. The Corps also has acquired about 105 acres of easements within the reservoir that includes right of way access to the trans-basin channel. The US Fish and Wildlife Service owns approximately 10,540 acres of project lands and waters just upstream of Highway 75 Dam.

2-06. Public Facilities. The *Master Plan for Resource Management, Big Stone Lake Whetstone River* was submitted by the St. Paul District Engineer to the Division Engineer, North Central, in June 1973. This report included a development plan that would provide: (1) access to water oriented facilities for picnicking, hiking, and bank fishing; (2) an overlook point; and (3) a canoe trail. In addition to the initial facilities constructed by the Corps of Engineers (COE), the US Fish and Wildlife Service (USFWS) has provided various public-use facilities. These include a visitor contact station, an interpretive walking trail, a canoe trail, and interpretive signs at the Highway 75 Dam overlook and auto tour road. A list of COE and USFWS recreation facilities are provided in **Table 2-2**.

Table 2-2
Highway 75 Dam and Reservoir Public Facilities

Item	Responsible Agency	Initial Cost $	Responsible Agency	Initial Cost $
Primary Public Use Area				
2-way entrance road	COE	42,500		
Parking area, barriers, guard posts	COE	1,047		
Road to picnic area & auto tour road	COE	32,000		
Contact Station, trash containers			USFWL	3,080
Picnic Area				
Parking area, barriers, guard posts	COE	5,605		
Well, vault toilet	COE	17,200		
Picnic shelter	COE	6,000		
Picnic tables, grills, fireplaces			USFWL	1,500
Inform. station, trash containers			USFWL	5,400
Electricity	COE	2,000		
Canoe Trail				
Parking area, barriers, guard posts	COE	2,660		
Trail preparation, signs			USFWL	23,800
Trash containers			USFWL	200
Interpretive Walking Trail				
Trail preparation, signs			USFWL	24,000
Auto Tour Road				
Asphalt road	COE	88,000		
Parking area, barriers, guard posts	COE	1,748		
Interpretive signs			USFWL	1,000
Trash containers			USFWL	160
Tailwater Fishing Area				
Entrance road	COE	6,000		
Parking area, barriers, guard posts	COE	4,902		
Well, vault toilets	COE	6,200		
Signs			USFWL	500
Trash containers			USFWL	200
Highway 75 Overlook				
Roadway, guard posts	COE	9,430		
Parking area, barriers, guard posts	COE	3,877		
Overlook trail, structure	COE	10,500		
Landscaping	COE	600		
Interpretive signs			USFWL	6,200
Trash containers			USFWL	200
Contingencies $		34,731		9,960
Total Cost $		275,000		76,200

III - HISTORY OF PROJECT

3-01. Authorization. Highway 75 Dam and Reservoir, which is part of the Big Stone Lake-Whetstone River Project, was authorized by the Flood Control Act as approved on 27 October 1965 (PL 89-298) to be constructed substantially as recommended by the Chief of Engineers in House Document No. 579, 87th Congress, 2nd Session. House Document No. 193, 88th Congress, 2nd Session, contains supplemental information relating to land acquisition for the national wildlife system. The authorized improvements included a dam and reservoir on the Minnesota River above United States Highway 75, with acquisition of 1,600 acres of additional lands bordering the reservoir to be used for wildlife conservation and development; modifications of the existing Big Stone Lake outlet control dam and silt barrier; bank stabilization along the lower 6-mile reach of the Whetstone River; and channel improvement on the Minnesota River for 3 miles below the outlet control dam at Big Stone Lake. The project document specifies the following requirements of local cooperation:

a. Project as a Whole: (1) Contribute in cash 20 percent of the cost allocated to flood control to be paid in a lump sum prior to the commencement of pertinent work items, in accordance with construction schedules as required by the Chief of Engineers. **(2)** Hold and save the United States free from damages due to the construction works.

b. Project Exclusive of the Dam and Reservoir: (1) Provide without cost to the United States all lands, easements, rights-of-way necessary for construction of the project. **(2)** Maintain and operate the works after completion in accordance with regulations prescribed by the Secretary of the Army. **(3)** Make at their own expense all necessary changes to highways, highway bridges and approaches, utilities, and miscellaneous existing improvements. **(4)** Prevent encroachments that would reduce the flood-carrying capacity of the improved channel.

c. Interagency Coordination. The project document also specifies that prior to commencement of construction of the dam and reservoir, the Chief of Engineers and the Director, US Fish and Wildlife Service shall prepare a General Plan, mutually acceptable to the Secretary of the Army and the Secretary of the Interior, for administering the use of waters, land, or interest therein for wildlife conservation and development so as to provide the best use for all project purposes; and provided further, that the upstream work not be undertaken until construction has been started on the dam and reservoir. The General Plan (**Appendix C**, Exhibit 2) designates the type of use, in this case a natural migratory bird management program, and defines the land and water areas to be made available for the designated purpose. The US Department of the Army made the land and water areas of the Highway 75 Reservoir available to the US Fish and Wildlife Service through a cooperative agreement (**Appendix C**, Exhibit 1). A Memorandum of Understanding documenting the interagency cooperation involved in operation of the Highway 75 Dam and Reservoir was signed on 3 July 1975 and is shown in **Appendix C**, Exhibit 3.

d. Pre-authorization Studies. The pre-authorization investigations were closely coordinated with other interested and affected Federal, State, and local agencies. Following completion of these studies, public hearings were held to inform all concerned of the proposed plan and of the local cooperation required. Representatives of the Board of Engineers for Rivers and Harbors and of the Office, Chief of Engineers, attended a hearing on this matter that was held at Ortonville, Minnesota on 18 May 1961.

e. Post-authorization Studies. Following project authorization and funding for preconstruction planning, topographic maps were developed from aerial surveys of the entire reservoir area. Additional topographic data were obtained from spot field surveys made in areas for which more detailed information was required. Borings were obtained to adequately define foundation conditions in all project construction areas. Hydrologic and hydraulic data were updated to include information collected since project document studies were completed. Similarly, damage evaluations and

benefits analyses were updated to reflect current conditions and price levels. Thus, hydraulic studies included a review of reservoir capacity and determination of dam height, based on the new topography obtained, and review of the hydraulic design for outlet structures and the channel below the service spillway structure for the dam. Similarly, all earthwork designs for the dam and reservoir were reviewed and modified or expanded as necessary to meet project requirements and current design criteria. A public meeting was held at Ortonville, Minnesota on 15 February 1968, to describe the project plan and land acquisition procedures. The project plan was discussed with representatives of other Federal, State and local agencies.

3-02. Planning and Design. The original Big Stone Lake-Whetstone River project was undertaken by the State of Minnesota in the mid-1930's primarily as a measure to restore Big Stone Lake levels which had receded to undesirably low levels during the drought of that period. Thus, a stop-log control structure was constructed, in part with Federal Emergency Relief funds, just downstream of the outlet of the lake. In addition, the Whetstone River was diverted to discharge into the Minnesota River between the lake outlet and the control structure. The project was also planned to serve flood control by storing surplus floodwaters in the lake and discharging regulated flows from the lake after flood conditions had subsided. However, the State of Minnesota was unable to acquire necessary flowage rights on Big Stone Lake and through court action was required to pay claims for damages brought about by storage of flood flows in the lake. Therefore, in 1947 the State ceased any attempts to regulate levels on Big Stone Lake. Local interests then claimed that the Big Stone Lake-Whetstone project had resulted in acceleration of silt deposition in the lower end of Big Stone Lake and with no operation of the stop-log control structure still caused undesirably high lake levels without adequately providing for maintenance of lake levels during drought periods.

As a result, the Minnesota Department of Conservation in the 1950's in cooperation with State interests in South Dakota developed a plan of improvement with associated project costs. The plan was designed to direct flood flows from the

Whetstone River directly into the Minnesota River below the control structure thus bypassing Big Stone Lake. This plan included realignment of the Minnesota River channel downstream to a point below US Highway 75 and was designed to provide for Yellow Bank River flows. However, the estimated costs for the project plan exceeded available State funds and, consequently, Federal assistance was requested in view of the anticipated flood control benefits.

The Corps of Engineers conducted an investigation in 1960 that verified the existence of several flood and related problems on Big Stone Lake and in the immediate vicinity. These problems included unsatisfactory fluctuations of water levels and excessive silting in of Big Stone Lake, both attributable to the diversion of the Whetstone River into the lake; and flooding in the Minnesota River Valley in the reach immediately below the lake which was aggravated by prolonged periods of high discharges from the lake. Early in the investigation it became evident that solutions in Big Stone Lake resulting from transfer of flood storage downstream as proposed by the State would require provision of alternative storage in Lac qui Parle or Marsh Lake to prevent an increase in flood damages downstream of Lac qui Parle Reservoir. The estimated costs for providing compensating storage in either Lac qui Parle or Marsh Lake, when added to the costs of the other necessary components of the plan, resulted in total project costs that far exceeded the anticipated benefits. Increased use of Big Stone Lake for flood storage, although unacceptable to local interests, was also considered. However, when combined with necessary downstream channel improvements, acquisition of additional lands around the lake, and other necessary project modifications, was found not to be economically feasible. Each of these plans would have been met with strong opposition from conservation interests since wildlife habitat would be adversely affected.

The most practical plan included a new retarding reservoir located immediately above US Highway 75 combined with modifying the Big Stone Lake outlet structure. Modifications included the replacement of the stop-log structure with a gated spillway, raising the silt barrier by one foot, channel improvements on the Minnesota

River below the outlet structure, and constructing erosion control works on the Whetstone River. The gated spillway would have increased flow capacity thereby reducing the flood threat on Big Stone Lake. The reservoir was designed to permit retention of a variable level conservation pool. To insure that increased levels in the pool would not adversely affect an existing high ground-water problem at Odessa, improvement of a drainage channel north and east of the community was included in the plan. Improvements solely for flood control were found to lack economic justification and, in fact, to be undesirable in view of the substantial recreation and wildlife potential of the region. Therefore, the project was designed to be multipurpose in nature and provide for betterment of recreation conditions on Big Stone Lake and substantial enhancement of migratory wildlife values in the reservoir above US Highway 75. The latter benefits were assured through the creation of a national wildlife refuge as part of the proposed plan of improvement.

The spillway was designed to pass the largest flood of record with no flow over the emergency spillway. At the time of design the flood of record was 1952. This flood had an estimated peak discharge frequency of once in about 66 years and a volume frequency of once in about 83 years. The maximum spillway discharge for a recurrence of the 1952 flood was determined to be 6,600 cfs with a pool elevation of 956.3 feet. Based on a flat pool, the impoundment would be around 30,000 acre-feet with a pool area of approximately 6,000 acres. This established the crest elevation of the emergency spillway at 956.5 feet.

The emergency spillway was designed for the Standard Project Flood (SPF). The SPF was developed for a contributing drainage area of 995 square miles in accordance with Civil Works Engineer Bulletin No. 52-8 entitled, *Standard Project Flood Determination*. The SPF was routed through the reservoir using the combined service and emergency spillway rating-curve. The reservoir was assumed to be at 50 percent capacity and the storage capacity curve for a sloping water surface was used. The maximum pool elevation attained was 961.4 feet. By adding 3.0 feet of freeboard and raising the elevation to the nearest half-foot, the top of dam was

established at elevation 964.5 feet (1929 NGVD). The discharge over the emergency spillway was computed to be around 20,000 cfs with approximately 13,300 cfs through the service spillway. The impoundment would be 87,000 acre-feet with a peak tailwater elevation of 955.8 feet.

3-03. Construction. Construction of Highway 75 Dam was initiated in July 1971 and the project was completed in July 1974 at a cost of $3,092,006. A construction contract for the upstream Minnesota River channel improvement and modification to the existing Big Stone Lake outlet control structure was awarded in May 1983 and substantially completed in November 1985. A construction contract for a debris barrier upstream of the control structure and raising the silt barrier was awarded in August 1986 and substantially completed in December 1986. In the summer of 1999, adjustments were made to the Limitorque switches and gate stems at Big Stone Lake outlet to allow a maximum gate opening of 11.5 feet (up from 7.0 feet previously).

3-04. Related Projects. Big Stone Lake Dam, located immediately upstream of the Highway 75 Reservoir, is part of the Big Stone Lake-Whetstone River Project and is used for flood control and water conservation. **Paragraph 2-04** provides a description of specific features regarding the upstream portion of this flood control project. There are two hydropower dams downstream of Highway 75 Dam in the vicinity of Granite Falls, Minnesota. **Paragraph 4-11** provides additional information about these two structures.

Immediately downstream of the Highway 75 Dam is the Lac qui Parle Flood Control Project. The Lac qui Parle Project is shown on **Plate 2-2** and consists of Marsh Lake Dam, Lac qui Parle Dam, the Chippewa River Diversion structures, and the Minnesota River channel improvements down to Granite Falls, Minnesota. Lac qui Parle Dam is immediately downstream of Marsh Lake Dam. The reservoirs extend upstream for a distance of about 27 miles. The Chippewa River Diversion Dam and the Watson Sag Weir divert high flows on the Chippewa River into Lac qui Parle

Reservoir. For more complete information regarding this project see the *Lac qui Parle Reservoir Water Control Manual*, 1995.

3-05. Modification to Regulations. Prior to commencement of the construction of the Highway 75 Dam, the Chief of Engineers and the Director of US Fish and Wildlife Service prepared a general plan of operation that was considered mutually acceptable to the Secretary of Army and Secretary of the Interior, for administering the use of waters, land, or interest therein for wildlife conservation and development so as to provide the best use for all project purposes. As part of this agreement, the Corps of Engineers and the US Fish and Wildlife Service make modifications to the regulation of the reservoir on an annual basis. These annual modifications allow for variable conservation pool levels with specific consideration given to enhancement of waterfowl production and management at various times of the year. No modifications to this operating plan have been made.

3-06. Principal Regulation Problems

a. Highway 75 Dam

(1) Gate Vibration. Shortly after construction of the Highway 75 Dam, a vibration problem was detected in the 65-foot Bascule leaf gate. Subsequent analysis determined that the vibration was caused by a self-excited oscillating nappe due to a difference in air pressure on either side of the nappe. This phenomenon was most noticeable when a relatively small amount of water was flowing over the leaf gate with no break in the nappe surface. The problem was resolved by installing steel splitters along the gate lip at relatively close intervals to break up the nappe; thereby, eliminating the possibility of an oscillating nappe that could result in the vibration of the gate.

(2) Gate Settlement. Due to an apparent loss of hydraulic pressure that bleeds off over extended periods of time, the Bascule leaf gate tends to settle as much as 0.1 to 0.2 foot over several weeks and requires it to be reset.

(3) Icing Conditions. During the winter months when the pool freezes over, ice conditions around the service spillway prevent operation of the Bascule leaf gate. Any required discharges from the reservoir must be made through the low flow outlet works.

(4) Service Spillway Pool Gage. The wire weight gage that is anchored on the left wing wall on the upstream side of the service spillway is actually located within the upper nappe of the water surface and therefore doesn't accurately reflect the still water pool elevation. Therefore, the low flow pool gage is generally used to determine the elevation of the reservoir.

(5) Emergency Spillway Erosion. On 2 April 1997, for the first time ever in the existence of the Highway 75 Dam and Reservoir, the pool elevation exceeded the emergency spillway crest elevation of 956.6 feet and flow continued over the grass-lined spillway for a period of 10 days. The emergency spillway performed well with generally minimal erosion occurring at three locations within and near the pilot channel. At approximately 430 feet downstream of the crest and just to the left of the low flow channel, flows eroded an area approximately 65 feet long, generally 2 feet to 3 feet wide (9 feet at the widest spot) and 1 foot to 2 feet deep (3 feet at the deepest spot). A second hole was formed approximately 100 feet upstream of the utility pole at the downstream end of the low flow channel that was approximately 20 feet to 30 feet long, generally 1 foot to 2 feet wide and 3 inches to 6 inches deep. The third area was just upstream of the utility pole at the downstream end of the low flow channel where a hole was created approximately 20 feet to 30 feet long, generally 1 foot to 2 feet wide and 3 inches to 6 inches deep. Also, there appeared to be some erosion around small animal holes. Inspection of the grass-lined spillway following the 1997 flood event also revealed tire ruts 6 to 12 inches deep scattered across the spillway. Some erosion occurred along these tire tracks throughout the spillway. All eroded areas were repaired with clay fill placed in approximately 8-inch lifts and compacted. Topsoil was placed in the last 6 inches of fill and was seeded to provide adequate

grass cover.

Pool elevations exceeded the emergency spillway crest again on 7 April 2001. Flow over the emergency spillway lasted seven days. The grass-lined emergency spillway performed well as inspection of the spillway revealed no visible signs of erosion.

b. Big Stone Lake Dam

(1) Gate Capacity. The outlet control structure for Big Stone Lake was operated in the spring of 1997 in accordance with the flood control regulations prescribed in the Operation and Maintenance Manual. On March 28, with Big Stone Lake levels approaching elevation 965.7 feet, all eight slide-gates were raised to the maximum allowable opening in accordance with the operating plan. The slide gates reached a maximum vertical opening of approximately 7 feet before the Limitorque operator prevented any further vertical movement. Subsequent review of the original design documents for the structure showed that the design intent was to allow the gates to reach a maximum vertical opening of about 12.25 feet. In the summer of 1999, adjustments were made to the Limitorque switches and gate stems to allow a maximum gate opening of 11.5 feet.

(2) Debris Barrier. As part of the modification of the Big Stone Lake Dam in 1983, a debris barrier was constructed upstream of the outlet control structure that was designed to deflect debris to the right bank where it could be picked up and removed so as to not impact performance of the spillway and the control gates. The debris barrier consists of 40 steel pipe piles surmounted with a floating timber frame that is faced with wooden planks that serve as a fender to deflect debris to the shoreline.

In the spring of 1997 and 2001, flood flows in excess of the structure's design level caused significant damage to the timber framing and fender. Consequently, the accumulation of large debris upstream of the control structure threatened the

structure with overtopping flows that required the placement of backhoes and a fifty-foot crane on both sides of the dam for debris removal. Based upon past satisfactory performance of the debris barrier and without any additional investigation for an improved structure, it was the recommendation of the Corps of Engineers to the Upper Minnesota River Watershed District (UMRWD) that permanent repairs be made to the structure to ensure continued safe operation of the control dam for events up to the 100-year design level. The UMRWD is awaiting a response from the Federal Emergency Management Administration as to the availability of federal funds to assist in making these necessary repairs.

IV - WATERSHED CHARACTERISTICS

4-01. General Characteristics. The Minnesota River basin lies mostly in the southern part of Minnesota but also includes small portions of Iowa and South Dakota (**Plate 2-1**). Its total drainage area is considered to be 16,955 square miles, of which about 14,900 square miles are within the State of Minnesota.

From its source in Big Stone Lake, the Minnesota River flows southeast for 224 miles to Mankato where it turns and flows northeast 106 miles to its confluence with the Mississippi River in St. Paul, Minnesota. The average fall of the streambed over its entire length is about 0.8 feet per mile. Throughout its length, the river flows between the high bluffs of a valley and meanders widely across the alluvium deposits. Below Mankato the valley varies in width from one mile to three miles. The land is generally relatively flat to gently rolling and is nearly all cultivated.

In the upper northwest corner of the watershed, Big Stone Lake is formed by a natural lake with a concrete dam just downstream of the outlet. Big Stone Lake has a contributing drainage area of approximately 1,160 square miles of which the Little Minnesota River and the Whetstone River are the major contributors. The Little Minnesota River forms the headwaters of the Minnesota River within the hills of eastern South Dakota and drains an area of about 440 square miles. The Whetstone River, with a drainage area of about 400 square miles, which is almost entirely within South Dakota, flows into Big Stone Lake just upstream of Big Stone Lake Dam. The original confluence of the Whetstone River was downstream from the dam until it was diverted in the 1930's.

Highway 75 Dam is approximately nine miles downstream from Big Stone Lake Dam. The total contributing drainage area of the Minnesota River at the dam is about 1,890 square miles. The Yellow Bank River, with a total drainage of approximately 470 square miles, enters the Highway 75 reservoir just upstream of the dam.

Marsh Lake Dam is below the Highway 75 Dam. The Pomme de Terre River drains an area of about 875 square miles and enters the Marsh Lake reservoir immediately upstream of the dam. Lac qui Parle Dam is located just downstream of Marsh Lake Dam. The Lac qui Parle River has a drainage area of approximately 1,095 square miles and enters Lac qui Parle reservoir just above the dam from the southwest. The drainage area of the Minnesota River watershed above the Lac qui Parle reservoir is 4,050 square miles. Water from a portion of the 2,050 square-mile Chippewa River watershed is diverted to Lac qui Parle reservoir for flood control through the Chippewa River diversion project.

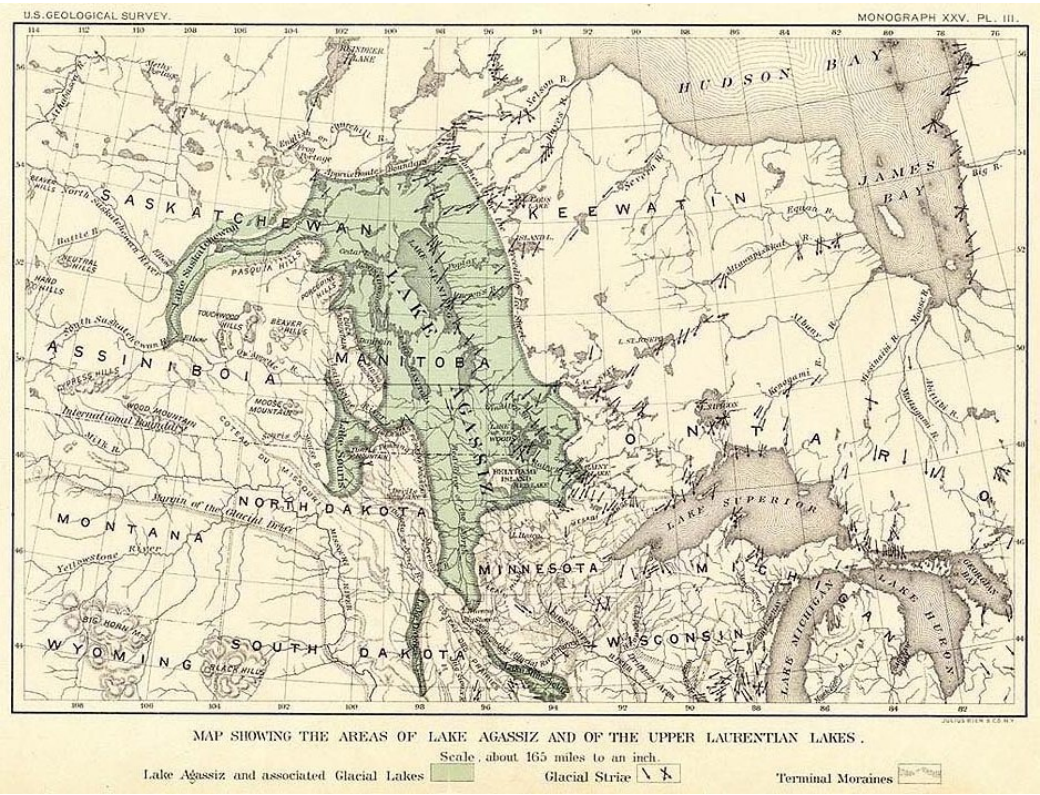
Big Stone Lake, Highway 75 Reservoir, Lac qui Parle Lake, Marsh Lake, and the Minnesota River are the most prominent surface water features in the region. The average stream discharges from the Pomme de Terre and Lac qui Parle Rivers combined, equal more than 30 percent of the average Minnesota River flow at the Lac qui Parle Dam. The Whetstone, Yellow Bank, and Chippewa Rivers contribute less than 10 percent of the average flow. A large artificial drainage network and huge extent of row-cropped land are the predominate features of the watershed.

4-02. Topography. The Minnesota River Valley is in a gently undulating prairie region with elevations ranging from 700 feet to 1,900 feet above sea level. The general topography of the basin is typically glacial characterized by gently rolling hills separated by level outwash plains. Throughout the valley there are numerous depressions ranging from a few feet to about 30 feet below the surrounding prairie. These depressions contain lakes and wetlands of which some have been drained.

4-03. Geology and Soils. Glacial deposits (also known as glacial drift) cover most of the State of Minnesota. Much of the land surface consists of features derived from the several different ice sheets that advanced and retreated from the state. During the Pleistocene Epoch, the entire state was overrun at various times by continental ice sheets except for a small area in the extreme southeastern corner. The debris left by

these ice sheets covered the original landscape to depths ranging from 100 feet to over 400 feet. The glacial till in the area of the Lac qui Parle Project and Highway 75 Dam and Reservoir is made up principally of clays containing a noticeable amount of sand and gravel. The surface soils of the watershed are dark loess and glacial till soils developed under prairie vegetation.

With the retreat of the last ice sheet (Keewatin) about 10,000 year ago, a huge lake known as Glacial Lake Agassiz began to form at the base of the melting glacier. Since the drainage system in the area had been filled by glacial drift, there was no place for this water to drain naturally. The rising water had to reach a height that would allow it to drain to the south. Before drainage in this direction became possible, the lake reached a size, estimated from its ancient beach ridges, ranging from 100 to 200 miles in width and more than 600 miles in length (**Figure 4-1**).



MAP SHOWING THE AREAS OF LAKE AGASSIZ AND OF THE UPPER LAURENTIAN LAKES.
Scale, about 165 miles to an inch.

Figure 4-1. Lake Agassiz.

When the outflow started, the general direction was southeast due to a flatiron shaped plateau known as the Coteau Des Prairies. The plateau is a morainal ridge extending from South Dakota in a southwesterly direction across Minnesota and into Iowa. The elevation of the crest of this ridge was nearly 2,000 feet above sea level. As the tremendous outflow from Lake Agassiz increased so did the erosion into the drift, creating the remarkable valley of the Minnesota River. This ancient river channel ranged in width from 1 mile to 5 miles with depths of 150 feet or more and stretched over 330 miles from Big Stone Lake to the mouth. From the lower end of the lake's outlet at Ortonville, Minnesota, to the vicinity of Lac qui Parle, the erosion carried down to the Archean bedrock of the original landscape. The outlet that was formed is now occupied by Big Stone Lake and Lake Traverse. The formation of these lakes was caused by the alluvial deposits of the Whetstone River and the Little Minnesota River after the drainage of Lake Agassiz was completed.

When the draining of Lake Agassiz was completed, siltation of the main channel began. Tributary streams created alluvial fans where they entered the main stream. These tributary streams within or adjacent to the project were also created by the draining of the water from the melting ice sheet. However, erosion of these tributary valleys did not reach the Archean rock as it did in the main channel. Erosion stopped at depths of 40 to 50 feet below the present drift on a moraine of an earlier ice age that was composed of granite, syenite, and gneiss. Tributary streams to the Minnesota River entering from the south and west have their origin in the above aforementioned Coteau des Prairies, and these streams descend rather rapidly from the upland areas with some dropping as much as 500 feet in a few miles. The Lac qui Parle River drops 790 feet over 66 miles with the greatest fall of 250 feet occurring in an eight-mile reach near Canby, Minnesota. In the lowland plains adjacent to the main Minnesota River channel, the gradient is usually less than 2.0 feet per mile. In the lower 18 miles to the mouth the fall is about 14.0 feet per mile. Tributaries entering from the north, such as the Pomme de Terre River and the Chippewa River, are divided by north-south morainal hills which rise less than 75

feet above the water courses. Drainage in the upland regions of these streams is rather poorly defined with small lakes and marshy areas marking the watercourses.

Between the Pomme de Terre River and Chippewa River mouths are some ancient channels apart from, but in the main Minnesota River Valley which were produced by these streams and carry flows only during periods of extreme floods. One of these abandoned channels is known as the Watson Sag and is now utilized by the Lac qui Parle Project as the Chippewa River Diversion Channel.

The prehistoric river, which created the Minnesota River Valley, was named the River Warren in honor of General G. K. Warren. General Warren explained the origin of the valley in his report on the Examination and Survey of the Minnesota River published as Examination Document #76, 43rd Congress, Second Session, 1866-67. General Warren's surveys, maps, descriptions, and discussions were considered a valuable contribution to science. The Minnesota River has had several names given it by the early explorers in the region. On one of the earliest maps of the region dated 1688, it was shown as the *Des Mascoutens Nadouscioux* or River of the Mascoutins after a tribe of Sioux Indians living in the valley. Another map dated 1754 referred to it as the *River Saint Piene*; however, the most complete map of the entire territory dated 1841 by the explorer J. N. Nicollet had it noted as the *St. Peters River*. By an act of Congress on 19 June 1852, the name was officially changed to *Minnesota River*.

4-04. Sediment. Silt deposition in the lower reach of Big Stone Lake started to become a problem of appreciable magnitude shortly after construction of the Whetstone River Diversion Project. While a silt barrier was part of the original construction, sediment from the Whetstone River still collected at the Big Stone Lake outlet. In 1986 the silt barrier was raised one-foot in an effort to reduce silt deposition in Big Stone Lake; however, no measurements of actual sediment entering the lake have been made. From information provided by the US Soil Conservation Service (now Natural

Resource Conservation Service) and soundings of lower Big Stone Lake obtained in 1956 and 1967, it was estimated that approximately 280 acre-feet of sediment per year would enter the project area from the Whetstone River and Yellow Bank River. This represents about 0.35 acre-feet of sediment per square mile of effective contributing drainage area. Of this amount it was estimated that about 14 acre-feet would move into Big Stone Lake and the remainder, or 266 acre-feet, would enter the Highway 75 project reservoir area.

The Natural Resources Conservation Service expected land treatment measures for the Whetstone River and Yellow Bank River watersheds to reduce the average annual sediment yield to an estimated 187 acre-feet by the year 1980 and to 173 acre-feet by the year 2000. The average annual silt deposition was expected to be 157 acre-feet at the year 1980 based on a trap efficiency of 84 percent and 137 acre-feet at the year 2000 based on a trap efficiency of 79 percent. Using this average annual rate of sedimentation and variable trap efficiency the silt deposition in the Highway 75 Reservoir would be 2,700 acre-feet after 15 years, 7,300 acre-feet after 50 years and about 12,000 acre-feet after 100 years. The high pool elevation of 952.3 feet has a storage capacity of 11,700 acre-feet. However, because of the nature of the terrain and the shape of the pool, sediment will not be deposited uniformly in the pool. The sediment transported by the Whetstone River to the Minnesota River will form a delta in the upper end of the reservoir while the sediment carried by the Yellow Bank River will be deposited in a delta at the mouth of the Yellow Bank River in the lower reaches of the reservoir.

Sediment ranges were established in the Highway 75 Reservoir in June 1975 for purposes of periodic sediment surveys. The locations of sediment ranges are shown on **Plate 4-1**. The original elevation-storage table is presented at the end of **Appendix E**. No sediment surveys have been completed since the construction of Highway 75 Dam.

4-05. Climate. The climate in the region is characterized by moderate precipitation and wide variations in temperature. The area is subject to cold winters and warm summers, typical of continental conditions in the temperate zone. The average length of the growing season, or the interval between killing frosts, is about 150 days. The climate is favorable for wheat, corn, soybeans, and other small grains.

a. Temperature. The average annual temperature is about 44 degrees Fahrenheit with average monthly temperatures varying between 11 degrees Fahrenheit in January and 72 degrees Fahrenheit in July. Extremes in temperatures, which have been observed in the general area, range from a low of -42 degrees to 114 degrees Fahrenheit. The National Weather Service has temperature gages at Milan, Madison, and Montevideo (Monte), Minnesota. The average monthly temperature for a period of record from 1948 to 2001 at these locations is listed in **Table 4-1**. On the average, the first killing frost occurs on 22 September.

Table 4-1
Average Temperatures in Degrees Fahrenheit

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Milan	10.2	16.8	28.8	44.9	58.2	67.4	71.7	69.5	59.7	48.1	30.8	16.5
Madison	12.3	19.2	30.1	46.2	59.3	69.2	73.1	71.3	61.4	50.3	33.2	19.5
Monte	10.8	17.2	29.2	45.2	58.6	67.8	72.2	70.1	60.3	48.9	31.6	17.5

b. Precipitation. The mean annual precipitation over the basin is about 22.0 inches, with more than 75 percent of the precipitation falling during the months of April through September. Precipitation in the winter generally occurs as snow. The National Weather Service has precipitation gages at Ortonville, Milan, Madison, and Montevideo (Monte), Minnesota. Average monthly precipitation values for these sites are listed in **Table 4-2**. The period of record is 1948 to 2001 with the exception of Ortonville, which is 1948 to 1983.

Table 4-2
Average Precipitation in Inches

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Ortonville	0.56	0.61	1.19	2.14	2.59	3.66	3.04	2.87	1.60	1.69	0.86	0.56
Milan	0.75	0.73	1.40	2.43	2.96	4.00	3.73	3.26	2.35	1.95	1.15	0.63
Madison	0.68	0.70	1.37	2.54	2.95	4.10	3.47	2.98	2.27	2.01	1.19	0.59
Monte	0.87	0.95	1.45	2.36	3.14	4.37	3.39	3.23	2.48	1.79	1.29	0.75

c. Evaporation. Evaporation represents a major portion of the water lost from the Highway 75 Reservoir during the period April through October. The National Weather Service Station in Fargo, North Dakota performed average monthly pan evaporation measurements for open water months from 1963 to 1980. This was used to estimate the lake evaporation rate at Highway 75. Evaporation from lakes is less than pan evaporation due to cooler water temperatures, therefore a pan coefficient of 0.7 was assumed. The results are shown in **Table 4-3**.

Table 4-3
Pan Evaporation at Fargo and Lake Evaporation at Highway 75 (inches)

Location	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
Fargo	3.64	7.15	7.41	8.43	7.31	4.95	3.29	42.2
Hwy 75	2.55	5.01	5.19	5.90	5.12	3.47	2.30	29.5

d. Wind. The average wind speed in this area is about 10 miles per hour. The prevailing winds are from the northwest, but southeast winds are very common during the summer months. Wind speeds are usually highest during the afternoon and lowest at night. The *Climatic Atlas of the United States* (June 1968) contains monthly fastest-mile wind speeds for Huron, South Dakota based on 29 years of record. Fastest-mile wind speeds are defined as the fastest speed at which wind travels one mile measured over one month. Fastest-mile wind speeds are obtained from measurements taken over a short period of time, usually less than two minutes.

The fastest-mile wind speeds presented in the Atlas were modified to time dependant (1-hour) average wind speeds using the procedure presented the US Army Corps of Engineers' *Shore Protection Manual* (1984). The results are presented in **Table 4-4**.

Table 4-4
Highest Monthly Wind Speed (mph) and Direction for Huron, SD

Month	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Direction	NW	NW	NW	SE	NW	SE	NW	S	NW	W	NW	NW
Fastest-mile	57	56	68	73	70	65	77	70	64	72	73	56
1-Hour	48	47	54	57	55	52	60	55	51	56	57	47

e. Wind Setup. The wind blowing across the lake surface exerts a horizontal force on the water surface and induces a surface current in the general direction of the wind. The horizontal currents induced by the wind essentially cause water to "pile up" on the downwind side resulting in a water level rise downwind and a water level drop upwind. The lowering of the water surface is called "wind set down" and the rise in water level is called "wind setup". The rise in water can be estimated by the following equation taken from Engineering Manual (EM) 1110-2-1414:

$$S = (U^2 F) / (1400 D)$$

S = Wind Setup (ft)
U = Wind Speed (mph)
F = Fetch Length (miles)
D = Average Depth over Fetch (ft)

Computations made using this equation indicate that it under predicts wind setup. While it is recognized the relationship between wind speed and wind setup is not linear, a rule of thumb has been developed that seems to work out quit well. For every ten miles per hour of wind speed, assume the pool level change to 0.1 feet. Therefore a northwest wind at 20 mph would cause a 0.2-foot rise in the pool surface at the dam. Conversely, a southeast wind of 10 mph would result in a lowering of the water surface at the dam by 0.1 feet.

4-06. Storms and Floods. Floods of damaging proportions occur quite frequently in the Minnesota River Basin. Floods that occur as a result of melting snow during the spring breakup are more prevalent; although floods may also result from heavy summer rains extending over the watershed. While flooding of Big Stone Lake can run into high damage levels, the most destructive floods are those that affect the agricultural economy downstream of the Highway 75. There were several floods in the Minnesota River headwaters prior to the construction of the Highway 75 Dam in 1974. **Table 4-5** shows peak pool elevations and discharges for the largest floods in the upper basin since 1952. This is followed by a brief description of all known upper basin floods. For a more complete history of floods in the Minnesota River Basin, see the *Lac qui Parle Water Control Manual*.

Table 4-5
Historic Peak Discharges and Elevations

Date	Big Stone Lake		Highway 75	
	Elevation	Discharge	Elevation	Discharge
April 1952	970.42 ft	3,060 cfs	na	Na
April 1969	970.16 ft	2,550 cfs	na	Na
April 1979	969.34 ft	2,260 cfs	953.40 ft	3,480 cfs
March 1985	966.99 ft	3,060 cfs	953.03 ft	3,330 cfs
March 1986	966.59 ft	2,570 cfs	956.48 ft	4,090 cfs
July 1993	967.57 ft	2,950 cfs	954.16 ft	5,100 cfs
April 1995	Na	2,530 cfs	955.09 ft	5,580 cfs
April 1997	973.20 ft	5,070 cfs	957.70 ft	11,700 cfs
April 2001	970.50 ft	4,830 cfs	957.89 ft	11,900 cfs

a. April 1897. The only evidence that there was a flood of high magnitude in the upper reaches of the river was a high water mark at Big Stone Lake. This high water mark indicated a flood stage only 0.26 feet lower than the stage recorded in April of 1952. This would correspond to a peak elevation of 970.16 feet (NGVD 1929) in 1897 at Big Stone Lake. There is no other known information available on this flood.

b. May - June 1942. A series of frequent storms of high intensity began in the last week of April and continued for several months. These storms covered widespread areas of the Minnesota River watershed producing recurrent high discharges on a number of the tributaries in the upper reaches of the basin. Rainfall from the 25th to the 30th of April averaged 3.5 inches. May and June received an average of 8.0 inches and 3.5 inches respectively. During this period, the Little Minnesota River and the Whetstone River basins received approximately 15.0 inches of rainfall. The Whetstone River had a peak discharge of 3,740 cfs, while the Little Minnesota River had a peak discharge of 2,960 cfs. Flood flows from these streams filled Big Stone Lake to 0.1 foot above the top of flood control storage. However, outflow from Big Stone Lake was only 1,200 cfs (measured at Ortonville).

c. April 1947. Precipitation during the winter was below normal with the month of March being the driest for the State of Minnesota since 1939. However, above normal rainfall during April averaged 3.5 inches over the watershed and this was augmented by snowmelt. While the Little Minnesota River peaked at 2,780 cfs and the Whetstone River peaked at 5,500 cfs, Ortonville's peak flow was only 1,660 cfs. The Yellow Bank River peaked at 5,090 cfs. Floodwaters on the Yellow Bank River overtopped US Highway 75 near the head of Marsh Lake and eroded the shoulder of the roadway.

d. April 1951. Above normal precipitation occurred during the fall and winter months. Flooding in the upper basin was confined to the Yellow Bank River where the peak discharge was 4,080 cfs. Stages were sufficient to overtop US Highway 75 near the head of Marsh Lake.

e. April 1952. Above normal rainfall occurred during the fall. Heavy snowfall fell during the winter months resulted in an accumulation of snow about twice the normal amount. The snow survey made in mid-March indicated a snow-water content of about 4.0 inches. Temperatures rose sharply in early April, exceeding 50 degrees

Fahrenheit on 7 April. The Little Minnesota peaked at 4,730 cfs and the Whetstone River at 5,710 cfs. Big Stone Lake crested at elevation 970.42 feet with a discharge of 3,060 cfs (measured at Ortonville). The Yellow Bank River near Odessa peaked at 6,260 cfs.

f. April 1969. The water content of the snow in the headwaters of the Minnesota River Basin at the end of March was about 6 inches. The upper part of the basin received 1 inch to 1.5 inches of rain from the 7th to the 10th of April, just as the snowmelt runoff was reaching its peak. Conditions were such that severe flooding was inevitable. The Little Minnesota River peaked at 3,270 cfs with the Whetstone River at 6,870 cfs. Big Stone Lake crested at elevation 970.16 feet with a peak outflow from of 2,550 cfs (measured at Ortonville). The Yellow Bank Rive near Odessa peaked at 6,970 cfs.

g. April 1979. The flood of 1979 was the first flood experienced by the Highway 75 Dam. The Little Minnesota peaked at 4,730 cfs with the Whetstone River at 4,210 cfs. Big Stone Lake crested at 969.34 feet with a peak discharge of 2,260 cfs (measured at Ortonville). The Yellow Bank River near Odessa peaked at 3,190 cfs on 14 April. The pool at Highway 75 Dam reached a peak elevation of 953.40 feet with a maximum outflow of 3,480 cfs.

h. March 1985. Heavy snow pack resulted in significant runoff in the upper basin. Inflow to Big Stone Lake peaked at 6,870 cfs on the Whetstone River. There was no record for the Little Minnesota River. Big Stone Lake crested at 966.99 feet with a peak outflow of 3,060 cfs (measured at Ortonville). The Yellow Bank River near Odessa peaked at 2,620 cfs on 20 March. The pool at Highway 75 Dam peaked at 953.03 feet on 24 March with a corresponding maximum outflow of 3,330 cfs.

i. March 1986. Heavy snow pack again caused significant runoff in the upper basin. Inflow to Big Stone Lake peaked at 4,730cfs with no record at Little

Minnesota. Big Stone Lake crested on 30 March at elevation 966.59 feet with a peak outflow of 2,570 cfs (measured at Ortonville). The Yellow Bank River near Odessa peaked at 4,070 cfs on 16 April; however, the first peak of 3,100 cfs occurred on 24 March. Therefore, Highway 75 Dam pool peaked on 31 March at 956.48 feet with a maximum outflow of 4,090 cfs. The second crest on the Yellow Bank River kept the pool high until the end of May.

j. July 1993. By the end of April, stream flow in the Minnesota River basin was in the excessive range. Wet antecedent conditions existed in the basin dating back to 1991. As a result, heavy summer rains brought flooding to the Minnesota River Valley. Inflow in the upper basin was most significant on the Little Minnesota River with only a mild impact on the Yellow Bank River. Peak inflow to Big Stone Lake was 8,900 cfs on the Little Minnesota River and 3,890 cfs on the Whetstone River. Big Stone Lake crested at 967.57 feet with a peak outflow of 2,950 cfs on 28 July (measured at Ortonville). The Yellow Bank River near Odessa had a peak discharge of 1,910 cfs on 26 July. On 28 July, the pool at Highway 75 Dam crested at elevation 954.16 feet with a peak discharge of 5,100 cfs.

k. April 1997. Above normal snowfall in western Minnesota during the winter along with significant precipitation in the form of rain and snow on the 5^{th} and 6^{th} of April caused the worst flooding in recorded history in the upper portion of the Minnesota River basin. Other factors that contributed to the record flooding included high soil-moisture levels produced by substantial precipitation in the fall that averaged around 6 inches in the upper basin, a late spring thaw coupled with frozen saturated soil that prohibited infiltration of moisture, and above normal precipitation during the spring thaw.

During September through October of 1996, precipitation in the flood-affected region generally was between 4 and 7 inches. During November through March, a series of winter storms moving through the region caused above-normal

precipitation. On 5-6 April, 1997 a rainstorm that produced rainfall amounts as high as 4 inches, turned into blizzard conditions with wind speeds as much as 70 miles per hour and a severe drop in temperature. The above-normal precipitation during the winter and early spring produced record and near-record snowfalls in much of western Minnesota with amounts as high as 80 to 90 inches. Inflow to Big Stone Lake peaked at 3,590 cfs on the Little Minnesota River on 28 March and 7,930 cfs on the Whetstone River on 6 April. Big Stone Lake crested at elevation 973.20 feet with a peak outflow of 5,070 cfs (measured at Ortonville). The Yellow Bank River near Odessa peaked at 6,770 cfs on 2 April. Highway 75 Reservoir crested at elevation 957.70 feet on 8 April with a peak discharge of 11,700 cfs.

For the first time pool elevations exceeded the emergency spillway crest elevation of 956.6 feet as flows continued over the grass-lined spillway for a period of 10 days from 2 to 12 April. The emergency spillway performed well with generally minimal erosion occurring at some locations within and near the pilot channel.

l. April 2001. Many factors contributed to the 2001 flood. There was greater than normal precipitation starting with late fall rains in 2000, followed by greater than normal snowfalls, a delayed snowmelt, and record rains in April. Above normal rains in early November 2000 followed by snowfalls later in the month resulted in precipitation totals that were well above historical averages for the month. With additional snowfall throughout the winter, total accumulation in parts of Minnesota was 18 to 24 inches greater than a normal winter, placing snowfall in the 90 to 95 percentiles. Below-normal temperatures for February and March delayed the snowmelt and only compacted the existing snow cover. Snow-water equivalents in early March ranged from 3 to 5 inches and by the end of March had changed little. In April, heavy rains fell over much of the basin. Precipitation totals for the month were greater than 6 inches in some areas, which was more than 4 inches above normal. This rainfall, along with the greater than normal snow-water equivalents, provided the runoff that resulted in the spring flooding of 2001. Ground frost depths

were minimized by the early snowfalls that served to insulate the ground from the cold winter air. Inflow to Big Stone Lake was 3,180 cfs from the Little Minnesota River on 12 April and 9,930 cfs from the Whetstone River on 8 April. While Big Stone Lake crested almost three feet lower than in 1997, discharge from the lake was only 240 cfs less. This was due to the improvements made to the gates at the Big Stone Lake outlet following the 1997 flood. Big Stone Lake crested at elevation 970.50 feet with an outflow of 4,830 cfs (measured at Ortonville). The Yellow Bank River near Odessa peaked at 5,800 cfs on 8 April. Highway 75 Pool crested at elevation 957.89 feet on 14 April with a peak outflow of 11,900 cfs. The peak outflow from Highway 75 Dam was very similar to 1997.

For the second time pool elevations exceeded the emergency spillway crest elevation of 956.6 feet as flows continued over the grass-lined spillway for a period of 7 days from 10 to 17 April. The grass-lined emergency spillway performed well as inspection of the spillway revealed no visible signs of erosion from the overtopping flows of the 2001 flood event.

4-07. Runoff Characteristics. Floods on the Minnesota River and its tributaries are caused by both snowmelt runoff and summer storms. Floods occurring as a result of melting snow can encompass the entire basin. During the spring breakup, floods are often aggravated by ice jams forming in the river. Floods can also occur from heavy rains extending over the entire basin or from intense rainfall events that are local in nature.

Outflows are computed daily at 0800-hours. Outflow over the leaf gate is calculated by the weir equation and flow through the low flow culvert is based on a tailwater rating curve. The total is recorded as the daily outflow. Inflows are computed internally based on the input outflow and reservoir elevation. A computer program computes the change in volume in the reservoir for the past 24-hours and converts this to a discharge (cfs). Assuming the outflow was constant for the past 24-hours,

daily inflow is computed. The volume for change in pool elevation is based on the original reservoir survey of 1975 (end of **Appendix E**). Outflow data and reservoir pool elevations were recorded on log sheets beginning in 1977; however, digitally stored data are only available starting on 1 October 1983. Therefore, a monthly mean inflow-duration table and a monthly mean outflow-duration table was developed for the years 1984 through 2002. The results are presented in **Table 4-6** and **Table 4-7**. The tables indicate the percent of time a given inflow is equaled or exceeded.

Table 4-6
Highway 75 Reservoir
Inflow – Duration (1984 through 2002)

Flow	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
9000				1.0								
8500				1.9								
8000				2.0								
7500				2.7								
7000				3.8								
6500				4.3								
6000				5.3								
5500			0.7	6.6								
5000			1.3	7.7			0.7					
4500			2.7	8.5			1.7					
4000			3.7	10.2	0.9		2.9	0.6				
3500			5.2	11.8	2.4		4.6	1.0				
3000			7.3	14.5	5.8	0.6	5.3	1.6				
2500			9.7	18.1	7.7	1.3	7.0	2.0				
2000			13.7	26.1	10.6	2.7	9.5	2.8				
1500			17.0	35.1	17.6	9.6	11.9	4.8		0.9	0.5	
1000		0.8	19.7	44.3	28.2	17.8	17.2	7.0	0.6	3.2	1.8	
500		2.5	28.5	60.8	50.2	35.4	28.6	16.2	4.5	7.7	4.1	
0	100	100	100	100	100	100	100	100	100	100	100	100

Table 4-7
Highway 75 Reservoir
Outflow – Duration (1984 through 2002)

Flow	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
8500				0.5								
8000				1.2								
7500				2.3								
7000				3.8								
6500				4.8								
6000				6.2								
5500				7.0								
5000			0.5	8.0			0.5					
4500			2.3	8.8			1.5					
4000			3.1	10.0	1.1		2.3	0.7				
3500			4.7	12.5	2.6		4.0	1.0				
3000			6.8	15.3	5.3		5.0	1.4				
2500			8.7	19.8	7.4	1.3	6.2	2.0				
2000			11.3	27.3	11.5	1.7	8.9	3.0				
1500		0.5	15.0	35.7	17.4	8.8	11.2	4.1		0.7	0.5	
1000		0.5	18.7	45.3	27.3	17.5	16.5	5.1	0.7	3.9	1.3	
500		2.3	27.7	60.7	47.6	31.7	27.2	12.8	4.4	6.8	4.3	
0	100	100	100	100	100	100	100	100	100	100	100	100

The average monthly inflows and outflows were computed from the digitally stored data files for the period of record starting in 1984 and going through 2002. **Tables 4-8** and **4-9** show the monthly data for each year with the monthly mean presented in the final row. The monthly inflow is a 24-hour average whereas the outflow is the instantaneous outflow computed at 0800-hours. In addition, evaporation from the pool is unaccounted for in the change of volume calculation. Therefore, monthly outflow values will often exceed inflow values. The wild card in the change in volume calculation is the impact from wind on the pool elevation. High winds will always have a significant impact on the volume calculation be it positive or negative. Note in the tables the similarities between mean inflow and mean outflow values. While there may be a significant daily difference, the monthly difference is smoothed out since water is not stored for long periods of time.

Table 4-8
Monthly Average Inflows to Highway 75 Reservoir (cfs)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1984	7	112	714	1734	482	1141	641	10	12	93	35	12
1985	9	24	1315	814	146	12	11	13	409	124	27	9
1986	32	111	1480	2810	1351	424	302	221	244	481	55	29
1987	11	35	291	355	28	24	25	2	3	3	9	11
1988	8	9	54	61	3	7	7	7	7	7	7	7
1989	7	8	455	697	12	8	8	8	4	3	3	3
1990	3	3	52	7	12	46	18	3	3	3	3	3
1991	2	3	3	35	93	904	1128	1083	167	120	32	16
1992	23	29	210	166	102	825	700	116	56	3	41	4
1993	5	16	443	1993	627	693	3688	1694	261	124	66	52
1994	31	52	3457	1823	2126	526	1924	387	192	180	101	138
1995	94	33	1789	2974	2100	862	1262	698	438	1119	816	296
1996	215	371	1551	1673	1515	978	143	53	34	74	121	43
1997	50	177	1114	6307	1832	257	184	180	75	87	73	66
1998	80	359	747	1481	1114	369	195	56	20	108	405	352
1999	168	225	424	560	569	609	200	69	61	32	32	28
2000	28	43	99	79	135	45	41	21	28	30	36	25
2001	28	13	212	5517	1742	1219	232	29	22	23	35	50
2002	40	48	114	687	548	110	70	13	5	25	43	48
Mean	**44**	**88**	**764**	**1567**	**765**	**477**	**567**	**245**	**107**	**139**	**102**	**63**

Table 4-9
Monthly Average Outflows from Highway 75 Reservoir (cfs)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1984	5	43	533	1798	577	968	876	7	8	60	73	76
1985	9	4	1195	816	141	14	3	14	414	131	37	10
1986	58	130	1154	3020	1396	422	271	255	235	516	53	33
1987	43	56	202	387	41	5	140	2	2	2	2	2
1988	2	2	3	82	7	2	2	2	2	2	2	2
1989	2	2	245	719	328	5	3	2	2	2	2	2
1990	2	2	3	4	6	45	30	4	2	2	2	2
1991	2	2	14	3	45	951	1103	1114	138	160	34	20
1992	17	25	198	156	139	784	708	128	76	9	11	29
1993	10	10	350	2135	641	673	3628	1708	246	137	59	65
1994	40	32	3515	1791	2187	518	1939	364	179	112	102	136
1995	110	51	1747	3065	2112	882	1265	694	352	1118	801	269
1996	246	373	1631	1689	1497	1004	101	31	7	56	132	44
1997	45	122	1111	6362	1926	251	184	165	31	86	73	57
1998	82	377	700	1591	1116	373	193	48	20	33	418	350
1999	164	238	466	584	587	610	208	78	18	19	11	11
2000	12	48	139	100	141	49	60	35	11	9	11	11
2001	12	12	199	5434	1854	1259	251	31	9	10	10	13
2002	46	48	116	756	488	118	143	9	3	4	6	32
Mean	**48**	**83**	**712**	**1605**	**802**	**470**	**585**	**247**	**92**	**130**	**97**	**61**

4-08. Channel and Floodway Characteristics. The Minnesota River channel was modified for 3.0 miles below the outlet control dam at Big Stone Lake Dam as part of the improvements to the Big Stone Lake-Whetstone River Project that were made in the mid-1970s. The Minnesota River channel was also modified between Lac qui Parle Dam and Granite Falls, Minnesota. This project consisted of rock and snag removal and cutoffs at various locations to increase the bank full capacity of the channel. The portion of the channel from Lac qui Parle Dam to Granite Falls was designed to handle a 15-year recurrence interval event.

The width of the flood plain varies from about ½ mile to 2 miles from Big Stone Lake to the Lac qui Parle Dam. Below Lac qui Parle Dam to the vicinity of New Ulm (river mile 146.3), the width is quite uniform, varying between 3,000 and 4,000 feet. In regions containing granite outcrops, the valley suddenly widens to about 10,000 feet. The depth of the valley varies from 100 to 200 feet. Once flow leaves the banks of the river, it can spread quite rapidly to the valley walls due to the relatively flat topography of the flood plain between the bluffs.

The Little Minnesota River forms the headwaters of the Minnesota River within the hills of eastern South Dakota. The Whetstone River is a tributary to Big Stone Lake and enters from the west just above the Big Stone Lake outlet. There is a stream gage on the Minnesota River downstream of the Big Stone Lake outlet at Ortonville. The Yellow Bank River is a tributary to the Minnesota River above Highway 75 Dam and enters from the south. Stage-discharge tables for the *Little Minnesota River near Peever*, the *Whetstone River near Big Stone City*, the *Minnesota River at Ortonville*, and the *Yellow Bank River near Odessa* are presented in **Appendix D**.

4-09. Upstream Structures. Upstream of the Highwway 75 Dam is the Big Stone Lake Dam and outlet. As discussed in detail in **Paragraph 2-03**, Big Stone Lake Dam, which is located upstream of Highway 75 Dam and Reservoir, is part of the Big Stone Lake-Whetstone River Project.

4-10. Downstream Structures. There are two dams downstream of the Lac qui Parle Project. One is located at Granite Falls, Minnesota and the other is located 3.7 miles downstream near Minnesota Falls, Minnesota.

a. Granite Falls Dam. The Granite Falls Dam is a concrete gravity structure with 2.8 feet of flashboards on the crest of the overflow section. The overflow section has a nominal height of 21 feet and is 300 feet long. The dam was built in 1911 and is owned and operated by the City of Granite Falls. It is operated for hydroelectric power production and to provide an impoundment for the withdrawal of surface water for municipal use. The drainage area above Granite Falls is 6,370 square miles.

b. Minnesota Falls Dam. The Minnesota Falls Dam is primarily a concrete and granite masonry structure with earth embankments at each end. The dam has a maximum height of 18 feet and is 600 feet long. Northern States Power Company (now Xcel Energy) built the dam in 1905 for the production of hydroelectric power. It is still owned by Xcel Energy and is no longer operated for hydropower. The impounded water is used to cool a 47-kilowatt steam electric generating plant also owned by Xcel Energy.

4-11. Economic Data.

a. Population. The portion of the Minnesota River watershed located above the Highway 75 Dam and Reservoir includes portions of the following four counties: Big Stone County and Lac qui Parle County are located in Minnesota, and Grant County and Roberts County are located in South Dakota. Over the past 10 years the population of these counties has decreased by 6 to 10 percent with the exception of Roberts County that showed a 1 percent increase. **Table 4-10** provides information pertaining to population, geography, housing and income for each of the four counties located within the watershed of the Big Stone Lake-Whetstone River Project. Specific geographic data is provided for land size and persons per square

mile. Population data includes the year 2000 population and the percent change in population from the year 1990. Housing data includes the number of units, the median value and the number of households. Income data is provided for the median household, per capita and the percent below poverty.

Table 4-10
Geography, Population, Housing and Income Data
Upstream Counties

County	Big Stone, MN	Lac qui Parle, MN	Grant, SD	Roberts, SD
Geography				
Land Size (sq mi)	497	765	683	1,101
Person/sq mi	11.7	10.5	11.5	9.1
Population				
Year 2000	5,820	8,067	7,847	10,016
% Change (1990)	-7.4%	-9.6%	-6.3%	1.0%
Housing				
Units	3,171	3,774	3,456	4,734
Median Value	$41,900	$43,100	$60,400	$43,500
Households	2,377	3,316	3,116	3,683
Income				
Median Household	$30,721	$32,626	$33,088	$28,322
Per Capita	$15,708	$17,399	$16,543	$13,428
% below Poverty	12.0%	8.5%	9.9%	22.1%

b. Agriculture. Agricultural data pertaining to the farms, crop commodities and market value of products sold for the year 1997 in the four counties that contribute to the watershed of the Big Stone Lake-Whetstone River Project are presented in **Table 4-11**. Specific data provided includes the number of farms with the percent change from the year 1992 and the number of acres harvested with the percent change from 1992. Also, displayed is the number of acres harvested for the crop commodities of soybeans, corn (both grain and silage), wheat and hay. The market value of products sold is provided for crops, livestock and poultry.

Table 4-11 Agricultural Data for Year 1997 Upstream Counties				
County	**Big Stone, MN**	**Lac qui Parle, MN**	**Grant, SD**	**Roberts, SD**
Farms				
Number (1997)	362	678	465	684
% Change from 1992	-14.6%	-11.7%	-18.1%	-11.5%
Acres Harvested	207,388	327,013	228,560	361,349
% Change from 1992	-1.7%	2.4%	-5.5%	-5.0%
Crop Commodities (ac)				
Soybeans	101,532	160,348	88,813	141,491
Corn – grain	61,782	127,903	58,283	88,747
Wheat	36,384	24,666	36,894	68,825
Hay	5,982	12,198	36,587	50,989
Corn – silage	1,697	2,412	6,754	6,818
Market Value of Products Sold ($1,000)				
Crops	$38,297	$70,574	$41,561	$54,861
Livestock, Poultry	$16,320	$42,506	$36,278	$31,769

c. Industry. Employment of the labor force by industry within the four-county area is presented in **Table 4-12**. Approximately 23 percent of the labor force in the four-county area is employed in the educational, health and social services fields. About 14 percent of the labor force is employed in the agriculture and forestry areas. **Table 4-13** shows how the counties compared with the United States and the states of Minnesota and South Dakota in terms of unemployment in the year 2000. All four counties demonstrated unemployment rates that varied from 3.3% to 7.2% (Roberts County, SD) that were higher than the state average of 2.9%.

Table 4-12
Employment by Industry in Year 2000

County	Big Stone, MN		Lac qui Parle, MN		Grant, SD		Roberts, SD	
	No.	%	No.	%	No.	%	No.	%
Industry								
Agriculture, Forestry	338	13.4	554	14.4	583	15.5	608	14.4
Construction	176	7.0	203	5.3	176	4.7	250	5.9
Manufacturing	153	6.1	502	13.1	353	9.4	214	5.1
Wholesale Trade	154	6.1	186	4.8	272	7.2	104	2.5
Retail Trade	242	9.6	424	11.0	390	10.4	466	11.0
Trans, Warehousing,	155	6.2	214	5.6	284	7.5	172	4.1
Information	48	1.9	45	1.2	65	1.7	65	1.5
Finance, Insurance, RE	109	4.3	184	4.8	264	7.0	200	4.7
Professional, Administration	76	3.0	100	2.6	192	5.1	181	4.3
Educational, Social Services	682	27.1	886	23.1	693	16.8	1089	25.8
Arts, Entertainment	127	5.0	172	4.5	247	6.6	404	9.6
Other Services	140	5.6	211	5.5	180	4.8	213	5.0
Public Administration	117	4.6	158	4.1	124	3.3	257	6.1
Totals	2517	100%	3839	100%	3763	100%	4223	100%

Table 4-13
Unemployment in the Year 2000

Location	Number Unemployed	Percent Unemployed
Big Stone County, MN	140	5.3 %
Lac qui Parle County, MN	131	3.3 %
Grant County, SD	127	3.3 %
Roberts County, SD	326	7.2 %
Minnesota	109,069	2.9 %

d. Flood Damages. Highway 75 Dam and Reservoir was constructed as part of the Big Stone Lake-Whetstone River Project to offset the flood damage potential from higher flows due to the increased outlet capacity at Big Stone Lake Dam. The project was designed to produce no change in flood damage potential downstream of the Big Stone Lake outlet.

V - DATA COLLECTION AND COMMUNICATION NETWORKS

5-01. Hydrometeorological Stations.

a. Facilities. The regulation of Highway 75 Dam and Reservoir requires the collection and evaluation of several meteorological, hydraulic, and hydrologic parameters. This requires cooperation from the Corps of Engineers (COE), the US Geological Survey (USGS), and the National Weather Service (NWS). Gages are located on the pool and tailwater, the Minnesota River at Ortonville, and on the Yellow Bank River near Odessa. All are Data Collection Platforms (DCP). Because the USGS has the infrastructure in place to monitor stream gages, the COE enters into an annual cooperative stream gage agreement to maintain the Ortonville and Odessa gages. The Water Control gage crew maintains the pool and tailwater gages. While the Whetstone River near Big Stone City is of importance to the COE, it is not necessary for the operation of the Highway 75 Dam and therefore is not funded by the COE. However, it is of sufficient importance that the equipment at the site belongs to the COE. Below is a description of each gage site followed by a table summarizing information regarding each hydrometeorologic station. **Plate 5-1** shows the locations of hydrometeorological stations in the Upper Minnesota River Basin.

There are four snow survey sites upstream of Highway 75 Dam. These sites are included with the list of sites for the Lac qui Parle Reservoir located downstream. The sites are Sisseton, South Dakota (near the Little Minnesota River), Wilmot and Millbank, SD (near the Whetstone River), and Ortonville, MN just downstream of Big Stone Lake.

(1) Big Stone Lake near Big Stone City. This is a non-recording USGS gage read once a day. The gage has been relocated several times over the period of record, which begins in 1937. The gage has always had the same gage zero datum of 957.69 feet (1929 NGVD). Prior to January 1989 it was located at the old power plant site at the west edge of Ortonville. It was relocated to the new power plant

intake, 1.2 miles north of Big Stone City, 1.2 miles northwest of the outlet, and 1.0 mile west of Ortonville. The gage was discontinued by the USGS following FY 1993; however, it is now maintained by Xcel Energy. Gage readings are telephoned to the office of Upper Minnesota River Watershed District once a day.

(2) Whetstone River near Big Stone City. This gage is located on the right bank, 1.5 miles west of Big Stone City, SD, and 4.5 miles upstream of Big Stone Lake. The latitude is 45° 17' 32" and the longitude is 96° 29' 14". The period of record is March 1931 to current year. The USGS publishes the hourly stage and discharge on their web site. The COE does not fund the site; however, the equipment at the site belongs to the Corps. The site is a DCP and consists of a Sutron 8200 data logger with GOES telemetry. The gage is a well with an encoder. There is a staff gage in the well to verify the gage reading. An electric tape gage is located in the gage house for measurements. The AC power on site. A heating lamp is used during the winter months to keep the well open.

Figure 5-1. Whetstone River near Big Stone City.

(3) Minnesota River at Ortonville. This gage is located on the left bank, 400 feet downstream of the US Highway 12 bridge, and 1,300 feet downstream of the Big Stone Lake outlet. The latitude is 45° 17' 44" and the longitude is 96° 26' 38". The period of record is February 1938 to the current year. The USGS publishes the hourly stage and discharge on their web site. The gage is maintained by the USGS through a cooperative agreement. The site is a DCP and consists of a Sutron 8200 data logger with GOES telemetry. It is a well with an encoder. There is a staff gage in the well to verify the gage reading. An electric tape gage is located in the gage house for measurements. AC power is available at the site. A heating lamp is used during the winter months to keep the well open. The USGS has a Sutron 8400 data logger at the site for backup.

Figure 5-2. Minnesota River at Ortonville (picture label wrong).

(4) Yellow Bank River near Odessa. This gage is located on the left bank, 1,200 feet upstream of County State Aid Highway (CSAH) #15, and 4.5 miles upstream of the mouth. The latitude is 45° 13' 37" and the longitude is 96° 21' 12". The period of record is October 1939 to September 1999. In an effort to reduce

operating costs, the cooperative agreement between the COE and the USGS was limited to "peak flow only" for the period October 1999 to March 2001. The gage was reinstated as a DCP site in 2002 and is that way to current year. The USGS maintains the gage and publishes the hourly stage and discharge on their web site. The site consists of a Sutron 8210 data logger with GOES telemetry and voice modem. It is a well with an encoder. There is a staff gage in the well to verify the gage reading. An electric tape gage is located in the gage house for measurements. AC power is available at the site. The gage house is very damp during the spring and summer months such that stalactites would form on the ceiling. Therefore, the heating lamps used in the winter are left on year round to keep the site dry.

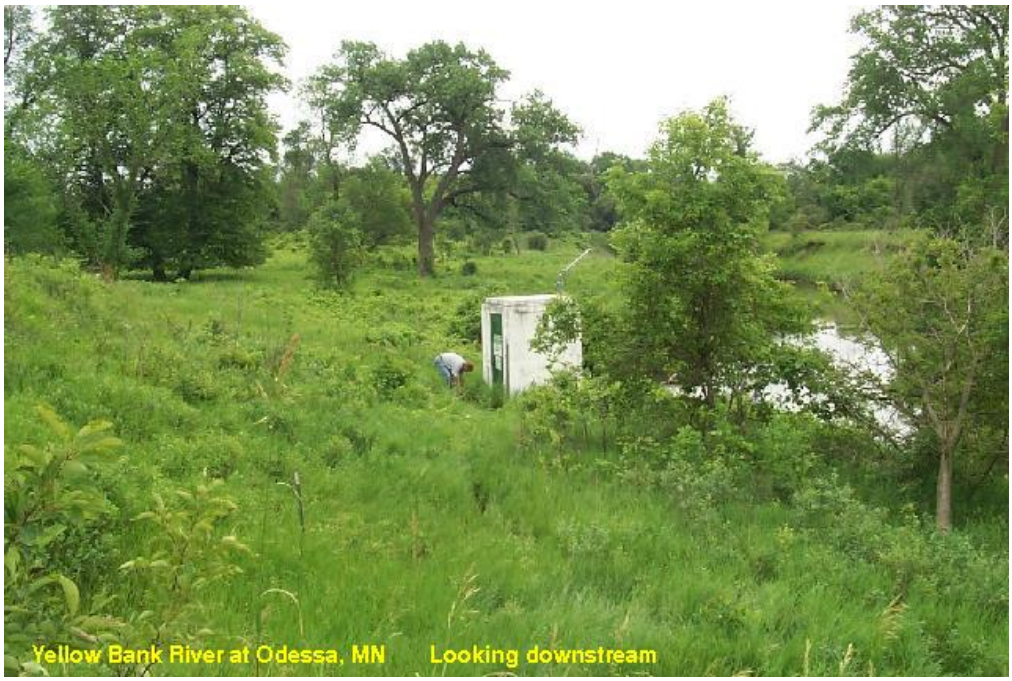


Figure 5-3. Yellow Bank River near Odessa.

(5) Highway 75 Dam Pool and Tailwater. The pool and tailwater gage is located on the dam at the low flow outlet. Both the pool and tailwater have Design Analysis bubbler systems. Both gages are fed into the same gage house and utilize a Sutron 8210 data logger with GOES telemetry and voice modem. There is an additional Sutron 8200 data logger that serves as a backup. When AC

power became available the solar panel that previously provided power was disconnected but not removed. The latitude is 45° 14' 56" and the longitude is 96° 17' 51". Pool and tailwater elevations were recoded following construction The Highway 75 Project was completed in July 1974; however, pool and tailwater readings started on Monday 15 April 1974. Values are available from the Water Control web site back to 1 October 1983. The Water Control gage crew maintains the gages. A tipping bucket is located atop the gage house for hourly measurements of precipitation (**Figure 5-4**). A wire weight gage is located to the south of the gage house. Because it was originally located in the drawdown of the low flow inlet, the wire weight was strung out onto a boom reaching upstream beyond the drawdown effect.

Figure 5-4. Highway 75 Pool and Tailwater Gage.

The low flow outlet has an energy dissipater followed a sheet pile V-notch with an angle iron cap (**Figure 5-5**). The intent of the V-notch weir was to aid in computing low flows. The 1979 *Reservoir Regulation Manual* states that "obstructions in the channel resulted in the cessation of use of the weir for this

purpose." This hard to imagine since there is a trash rack on the culvert inlet. Suffice it to say that we no longer use the weir to determine low flow discharge values in favor of a rating table based on available head (**Table 7-2**). The bubbler for the tailwater gage is located between the V-notch and the culvert outlet. There is also a staff in the same locale to serve as backup to DCP and to verify the DCP reading.

Figure 5-5. Highway 75 Dam Low Flow Outlet.

Pool elevation data is recorded from the gage equipment at the low flow outlet. As a backup to this gage, there is a wire weight gage located on the wing wall of the service spillway. When there is flow over the leaf gate, the gage is located in the draw down of the nappe.

(6) Other Gages. The USGS maintained a water-stage recorder on the Little Minnesota River at Peever, South Dakota from October 1939 to September 1981 and from October 1989 to September 2002. The Little Minnesota River is tributary to Big Stone Lake. The gage was located on the right bank 5.3 miles

northwest of Peever and 8.0 miles upstream of Big Stone Lake. Published discharges for the period of record are available from the Minnesota USGS annual *Water Resources Data*.

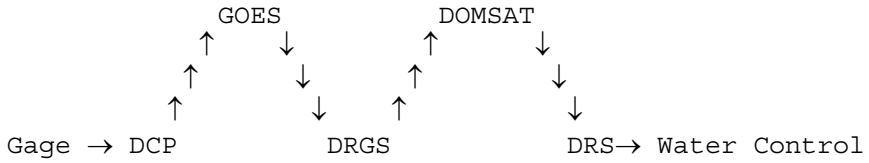
Table 5-1
Hydrometeorological Stations

Location	Data Type	Equipment	Notes
Whetstone River Near Big Lake City	Water Stage	Sutron 8200 Data Logger Well with Encoder GOES Telemetry Staff Gage in Well Electric Tape Gage	Gage Zero: 996.96 ft (1912 adjustment) All equipment belongs to the COE. Gage is not funded by the COE.
Big Stone Lake at Xcel Energy	Lake Elevation	Staff Gage	Gage is maintained by Xcel Energy and recorded by the Upper Minnesota Watershed District.
Minnesota River at Ortonville	Water Stage	Sutron 8200 Data Logger Well with Encoder Staff Gage in Well Electric Tape Gage Sutron 8400 Data Logger	Gage Zero: 956.38 ft (1929 NGVD) All equipment belongs to the COE except for the Sutron 8400. This belongs to the USGS.
Yellow Bank River Near Odessa	Water Stage	Sutron 8210 Data Logger Well with Encoder GOES Telemetry Voice Modem Staff Gage in Well	Gage Zero: 1,020 ft (1929 NGVD) Heat lamps left on during the summer months to keep the gage house dry.
Highway 75 Dam Service Spillway	Pool Elevation	Wire Weight Gage	Located on the wing wall within the nappe of the drawdown.
Highway 75 Dam Low Flow Outlet	Pool Elevation Tailwater Elevation Precipitation	Sutron 8210 Data Logger Sutron 8200 Data Logger Design Analysis H-350/H-355 Smart-Gas GOES Telemetry Voice Modem Wire Weight Gage Staff Gage Tipping Bucket	One gage house for both gages. The Sutron 8200 is used as a backup.

b. Reporting. With the exception of Big Stone Lake, all of the gages listed in **Table 5-1** are Data Collection Platforms (DCP). Being designated as a DCP

indicates that the site transmits data on an hourly basis via a satellite system. Stage/elevation data is collected at the DCP. It is then transmitted to the US Geostationary Operational Environment Satellite (GOES). The GOES satellite transmits the data to the Direct Readout Ground Station (DRGS) at Wallops Island, Virginia. The information is reformatted and sent to the Domestic Communications Satellite (DOMSAT), which transmits the data to the DOMSAT Receive Station (DRS) located at the Paul District Office. The data set is transmitted hourly to Water Control where it is then posted on the Water Control web site.

Transmission Path of DCP Data



c. Maintenance. The Water Control gage crew maintains the pool and tailwater gages at the Highway 75 dam site. This includes the DCP equipment as well as the wire weight gages, the staff gages, and the tipping bucket gage. The USGS maintains the gages at the Minnesota River at Ortonville and the Yellow Bank River near Odessa through a cooperative stream gage agreement with the COE. While all the equipment at the Whetstone River gage belongs to COE, it is not funded by the Corps and is therefore maintained entirely by the USGS.

5-02. Water Quality Stations. The Corps of Engineers does not maintain any water quality stations within the Big Stone Lake-Whetstone River Project; however, the US Geological Survey previously maintained stations at Big Stone Lake, the Minnesota River at Ortonville, and the Yellow Bank River. **Table 5-2** gives the site locations and the period of record.

Table 5-2
Discontinued USGS Water Quality Sites

Site Name	Operation Period		Count
	From	To	

Big Stone Lake at Ortonville	Jun 1960	Jun 1966	15
Minnesota River at Ortonville	Oct 1963	Dec 1968	6
No Fork Yellow Bank nr Odessa	Mar 1991	Aug 2001	107
Yellow Bank River nr Odessa	Oct 1960	Aug 1988	158

5-03. Sediment Stations. The Corps of Engineers does not monitored sediment in Highway 75 Reservoir. Sediment ranges (**Plate 4-1**) were established in June 1975 for the purpose of periodic sediment surveys but none have been conducted.

5-04. Recording Hydrologic Data. Water Control currently has three forms of recording and storing hydrologic data for Highway 75 Dam and Reservoir; (1) weekly log sheets, (2) Sutron 8200 data logger, and (4) Hydraulic Engineering Center's Data Storage System (HEC-DSS). In addition to the Corps of Engineers, there is additional hydrologic data collected and stored by others such as the National Weather Service, the US Geological Survey, and the Upper Minnesota River Watershed District.

a. Weekly Log Sheets. Site personnel at the Lac qui Parle Project Office record daily data for Highway 75 Dam and Reservoir on form CEMVP 405A revised 10-01-99. It is titled *Minnesota River Headwaters Weekly Log Sheet*. All data entries are 0800-hour values. They include the stages on the Minnesota River at Ortonville and the Yellow Bank River near Odessa, elevations at the pool and tailwater, the low flow gate opening and the elevation of the leaf gate, the discharge through the low flow culvert and over the leaf gate, and the 24-hour precipitation. The original log sheet is stored at the Lac qui Parle Project Office and a copy is mailed to Water Control.

b. Sutron 8200 Data Logger. This data logger is located in the gage house at the low flow outlet. It replaces the old Stevens roll charts. The purpose of the roll charts was to maintain a permanent record of pool elevations. The Sutron 8200 acts as backup to the Sutron 8210 that transmits hourly pool and tailwater elevations. Data

on the 8200 is downloaded a minimum of once a year. It is then stored electronically at Water Control.

c. Data Storage System (DSS). Site personnel at the Lac qui Parle Project Office enter the daily data for Highway 75 Dam and Reservoir, via a remote computer terminal, into "Secure CRT". This data set is dissected by Water Control and stored in separate DSS files. A list of the DSS files are presented in **Table 5-3**. Inflow is computed internally based on outflow and pool level change. **Table 5-3** shows the start date for the electronically stored data.

Table 5-3
Electronically stored Daily Data – *Reservoirs*

Data Type	Start Date
Pool Elevation	01 Oct 1983
Tailwater Elevation	01 Oct 1983
Inflow	01 Oct 1983
Outflow	01 Oct 1983
Leaf Gate Setting	01 Oct 1983

Hourly stage/elevation data from the DCPs are received directly into Water Control where the information is stored in separate DSS files. All data is available from the Water Control web site at www.mvp-wc.usace.army.mil. The following table shows the start dates for electronically stored hourly data.

Table 5-4
Electronically stored Hourly Gage Data – *Real Time*

Gage	Data	Start Date
Whetsone River nr Big Stone City	Stage	01 Jan 1996
Minnesota River at Ortonville	Stage	01 Jan 1996
Yellow Bank River at Odessa	Stage	01 Feb 1996
Highway 75 Pool	Elevation	01 Jan 1996
Highway 75 Tailwater	Elevation	13 Nov 1997
Highway 75	Precipitation	18 Jun 2002

5-05. Communication Network. Communication between the staff at the Lac qui Parle Project Office and Water Control can be made by telephone, facsimile, email or the US Mail Service. **Table 5-5** shows the numbers and email address involved with the communications network. Daily communication is typically by email but may involve use of the telephone. Facsimile is used to transmit the US Fish and Wildlife

Service's letter of request for reservoir operations from Water Control to the project site. The US Mail Service is used to transfer weekly slog sheets from the project site to Water Control. During flood events, reconnaissance teams also communicate field information to Water Control by cellular phone and facsimile.

Table 5-5
Communication Network

Communication Means	Lac qui Parle Project Office	Water Control
Telephone	320-269-6303	651-290-5619
Cellular	320-226-3299	Not Available
Facsimile	320-269-5858	651-290-5841
email	randy.d.melby @usace.army.mil	ferris.w.chamberlin @usace.army.mil

5-06. Communication with Project.

a. Regulating Office with Project Office. Water Control contacts the Lac qui Parle Project Office every normal workday morning at approximately 0900-hours. Orders for gate changes include the Lac qui Parle Project as well as the Highway 75 Project. Simple orders are communicated by email while more complex orders require a telephone call.

b. Between Project Office and Others. The Project Manager at Lac qui Parle routinely provides information regarding operation of the Highway 75 Project to interested agencies and private parties. Any public announcements of importance however, are handled through Water Control and the Public Affairs Office.

5-07. Project Reporting Instructions. The Project Resource Manager at Lac qui Parle reports the necessary information to regulate the Highway 75 Project every normal work day by 0930-hours. Should additional information be required, Water Control will contact the site by telephone. The weekly log sheet for the Highway 75 Project

is contained within the weekly log sheet for the Lac qui Parle Project. This log sheet is to be mailed to Water Control every week.

5-08. Warnings. In the event of impending emergency conditions, or advisories requiring interim gate changes, Water Control will call the Resource Manager at the Lac qui Parle Project. **Table 1-1** provides phone numbers for project personnel associated with the Highway 75 Project. **Page iv** contains phone numbers for Water Control and various District personnel. In the event of other emergencies affecting project regulation and concerns downstream, the officials listed in **Table 5-6** will be contacted.

Table 5-6
Points of Contact for Emergency Notification

Point of Contact	Telephone Numbers
Big Stone Lake County, Minnesota Emergency Management Director County Sheriff, 24 Hrs	 320-839-3558 320-839-3558
Lac qui Parle County, Minnesota Emergency Management Director County Sheriff, 24 Hrs	 320-598-3720 320-598-3720
Minnesota Division of Emergency Management Minnesota Statewide Emergency	651-649-5451 800-422-0798

VI - HYDROLOGIC FORECASTS

6-01. General. The National Weather Service (NWS) performs all river-stage forecasting for the public. The St. Paul District, Corps of Engineers (COE) provides current reservoir conditions and advisory forecasts of reservoir inflow and outflow along with pool elevations as needed for its projects. The Corps' forecasts may be required for either wet or dry conditions, and are used to assist the NWS and the Project Resource Manager in their tasks.

a. Role of Corps. The role of the COE is to assist the NWS in their forecasting efforts. While the COE provides the NWS with inflow and outflow values from the Highway 75 Project, it is of little concern to the NWS since their focus begins downstream of Lac qui Parle Reservoir. All snow-survey information for the basin is made available to the NWS. This includes the weekly measurements at Lac qui Parle as well as the basin measurements that are taken in late February or early March.

The COE does not provide any forecast information for public release and rarely does it ever report on project operations at Highway 75. However, Water Control may provide advisory forecasts of reservoir inflow and outflow along with pool elevation changes through the Public Affairs Office (PAO).

b. Role of other Agencies. The NWS is responsible for river forecasts. In the spring of 2001, the NWS instituted the Advanced Hydrologic Prediction Service (AHPS) for the Minnesota River basin. Note that it is pronounced "A-Hips". AHPS is a web-based suite of informational forecast products that provide the magnitude and uncertainty of occurrence of floods or droughts, from hours to days and months, in advance. The information is presented through user-friendly graphical products and includes:

1) A map of areas surrounding the forecast point that provides information about major roads, railways and landmarks prone to flooding along with past flood levels.

2) Hydrographs showing rate of rise and likely peaks.
3) The chance or probability of a river exceeding minor, moderate, or major flooding.
4) The chance of a river exceeding a certain level, volume, and flow of water at specific points on the river during 90 day periods.

The flood outlook includes current conditions as well as the long-range climatological forecast and is presented in text, as well as color graphics, for each forecast site. An additional feature is a map of the river basin and various points along the river for which information is available. The data is not limited to information about floods, but can also provide information about potential droughts. The nearest forecast site in the project area is the Little Minnesota River at Peever, South Dakota. All other forecast sites are downstream of Lac qui Parle Reservoir.

When runoff is underway and river levels are approaching flood stage, the NWS issues a seven-day forecast for its forecast points. The seven-day forecast is based on current river data and the 24-hour quantitative precipitation forecast (QPF). Forecasts can be accessed from the Water Control website www.mvp-wc.usace.army.mil through the tab labeled NWS Products.

6-02. Flood Condition Forecasts. The National Weather Service Forecast Office, in Chanhassen, Minnesota is the official source for all stream-stage forecast information. Water Control prepares flood forecasts of reservoir inflow/outflow and pool elevation for internal use during critical flood periods.

6-03. Conservation Purpose Forecasts. Forecasts for water conservation purposes are not required for regulation of the Highway 75 Reservoir. The US Fish and Wildlife Service mails their requested operation procedure to Water Control every spring. Water Control in turn makes an effort to adhere to their request.

6-04. Long Range Forecasts. Long-range forecasts of reservoir inflows are not available, nor are they required, for operation of the Highway 75 Reservoir.

6.05. Drought Forecast. During dry periods, Water Control monitors the National Weather Service's *US Drought Monitor* on their web site (Water Control web site, *Agency Links*, Federal Agencies, National Weather Service, *River Forecast Center*, For our Partners, *Drought Monitor*).

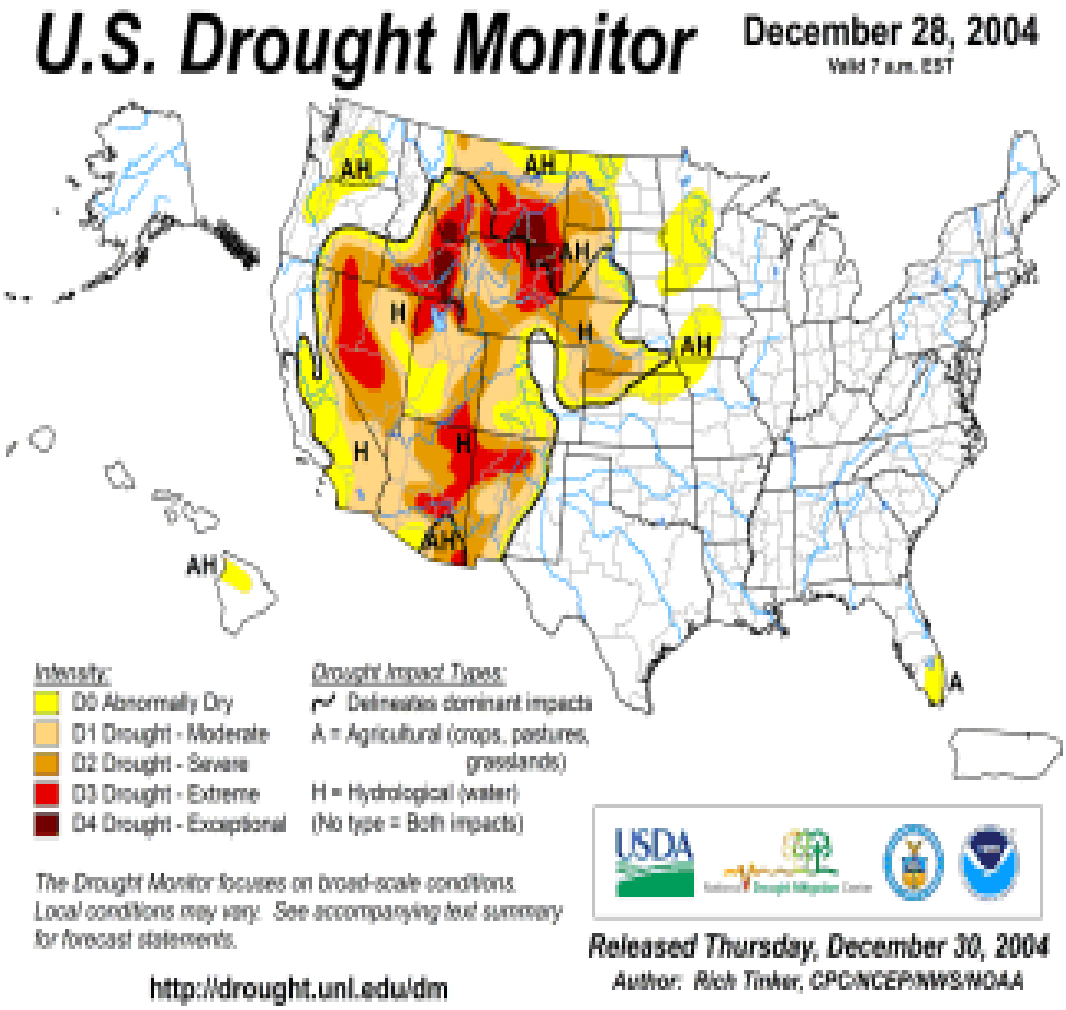


Figure 6-1. National Weather Service Drought Monitor

The drought monitor gives an indication of ground conditions at the present time. Also available on the web site is the *US Seasonal Drought* Outlook. This is the only drought forecast tool available for inflow to the reservoir.

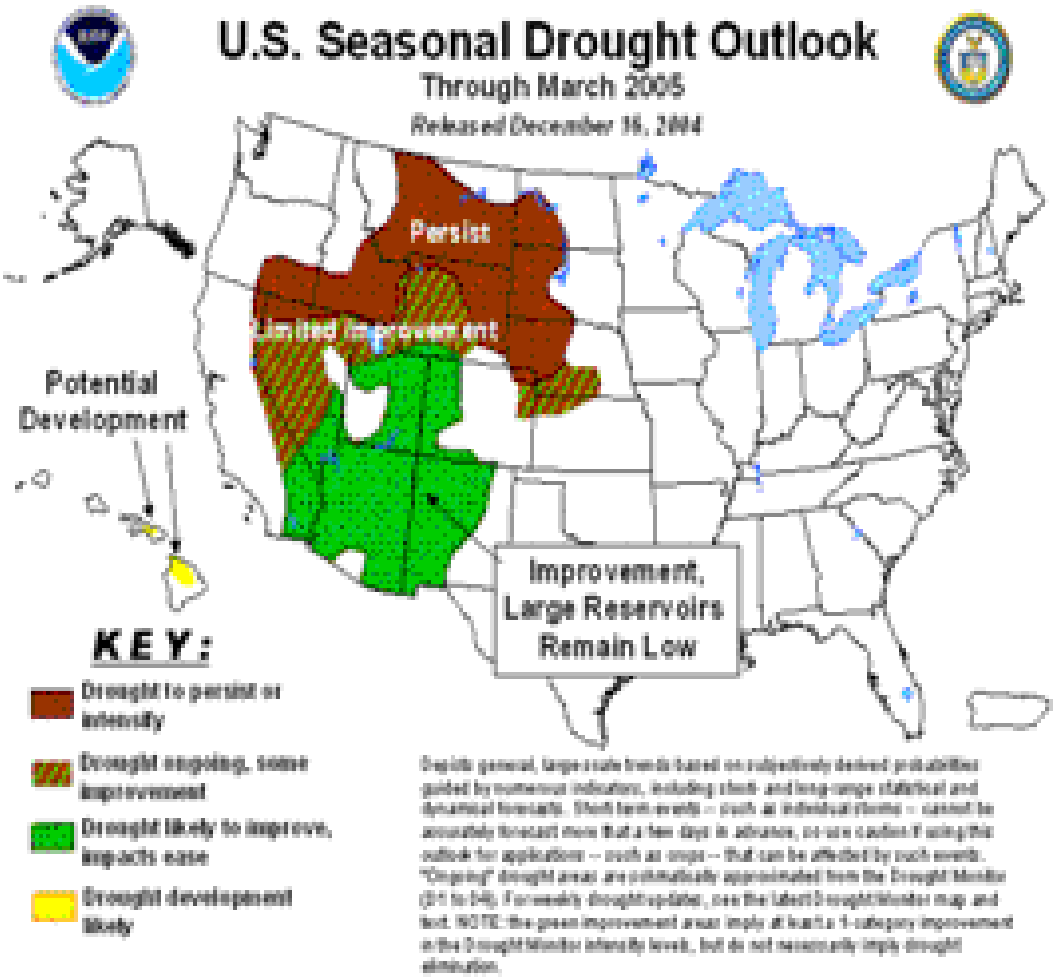


Figure 6-2. National Weather Service US Seasonal Drought Outlook.

During drought conditions, regulation of the project is in accordance with the approved drought contingency plan for the project as discussed in **Paragraph 7-12**.

VII - WATER CONTROL PLAN

7-01. General Objectives. Highway 75 Dam and Reservoir was a mitigation feature to the improved outlet at Big Stone Lake, all of which were part of the Big Stone Lake-Whetstone River Flood Control Project. The improved outlet on Big Stone Lake was to improve lake conditions during flood events and the Highway 75 Dam and Reservoir was to provide the needed storage to prevent additional flooding downstream. Highway 75 Reservoir also enhances the fish and wildlife resources by maintaining a desirable range of pool levels. An annual operating plan is prepared by the US Fish and Wildlife Service and is mailed to the Corps of Engineers, Water Control and Hydrology Section. The plan begins "following spring runoff" and will go into the winter months with a recommended pool elevation. An example is shown on the last page of **Appendix C**. With concurrence from Water Control, the plan is followed as best possible. While the plan recommends a winter pool elevation, the Corps of Engineers may perform a winter drawdown in preparation for spring runoff (see MOU **Appendix C**, Exhibit 3 paragraph 1.b.). Drawdown typically consists of lowering the gate to elevation 947.3 feet prior to spring runoff. Operation of the dam is at all times under the direction of the Water Control staff.

7-02. Constraints.

a. Pool Elevation. The known pool constraint levels are the low flow inlet invert at elevation 940.0 feet (dead storage level) and the Standard Project Flood level of elevation 961.4 feet. Top of flood control is the crest of the emergency spillway (elevation 956.5 feet). Two conservation pool levels were established during the reservoir concept. The high conservation pool level equates to the top of the raised leaf gate (elevation 952.3 feet) and low conservation pool level, which corresponds to a completely lowered leaf gate (elevation 947.3 feet). **Table 7-1** shows pool volumes and pool areas for various pool conditions. Elevation-area and elevation-storage curves are presented in **Plates 2-13** and **2-14** respectively.

Table 7-1 Elevation – Area - Volume				
Condition	**Pool Elevation (feet)**	**Surface Area (acres)**	**Total Volume (acre-feet)**	**Available Flood Storage (acre-feet)**
Emergency Spillway Design (Standard Project Flood)	961.4	7,900	87,000	
Top of Flood Control (Emergency Spillway Crest)	956.5	6,100	30,500	0
High Conservation Pool (Raised Bascule Leaf Gate)	952.3	2,800	10,800	19,700
Low Conservation Pool (Service Spillway Crest)	947.3	950	2,550	27,950

b. Low Flow Discharge. Downstream of the low flow outlet, there is a v-notch weir (**Plate 2-8**). The v-notch has an invert elevation of 940.0 feet and a crest elevation of 944.0.feet. Side slopes are 1V:4H. A tailwater rating table was developed through use of the v-notch weir equation;

$$\mathbf{Q = (8/15)\ C_c\ \tan(\alpha/2)\ [(2g)^{1/2}\ H^{5/2}]},$$

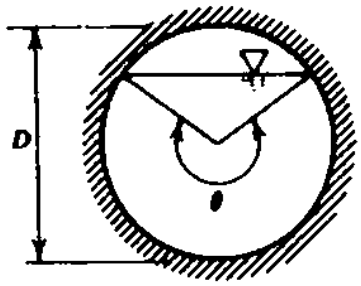
where $C_c = 0.5$
α (1V:4H) = 152^{O}
H = 0.0 to 4.0 feet

Table 7-2 shows the tailwater rating table. Because maximum discharge through the culvert is around 200 cfs, the table stops at elevation 943.5 feet.

Table 7-2 Low Flow Outlet - Tailwater Rating Table							
TW Elev	**Q cfs**	**TW Elev**	**Q Cfs**	**TW Elev**	**Q cfs**	**TW Elev**	**Q cfs**
940.6	2	941.4	20	942.2	62	943.0	134
940.7	4	941.5	24	942.3	69	943.1	146
940.8	5	941.6	28	942.4	77	943.2	158
940.9	7	941.7	32	942.5	85	943.3	170
941.0	9	941.8	37	942.6	94	943.4	183
941.1	11	941.9	43	942.7	103	943.5	197
941.2	14	942.0	49	942.8	113		
941.3	17	942.1	55	942.9	123		

Another concept for determining flow through the low flow culvert is to compute flow based on the gate opening and the differential head. The low flow culvert is a circular conduit 42 inches in diameter (3.5 feet). The sluice gate that controls flow through the culvert is square. Therefore, there is not a linear relationship between gate opening and flow area. Flow area can be computed from,

Area = 0.125 (θ – Sin θ) D^2



The angle θ is in radians and can be calculated from the known radius and the gate setting. For example, consider a gate opening of 0.5 feet.

Cos ½ θ = adj/hyp = 1.25/1.75 = 0.7143
Arc Cos ½ θ = 0.7752 (radians)
θ = 0.7752(2) = 1.55 (radians)
Area = 0.125 (1.55 – Sin 1.55) $(3.5)^2$ = 0.843 sq ft

The low flow conduit has inlet invert at elevation 940.0 feet and an outlet invert one-foot lower (elevation 939.0 feet). The v-notch weir downstream of the outlet has an invert of elevation at 940.0 feet. Therefore, the conduit is always partially full. Outflow can be calculated from;

$Q = CA\,(2gH)^{1/2}$, where C = 0.82
A = flow area
H = differential head

Differential head is simply the pool elevation minus the tailwater elevation. The discharge rating for half-foot incremental gate openings is shown in **Table 7-3**. This table can be used to select a gate openings based on the desired discharge. **Table 7-2** is to be used for reporting flow through the culvert up to tailwater elevation 943.5 feet. Once the tailwater is above this elevation, **Table 7-3** is to be used for determining low flow discharge. These tables also appear in **Appendix E** (page E1) for the convenience of the project staff.

Table 7-3 Low Flow Outlet Discharge Rating							
Head Pool-TW (feet)	**Discharge in cfs**						
	Gate Opening (ft) / Flow Area (sq ft)						
	0.5	1.0	1.5	2.0	2.5	3.0	3.5
	0.843	2.27	3.94	5.68	7.34	8.77	9.62
6.8	14	39	68	97	126	150	165
7.0	15	40	69	99	128	153	167
7.2	15	40	70	100	130	155	170
7.4	15	41	71	102	131	157	172
7.6	15	41	71	103	133	159	175
7.8	15	42	72	104	135	161	177
8.0	16	42	73	106	137	163	179
8.2	16	43	74	107	138	165	181
8.4	16	43	75	108	140	167	183
8.6	16	44	76	110	142	169	186
8.8	16	44	77	111	143	171	188
9.0	17	45	78	112	145	173	190
9.2	17	45	79	113	147	175	192
9.4	17	46	79	115	148	177	194
9.6	17	46	80	116	150	179	196
9.8	17	47	81	117	151	181	198
10.0	18	47	82	118	153	182	200
10.2	18	48	83	119	154	184	202
10.4	18	48	84	121	156	186	204

During periods of very low flow it will be necessary to maintain a constant flow of 2 cfs. It is recommended that a gate setting of 0.15 feet be approximated and then, to ensure the minimum discharge requirement is being met, have the US Geological Survey or Water Control staff make a discharge measurement.

c. Service Spillway - Bascule Leaf Gate. The crest of the Bascule leaf gate is constrained to operate between the fully raised position (elevation 952.3 feet) and the fully lowered position (elevation 947.3 feet). Discharges were computed for the gate in fully lowered position (**Table 7-4**) using the weir equation:

$$\mathbf{Q = CLH^{3/2}}, \qquad \text{where } C = 3.85 \text{ and } L = 65 \text{ feet}$$

When the gate is in the lowered position, the crest begins to assume an ogee shape. Therefore, a 'C' coefficient of 3.85 was selected.

Table 7-4
Bascule Leaf Gate in the Lowered Position (Elevation 947.3 feet)
Service Spillway Rating based on Pool Elevation

Pool Elev.	Q (cfs)	Pool Elev.	Q (cfs)	Pool Elev.	Q (cfs)	Pool Elev.	Q (cfs)
947.3	0	950.2	1,235	953.1	3,490	956.0	6,420
947.4	8	950.3	1,300	953.2	3,585	956.1	6,530
947.5	22	950.4	1,365	953.3	3,680	956.2	6,640
947.6	40	950.5	1,430	953.4	3,770	956.3	6,750
947.7	63	950.6	1,500	953.5	3,860	956.4	6,870
947.8	88	950.7	1,570	953.6	3,960	956.5	6,980
947.9	115	950.8	1,640	953.7	4,050	956.6	7,100
948.0	150	950.9	1,710	953.8	4,150	956.7	7,210
948.1	180	951.0	1,780	953.9	4,240	956.8	7,325
948.2	215	951.1	1,850	954.0	4,340	956.9	7,440
948.3	250	951.2	1,930	954.1	4,440	957.0	7,560
948.4	290	951.3	2,000	954.2	4,540	957.1	7,680
948.5	330	951.4	2,075	954.3	4,640	957.2	7,800
948.6	370	951.5	2,150	954.4	4,740	957.3	7,910
948.7	415	951.6	2,230	954.5	4,840	957.4	8,030
948.8	460	951.7	2,310	954.6	4,940	957.5	8,150
948.9	510	951.8	2,390	954.7	5,040	957.6	8,270
949.0	555	951.9	2,470	954.8	5,140	957.7	8,400
949.1	605	952.0	2,550	954.9	5,240	957.8	8,520
949.2	655	952.1	2,630	955.0	5,350	957.9	8,640
949.3	710	952.2	2,710	955.1	5,450	958.0	8,760
949.4	760	952.3	2,800	955.2	5,560	958.1	8,880
949.5	820	952.4	2,880	955.3	5,660	958.2	9,005
949.6	875	952.5	2,970	955.4	5,770	958.3	9,130
949.7	930	952.6	3,055	955.5	5,880	958.4	9,250
949.8	990	952.7	3,140	955.6	5,990	958.5	9,380
949.9	1,050	952.8	3,230	955.7	6,090	958.6	9,500
950.0	1,110	952.9	3,315	955.8	6,200	958.7	9,630
950.1	1,175	953.0	3,400	955.9	6,310	958.8	9,760

As the gate is raised upward, the crest moves away from an ogee shape and begins to form a horizontal sharp crested weir. Therefore, the 'C' coefficient transcends from 3.85 to some minimum value when the gate is fully raised. To determine a discharge for any gate setting would require an assessment of the 'C' coefficient for each gate setting. A table was required such that discharge could readily be assumed based on the differential head, thus eliminating the need for gate position. **Table 7-5** was developed assuming a constant 'C' value of 3.85 to avoid conflict with **Table 7-4**. Both tables are also presented in **Appendix E** (page E2 and E3).

Table 7-5
Service Spillway Rating based on Head

Head (feet)	Q (cfs)	Head (feet)	Q (cfs)	Head (feet)	Q (cfs)	Head (feet)	Q (cfs)
0.1	8	2.3	870	4.6	2,470	6.8	4,435
0.2	20	2.4	930	4.7	2,550	6.9	4,535
0.3	40	2.5	990	4.8	2,630	7.0	4,635
0.4	60	2.6	1,050	4.9	2,715	7.1	4,735
0.5	90	2.7	1,110	5.0	2,800	7.2	4,835
0.6	115	2.8	1,170	5.1	2,880	7.3	4,935
0.7	145	2.9	1,235	5.2	2,965	7.4	5,040
0.8	180	3.0	1,300	5.3	3,055	7.5	5,140
0.9	215	3.1	1,365	5.4	3,140	7.6	5,245
1.0	250	3.2	1,430	5.5	3,230	7.7	5,345
1.1	290	3.4	1,570	5.6	3,315	7.8	5,450
1.2	330	3.5	1,640	5.7	3,405	7.9	5,555
1.3	370	3.6	1,710	5.8	3,495	8.0	5,665
1.4	415	3.7	1,780	5.9	3,585	8.1	5,770
1.5	460	3.8	1,855	6.0	3,680	8.2	5,875
1.6	505	3.9	1,925	6.1	3,770	8.3	5,985
1.7	555	4.0	2,000	6.2	3,865	8.4	6,090
1.8	605	4.1	2,080	6.3	3,955	8.5	6,200
1.9	655	4.2	2,130	6.4	4,050	8.6	6,310
2.0	710	4.3	2,230	6.5	4,145	8.7	6,420
2.1	760	4.4	2,310	6.6	4,245	8.8	6,530
2.2	815	4.5	2,390	6.7	4,340	8.9	6,645

Prior to spring runoff, the gate is typically in the lowered position. When the discharge rises to around 6,500 cfs, the tailwater will rise to elevation 947.3 feet and submergence starts to become a factor. Peak pool events for the floods of 1997 and 2001 were examined for submergence in accordance with the Corps of Engineers' *Hydraulic Design Criteria*. Based on Hydraulic Design Chart III-4, the "percent reduction of coefficient" for the weir equation is zero.

d. Emergency Spillway. The emergency spillway can be seen in **Figure 2-2**, just to the left of the low flow outlet. The spillway is broad crested and was constructed to an approximate elevation of 956.5 feet. A v-notch ditch was constructed at the center of the spillway to concentrate flow away from the training dikes. As constructed, all dimensions and elevations associated with the emergency spillway are approximate. For calculation purposes, it was necessary to assume the spillway was precisely constructed to design values. The v-notch has a bottom elevation one-foot lower than the spillway crest and has side slopes of 1V:10H. Water begins to flow over the emergency spillway when the pool rises above elevation 955.5 feet. The v-notch equation was used to approximate discharge when the pool was at the spillway crest:

$$\mathbf{Q = (8/15)\ C_c\ \tan(\alpha/2)\ [(2g)^{1/2}\ H^{5/2}]},$$ where $C_c = 0.5$
α (1V:10H) = 169^{O}
H = 1.0 foot

When the pool is at elevation 956.5 feet, the v-notch is flowing full and conveys approximately 20 cfs. As the pool increases above elevation 956.5 feet, flow begins over the spillway crest. The spillway is 715 feet wide with training dikes at each end. The dikes have side slopes of 1V:3H. Therefore, as flow depth increases, the width of flow increases. For simplification of the computations, a constant flow width of 715 feet was assumed. The emergence spillway rating-table is presented in **Table 7-6** and in **Appendix E** (page E4). Computations were made for pool levels up to the Standard Project Flood elevation of 961.4 feet. The tailwater elevation for this design event would be 955.8 feet and therefore, all calculations are for free-flow.

Calculations were made using the weir equation:

$$\mathbf{Q = CLH^{3/2}}$$ where *C* was assumed to be 2.60

A discharge of 20 cfs was added to all the results in **Table 7-6** to account for the v-notch.

Table 7-6
Emergency Spillway Rating Table

Pool Elevation (feet)	Discharge (cfs)	Pool Elevation (feet)	Discharge (cfs)	Pool Elevation (feet)	Discharge (cfs)
956.5	20	958.1	3,780	959.7	10,660
956.6	80	958.2	4,140	959.8	11,160
956.7	190	958.3	4,510	959.9	11,670
956.8	325	958.4	4,890	960.0	12,190
956.9	490	958.5	5,280	960.1	12,720
957.0	675	958.6	5,675	960.2	13,250
957.1	880	958.7	6,085	960.3	13,790
957.2	1,110	958.8	6,505	960.4	14,340
957.3	1,350	958.9	6,930	960.5	14,890
957.4	1,610	959.0	7,350	960.6	15,450
957.5	1,880	959.1	7,815	960.7	16,020
957.6	2,165	959.2	8,270	960.8	16,600
957.7	2,465	959.3	8,730	960.9	17,180
957.8	2,775	959.4	9,200	961.0	17,770
957.9	3,100	959.5	9,680	961.2	18,360
958.0	3,435	959.6	10,170	961.3	19,570

7-03. Overall Plan for Water Control. The Cooperative Agreement (**Appendix C**, Exhibit 1) between the Corps of Engineers (COE) and the US Fish and Wildlife Service (USFWS) calls for an annual operating plan to be prepared by the two agencies. In the absence of such an annual agreement, the operation of the reservoir is in accordance with the plan presented in the Memorandum of Understanding (**Appendix C**, Exhibit 3) as established in August 1975 between the USFWS and the COE. Pool levels are to be in accordance with the following schedule;

Month	Pool Elevation
1 May - 31 October	952.3 ft
1 December	951.1 ft
1 January	950.4 ft
1 February	949.6 ft
1 March	948.4 ft
Prior to spring runoff	947.3 ft

Since this time, the development of the operating plan for Highway 75 Dam has been simplified. Every year prior to spring runoff, the USFWS provides the COE, via letter, an operating plan. The plan typically begins "following spring runoff" and proceeds "through January". The COE reviews the plan and if there are no comments, Water Control proceeds to operate according to the plan as best possible. Exhibit 3 of **Appendix C** implies that Corps will operate the pool to a tolerance of ± 0.5 feet. In practice, Water Control makes an effort to operate within a margin of ± 0.2 feet. Operation of the Highway 75 Dam is at all times under the direction of the Water Control staff. Prior to spring runoff, the COE may elect to draw the pool down to provide additional flood storage for spring runoff. Maximum drawdown is elevation 947.3 feet.

To maintain the water levels prescribed by the USFWS, operation of the dam is correlated with the operation of the control structure at Big Stone Lake and the inflows from Yellow River. Discharge at Ortonville and the Yellow Bank River at Odessa can be obtained from the US Geological Survey's web site. Big Stone Lake Dam is owned and operated by the Upper Minnesota River Watershed District. The operating plan for Big Stone Lake Dam is presented in **Appendix F** as part of the *Operation and Maintenance Manual*. The operating plan basically follows these two guidelines:

Operating Plan for Big Stone Lake

(1) From 1 May to 30 September, maintain a lake elevation of:
965.6 feet NGVD 1929 (Project Datum: 968.0 feet)

(2) Drawdown from 1 November to 1 December to elevation:
964.6 feet NGVD 1929 (Project Datum: 967.0 feet)

7-04. Standing Instructions to Project Staff. Project staff at the Lac qui Parle Project Office are to enter daily 0800-hour project data via remote computer to "Secure CRT". This data set includes pool and tailwater elevations, discharge through the low flow and over the service spillway, total discharge, and the Bascule leaf gate elevation. During flood events when flow is passing over the emergency spillway, this discharge is to be included with the "total discharge". All discharge values are to be obtained from the rating tables presented in **Appendix E** (pages E1 through E4).

In addition to the data entered to "Secure CRT", project staff are to enter Highway 75 Dam and Reservoir pertinent data, along with the daily Lac qui Parle Project data, on a weekly log sheet entitled "Minnesota River Headwaters weekly Log Sheet". The data set includes the same data reported to "Secure CRT" as well as, low flow head and gate opening, 24-hour precipitation, stage on the Minnesota River at Ortonville, and the stage on the Yellow Bank River near Odessa. Low flow head is simply the pool elevation minus the tailwater elevation. The 24-hour precipitation is to be obtained from hourly incremental recordings from the tipping bucket. Stage values can be obtained from the respective Data Collection Platforms (i.e. *Real Time*, Water Control web site) or the US Geological Survey web site, which can be accessed from the Water Control web site. The source of data is to be noted on the log sheet (i.e. "D" for DCP and "U" for USGS). If a wire weight measurement was used, it is to be note with a "W". The pool and tailwater elevations are to be noted "D" or "V" where *V* represents a *visual* reading from the tape or the staff gage.

In the event of failure of normal telephone communications, field staff will maintain contact with the District Office by any other means available (such as cellular phone service, internet). If necessary, a messenger will be sent to the Lac qui Parle Project Office with instructions. Meanwhile, the primary objective of field staff is to ensure the safety of the structure and to provide the most effective operation of the project by following the guidance in this chapter. During emergency operation, the appropriate schedule in this chapter will be followed until contact with the District Office is reestablished. Field staff should make an effort to maintain knowledge

concerning the effects of any reservoir releases on downstream damage centers. If Water Control cannot be contacted at the District Office, one of the Water Control regulators should be contacted at home, in order of preference as shown in the introduction to this manual.

7-05. Flood Control. Floods in the area generally are of two types: spring floods caused by snowmelt often combined with rainfall, and summer floods caused by periods of heavy or prolonged rainfall. No provisions are made for providing flood storage during a summer flood event; however, prior to spring runoff the pool is typically drawdown to elevation 947.3 feet (the lower elevation of the leaf gate). The ultimate drawdown level and the drawdown schedule are left to Corps of Engineers. The US Fish and Wildlife Service's request for pool regulation will always be worded "following spring runoff" or something similar (see **Appendix C**, last page).

As previously discussed, when spring runoff begins, the leaf gate is typically lowered to elevation 947.3 feet. This elevation is to be maintained until the peak inflow has past. During the recession of the spring inflow, the gate is to be raised so as to maintain the post spring runoff pool elevation recommended in the US Fish and Wildlife Service operating plan.

7-06. Recreation. The water control plan contains no specific operations for recreation. There are however many recreational opportunities in the project area and within the Big Stone National Wildlife Refuge. They include: a visitor contact station, wildlife observation, hiking trails, archaeological/historic sites, auto tour route, hunting, fishing and non-motorized boating.

7-07. Water Quality. The water control plan for Highway 75 Dam has no operating procedures regarding Water Quality other than minimum release. The minimum release for Highway 75 Dam is 2 cfs.

7-08. Fish and Wildlife. Highway 75 Dam and Reservoir is within the Big Stone National Wildlife Refuge, which is administered by the US Fish and Wildlife Service (USFWS). The Big Stone Refuge, along with the Minnesota River valley, forms a natural corridor that traverses the region from northwest to southeast. The refuge contains 11,521 acres, of which 1,028 acres are within Big Stone County and 10,493 acres are within Lac qui Parle County. Unique features include the lichen-covered granite outcrops for which the refuge was named and the nearly 2,000 acres of native tall prairie grass. The principle objective of the refuge is to provide optimum nesting cover for ground nesting waterfowl production by maintaining and restoring native prairie grassland habit. It is also a major migratory stopover for 21 species of waterfowl. The refuge has several impoundments that enable management of over 2,000 acres of marsh and open water habit. The annual operating plan as jointly developed by the Corps of Engineers the USFWS provide specific emphasis on waterfowl production and management. The refuge has several sub-impoundments that allow management of 300 acres independently from any flood control needs.

7-09. Water Supply. Granite Falls is the only community that is clearly dependent on Minnesota River flows for its water supply. The Granite Falls water treatment plant has a capacity of 620 gallons per minute, (0.893 MGD) or 1.38 cfs. The city has two 300,000-gallon supply tanks, and a 275,000-gallon post-clarification tank for a total storage of 875,000 gallons. Average daily use is 275,000 gallons per day, with a high usage of 700,000 gallons per day.

7-10. Hydroelectric Power. There are two hydropower dams at Granite Falls. Granite Falls Dam is in the town proper and is still producing hydropower today, while Minnesota Falls Dam is three miles downstream and was taken out of service in 1958 (its powerhouse was demolished). However, the pool at Minnesota Falls is still used to provide cooling water for an Xcel Energy power plant 1.5 miles upstream. Granite Falls Dam was built by the city in 1911 to produce electric power. The gravity overflow section has a nominal height of 21 feet, and is 300 feet long. In addition to hydropower production, the city also uses the impoundment to provide for its

municipal water supply. The dam has three turbines: two older units produce 470 kW together, and the new turbine (1986) produces 710 kW. The total maximum flow capacity of the turbines is 900 cfs.

7-11. Navigation. Navigation is not an authorized purpose of the project.

7-12. Drought Contingency Plans. The Drought Contingency Plan is a stand-alone document that was developed in September 1992. It is entitled *Drought Contingency Plan, Appendix to the Big Stone Lake-Whetstone River, Highway 75 Dam and Reservoir, Reservoir Regulation Manual*. The *Operation and Maintenance Manual* for Big Stone Lake (**Appendix F**) requires a minimum outflow of 5 cfs; however, it was decreased to 2 cfs in the *Drought Contingency Plan*. This complies with minimum outflow requirement for Highway 75 Dam, which is also 2 cfs. During the drought of 1988, an outflow of 2 cfs at Highway 75 Dam was maintained from 2 June to 26 March 1989. The pool achieved its lowest level on 10 November at an elevation of 946.57 feet. Copies of the drought contingency plan are located at the Lac qui Parle Project Office at Watson, Minnesota, and in the Water Control Office at the St. Paul District Office.

7-13. Flood Emergency Action Plans. The flood emergency action plan is a stand-alone document that was developed in May 1987 and is entitled *Emergency Plan for Highway 75 Dam and Reservoir*. This report serves as a guide for identifying, mitigating, and responding to various types of emergencies, which although unlikely, could occur during the operation of Highway 75 Dam and Reservoir. The emergency plan is located at the Lac qui Parle Project Office at Watson, Minnesota, and in the District Water Control Section in St. Paul.

7-14. Periodic Inspection. Every five years there is an inspection of the stilling basin at the Bascule leaf gate and at the low flow outlet. For the low flow outlet inspection, the sluice gate is closed and out flow is maintained via the Bascule leaf gate. Because of the culvert's small size (42 inches), only the lower portion is inspected

along with stilling basin. The leaf gate inspection is far more detailed. The leaf gate is raised to prevent any over flow while the low flow culvert is used to maintain the pool elevation. Because the tailwater is higher than the end sill elevation, an "L" shaped plywood closure was manufactured. It is held in place by sandbags, thereby allowing for the stilling basin to be pumped dry (**Figure 7-1**).

Figure 7-1. Periodic Inspection of the Bascule Leaf Gate Stilling Basin

7-15. Deviation From Normal Regulation. There are three forms of deviation; (1) a deviation because of an emergency situation, (2) an unplanned minor deviation due to an unplanned event, and (3) a planned deviation, typically to accomplish some task. To deviate from the operating plan requires permission from the Division Office (MVD), except for an emergency.

a. Emergency. Under an emergency deviation, the District Engineer may authorize a deviation in an attempt to abate the problem. The Division Office is to be notified as soon as practical. Written confirmation of the deviation is to be sent to the Division Water Control Manager.

b. Unplanned Minor Deviation. Should an unplanned instance create the need for a temporary minor deviation, permission to do so is to be obtained from the Division Office. Consideration must be given to upstream and downstream watershed conditions, potential flood threat, and alternative measures that can be taken. An e-mail explaining the deviation and its cause must be furnished to Division Water Control Manager. Approval for an unplanned minor deviation is typically obtained by e-mail.

c. Planned Deviations. Requests for planned minor deviations may be submitted to the Division Water Control Manager by e-mail. Major deviations must be presented formally to the Division Water Control Manager by a memorandum from the Chief, Engineering Division. The request should include sufficient data on flood potential, lake and watershed conditions, and benefits to be expected. Approval for minor deviations are typically by e-mail, while approval of major deviations are by memorandum.

7-16. Rate of Release Change. There are no rules regarding rate of release change, only guidelines. No rate of release change shall cause a drop in the pool level of 0.5 feet, or greater, within a 24-hour period. No gate change shall be made that will result in a rate of release change in excess of 1,000 cfs.

VIII - EFFECT OF WATER CONTROL PLAN

8-01. General. The primary purpose of the Highway 75 Dam was to offset the increased outlet capacity at the Big Stone Lake Dam by providing addition downstream storage. The primary benefits of the project are the enhancement of fish and wildlife resources and providing recreational opportunities.

8-02. Flood Control.

a. Spillway Design Flood. The spillway was designed to pass the flood of 1952. This was the flood of record at the time. The maximum spillway discharge for a recurrence of this flood was determined to be 6,600 cfs with a pool elevation of 956.3 feet. This established the emergency spillway crest at elevation 956.5 feet. (1929 NGVD).

b. Standard Project Flood. The Standard Project Flood (SPF) was developed for an assumed contributing drainage area of 995 square miles using methodology in accordance with Civil Works Engineer Bulletin No. 52-8 entitled "*Standard Project Flood Determination*". Using an initial reservoir level equivalent to 50 percent of capacity, the SPF was routed through the reservoir using the combined rating curve for the service and emergency spillways. The maximum resulting pool elevation was 961.4 feet. By adding 3.0 feet of freeboard above the SPF pool elevation and increasing that elevation to the nearest 0.5 foot, the top of dam elevation was established at 964.5 feet (1929 NGVD).

c. Unit Hydrograph. The 12-hour unit hydrograph for inflow to the reservoir was developed for the adopted contributing drainage of 955 square miles and does not include the 765 square mile drainage area above the Big Stone Lake silt barrier due to the attenuation of flows from the lake storage. The unit hydrograph was developed synthetically using general relations methodology based on unit graphs derived for the Minnesota River at Lac qui Parle Dam, Little Minnesota River near Peever, Whetstone River near Big Stone City, and the Yellow Bank River near

Odessa. All unit graphs were converted to 12-hour durations with peak flows per square mile plotted against drainage area. The regression analysis indicated that the peak of the 12-hour unit graph varied with the 0.56 power of the drainage area ratio. Using this relationship, the peak for the 955 square mile drainage area was computed to be 7,540 cfs.

d. Minimum Inflow. Inasmuch as the wildlife benefits from the pool above Highway 75 Dam depend on maintaining satisfactory pool levels, an investigation was made of the levels that could have been maintained in past years including the pronounced drought period from 1932 through 1940. For this analysis it was assumed that during dry periods all flow from the Whetstone River would be diverted into Big Stone Lake. It was further assumed that there be no outflow from Big Stone Lake Dam and the only inflow to the pool above Highway 75 Dam would be that from the Yellow Bank River. Mean monthly discharges as published for the Yellow Bank River near Odessa started in October 1939. For the period of March 1932 through September 1939 records from the Whetstone River near Big Stone City were used in the absence of Yellow Bank River records. These two basins are adjacent, are approximately equal in size with similar characteristics, and have very similar runoff during periods of simultaneous records. Evaporation losses were computed using Meyer's formula for small, shallow lakes using mean monthly temperatures. Precipitation was tabulated from National Weather Service records and the monthly net evaporation was determined by subtracting precipitation from evaporation. The Yellow Bank River monthly inflow volume was compared with the net evaporation to determine net inflow. The pool was assumed to be at elevation of 952.3 feet in the spring of 1932. Monthly routings were performed considering negative inflows and allowing for varying evaporation loss with changes in effective surface area of the pool due to reservoir elevation changes. For a recurrence of the dry period of 1932 through 1940, the computed minimum pool elevation would be approximately 949 feet and would occur in the fall of the third year (September 1934).

8-03. Recreation. Based upon the historic pool elevations of Highway 75 Reservoir from 1976 to 2004, the current operating plan has allowed for maintaining desired water levels consistent with the conservation pool range necessary for associated recreational opportunities. Recreation opportunities in the project area and within the Big Stone National Wildlife Refuge include: a visitor contact station, wildlife observation, hiking trails, archaeological/historic sites, auto tour route, hunting, fishing and non-motorized boating.

8-04. Fish and Wildlife. The US Fish and Wildlife Service coordinates the operation of Highway 75 Dam with the Corps of Engineers to utilize the reservoir as a wildlife refuge. The operating plan gives particular consideration to the reservoir water levels desired for waterfowl production and management. The effects of construction and continued operation and maintenance of the Big Stone Lake – Whetstone River Flood Control Project have been previously described (USACE 1971, 1980, 1985, 1986) and are incorporated by reference. The US Fish and Wildlife Service operates the Big Stone National Wildlife Refuge according to the 1986 Master Plan (USFWS 1986). No changes in the water control manual are being proposed with this update that have not been previously assessed in those documents.

8-05. Water Supply. The project does not have sufficient storage available to be a dependable long-term source of surface water for downstream water utilities. The City of Granite Falls is the only community in the area that is dependent on Minnesota River water for water supply.

8-06. Hydroelectric Power. The nearest hydroelectric power plant is at the City of Granite Falls on the Minnesota River. The dam has three turbines that produce a total of 1,180 kilowatts of power. The current maximum usable flow for hydropower at the plant is 900 cfs.

8-07. Navigation. Navigation is not an authorized purpose of the project.

8-08. Drought Contingency Plans. The Drought Contingency Plan is a stand alone document entitled *Drought Contingency Plan, Appendix to the Bigstone Lake-Whetstone River Highway 75 Dam and Reservoir, Reservoir Regulation Manual and the Lac qui Parle Reservoir and Minnesota River – Channel Improvement Reservoir Regulation Manual*, September 1992. The document provides a basic reference for water management decisions and responses to a water shortage in the basin above Highway 75 Dam as induced by climatological droughts. The plan includes a formulation process for the release of low flows and an interagency coordination matrix. During past droughts such as 1988, the Minnesota Department of Natural Resources has convened the initial meeting of the Governor's Drought Task Force, based on the status of the drought indicators. The Corps Drought Management Committee coordinator and Water Control personnel will participate in Interagency Drought Management Committee meetings. The Emergency Phase trigger is 2 cfs for the 72-hour average flow at the Montevideo gage. Essentially, as long as Big Stone Lake Dam maintains a minimum outflow of 2 cfs, the same minimum shall be discharged at Highway 75 Dam.

8-09. Flood Emergency Action Plans. The *Emergency Action Plan for Highway 75 Dam and Reservoir* is dated May 1987 and is a stand-alone document that serves as a guide for identifying, mitigating and responding to various types of emergencies, which although unlikely, could occur during the operation of Highway 75 Dam and Reservoir. The emergency plan is located at the Lac qui Parle Project Office at Watson, Minnesota, and in the District Water Control Section in St. Paul.

8-10. Frequencies.

a. Little Minnesota River near Peever – Discharge/Frequency. The US Geological Survey maintained a water-stage recorder on the Little Minnesota River near Peever, South Dakota from October 1939 to September 1981, and from October 1989 to September 2002. The gage was located on the Sisseton Indian Reservation, on the right bank 2 miles northwest of the town of Brown's Valley, Minnesota, 5.3 miles northeast of Peever, and 8 miles upstream of Big Stone Lake. The gage had a

datum of 1,002.20 feet above mean sea level (1929 NGVD) and a drainage area of 438 square miles. An annual instantaneous peak discharge frequency relationship for the Little Minnesota River near Peever was developed using the available published period of record flows for the water years of 1940-1981 and 1990-2002. It is presented in **Figure 8-1.**

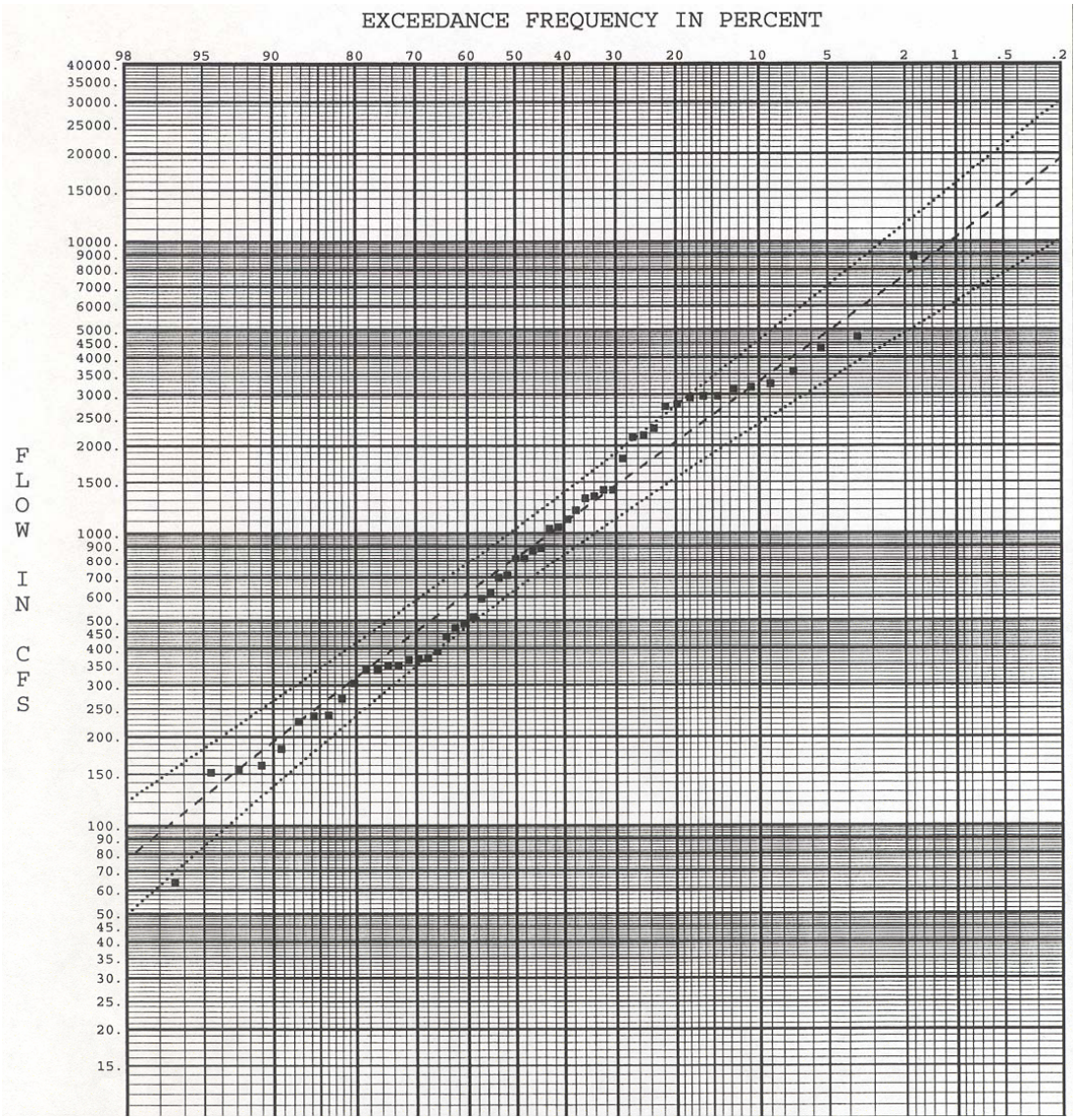


Figure 8-1. Little Minnesota River near Peever -Discharge/ Frequency

b. Whetstone River near Big Stone City – Discharge Frequency. The US Geological Survey maintains a continuous stream flow gaging station on the Whetstone River near Big Stone City, South Dakota. The gage is a water-stage recorder and is located on the right bank 20 feet downstream from the former highway bridge site, 1.5 miles west of Big Stone City, and 4.5 miles upstream from Big Stone Lake. The gage has a datum of 996.96 feet above mean sea level (1929 NGVD), drains an area of 398 square miles, and has a period of record from March 1910 to November 1912, and March 1931 to the current year. Shown on **Figure 8-2** is the annual instantaneous peak discharge frequency relationship for the Whetstone River near Big Stone City that was developed using the available published period of record flows for the water years of 1910 to 1912 and 1931 to 2002.

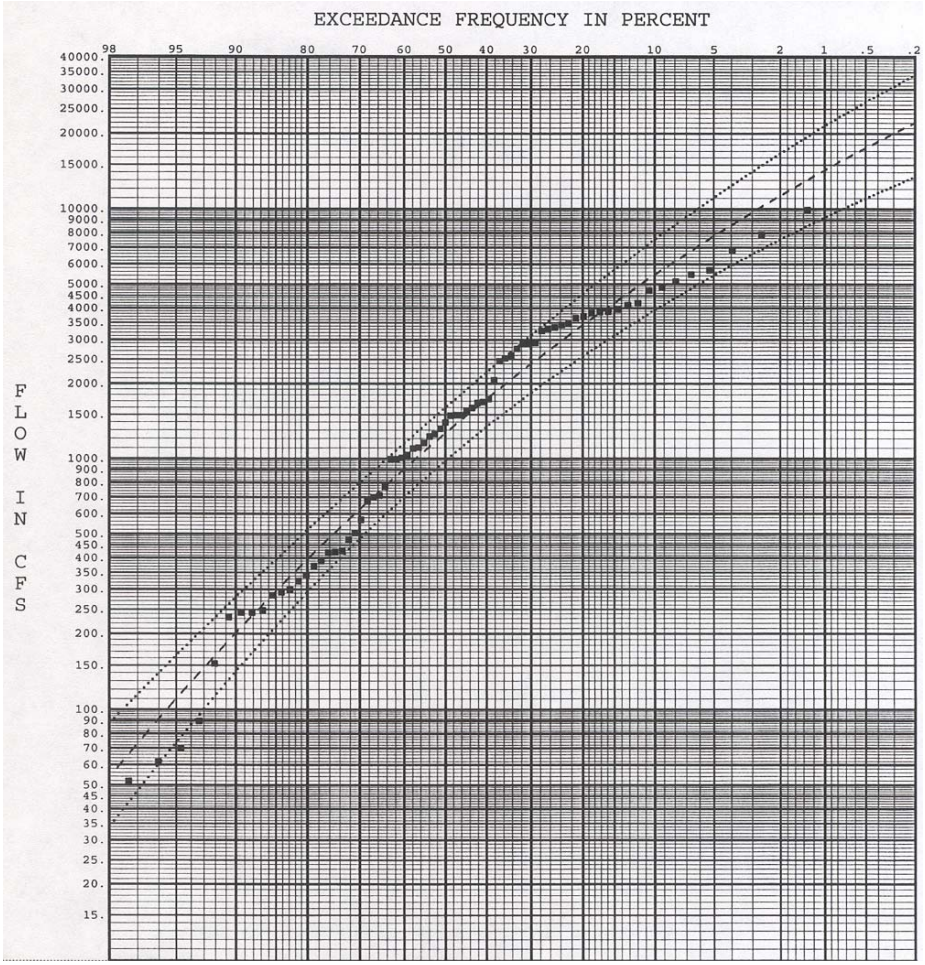


Figure 8-2. Whetstone River near Big Stone City – Discharge/Frequency

c. Big Stone Lake near Big Stone City – Stage/Frequency. Big Stone Lake stages are related directly to outflow rates. As part of the design for the Big Stone Lake-Whetstone River Project, the outflow rating-curve for Big Stone Lake was used to convert discharges from the Ortonville frequency curve for pre-project conditions to corresponding stages on Big Stone Lake. For deriving the Big Stone Lake project condition stage frequency relationship, six floods of record having sufficient volumes of inflow were routed during the design stage of the flood control project. The resulting maximum lake stages were plotted at the assigned frequencies of the floods for development of the project condition stage frequency curve for Big Stone Lake. The pre-project and post-project curves are shown in **Figure 8-3**. Note that gage zero 957.69 feet (1929 NGVD).

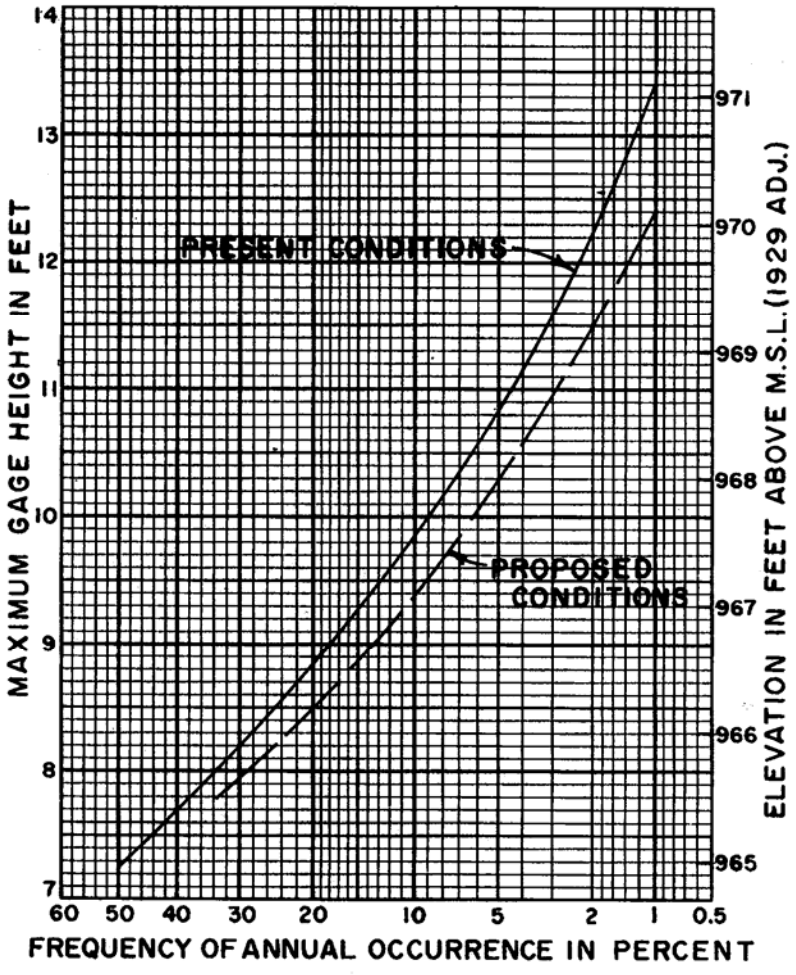


Figure 8-3. Big Stone Lake – High Stage Frequency

d. Minnesota River at Ortonville – Discharge/Frequency. During the design stage of the Big Stone Lake-Whetstone River Project, a discharge frequency curve for pre-project conditions was developed for the Minnesota River at Ortonville (Big Stone Lake Dam outflows). Pre-project conditions are defined as those conditions prior to the construction of the flood control project, which includes the major modifications to the outlet structure at Big Stone Lake Dam. The relatively short period of record at Ortonville was analytically correlated to 56 years of record (1910 – 1965) at Montevideo. This correlation resulted in the extension of the record to an equivalent 39 years of record at Ortonville. The 56 years of record at Montevideo were routed and adjusted to represent pre-project conditions upstream. The adopted discharge frequency curve for Big Stone Lake Dam outflows for pre-project conditions as developed in the original Design Memorandum is shown as "Present Conditions" on **Figure 8-4**.

The frequency of annual occurrence of the peak discharge of the 1952 flood and each routed flood under pre-project conditions was determined from the adjusted 39-year pre-project condition frequency curve for Ortonville. It was assumed that each of the historical floods would have the same recurrence frequency under project conditions as under pre-project conditions. The computed peak discharge for project conditions of each routed flood was plotted at its previously assigned frequency. A straight-line frequency curve was constructed passing through the 1952 flood, largest flood of record, to maintain the same frequency under both conditions. The project condition frequency curve for outflows from Big Stone Lake Dam is shown as "Proposed Conditions" on **Figure 8-4**.

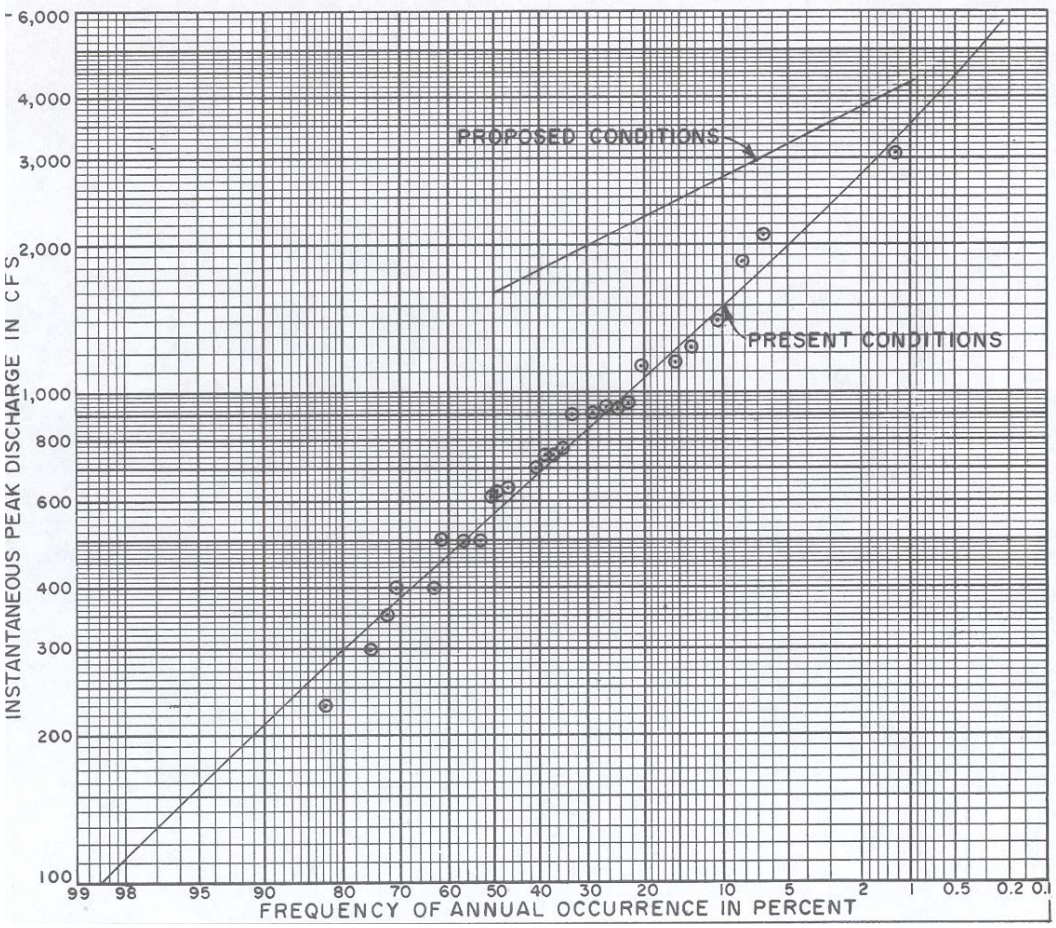


Figure 8-4. Minnesota River at Ortonville - Discharge Frequency

e. Annual Peak Mean Daily Inflow Probability – Highway 75. There are no actual records of instantaneous peak inflow to Highway 75 Dam and Reservoir; however, Water Control computes an average daily inflow based on the change in pool elevation and the known outflow. The water control database for inflow begins on 1 October 1983 and extends to the present. **Figure 8-5** shows the adopted annual peak mean daily inflow frequency curve for Highway 75 Reservoir that was graphically fitted to the 20 years of systematic record (1984 through 2003) with the adjusted median plotting positions for the 107-year historic period (1897 through 2003).

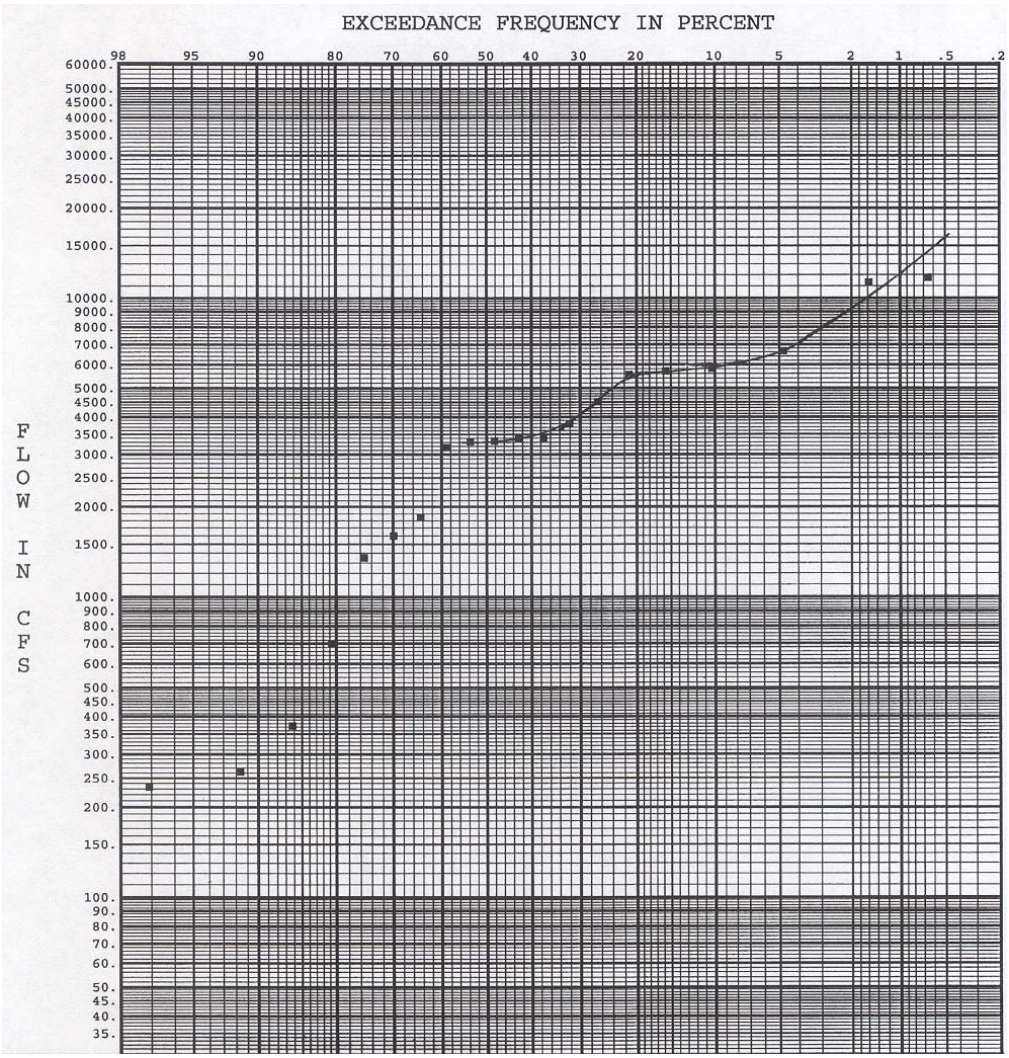


Figure 8-5. Annual Peak Daily Inflow Probability – Highway 75

Because the upstream control structure at Big Stone Lake appears to overtop at approximately the 0.5 percent exceedence frequency, the downstream inflow probability curve at Highway 75 Dam was not extended beyond that of the 200-year recurrence interval. No overtopping analyses of Big Stone Lake Dam have been conducted. With only 20 years of computed inflows, the probability relationship should be considered only as a relative indicator of frequency of peak mean daily inflows.

f. Annual Peak Pool Elevation Frequency – Highway 75. Stage data is available for the Highway 75 Reservoir from August 1977 through September 2003. The flood of record occurred on April 14, 2001 when the Highway 75 pool reached a peak elevation of 957.89 feet. Based upon available historic flood information at Big Stone Lake, the 1997 and 2001 flood events were considered to be the largest at Highway 75 Dam in the historic period dating back to 1897. Of the available 26 years of peak elevations available (1978 through 2003), only 25 years were used in the probability analysis. Since the structure was limited to an outflow of 2 cfs during much of the year of 1981 for a dam embankment stability study, the 1981 peak elevation of 950.20 feet was considered to be a singular, non-homogeneous event and was therefore excluded in the frequency analysis. As shown on **Figure 8-6**, a curve was graphically fitted to 25 years of plotted peak elevations to produce an annual peak elevation-frequency relationship for the Highway 75 Dam pool. Using historic flood information for the year 1897 produces a historic period of 107 years and provides an adjustment for the median plotting position of the 2001 flood event from 2.76 percent to 0.65 percent and the 1997 flood event from 6.69 percent to 1.58 percent. Because the upstream control structure at Big Stone Lake appears to overtop at approximately the 0.5 percent exceedence frequency, the downstream pool elevation probability curve at Highway 75 Dam was not extended beyond that of the 200-year recurrence interval. However, the Highway 75 Dam embankment would not be overtopped for these larger flood events.

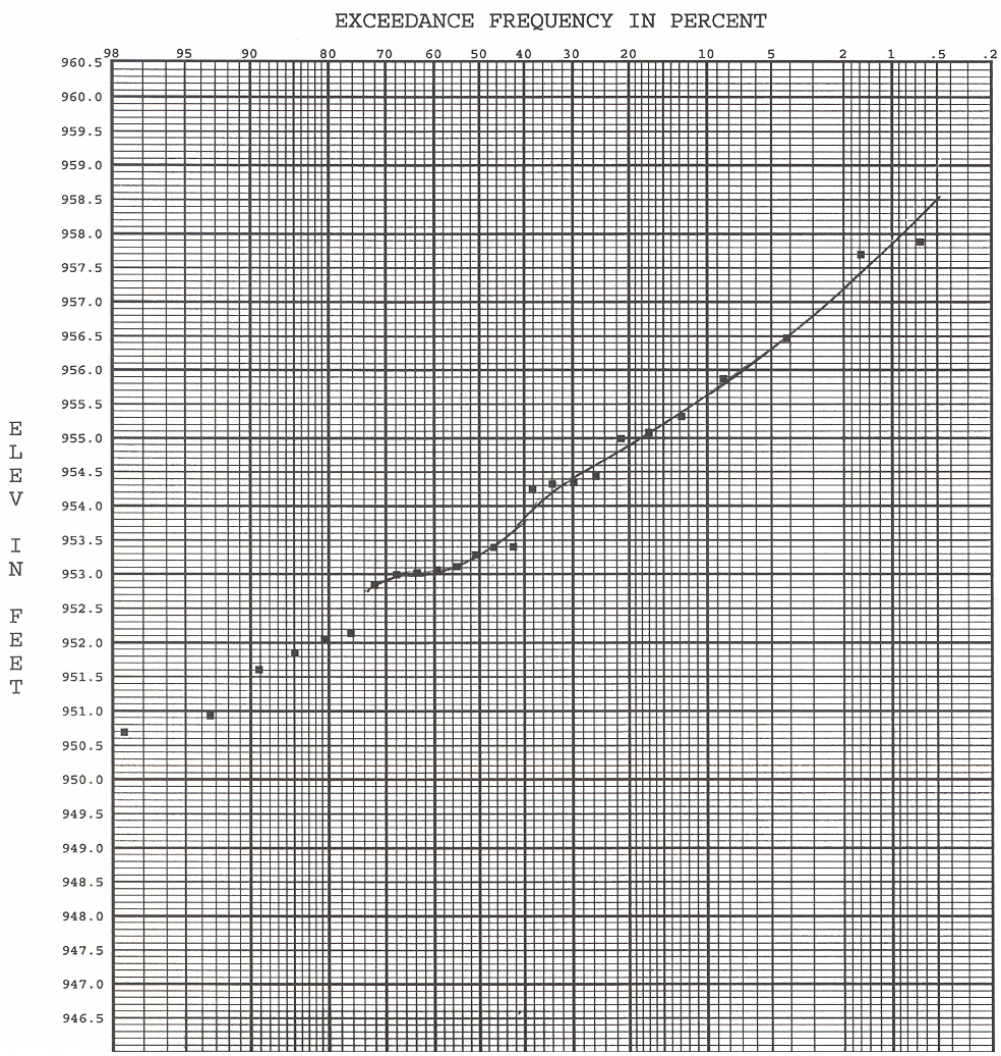


Figure 8-6. Annual Peak Pool Elevation Frequency – Highway 75

g. Annual Peak Outflow Probability – Highway 75. A peak discharge–frequency relationship was developed for total outflow from Highway 75 Dam. The same 25 years of data used to develop the elevation/frequency curve was for the graphical development of the discharge/probability curve. That is, the 1981 peak flow of 2 cfs was considered to be a singular, non-homogeneous event and was therefore excluded from the probability analysis. The flood of record occurred on 14 April 2001 with an estimated peak discharge of 11,900 cfs. Similar to the frequency analysis of pool elevations, the 1997 and 2001 flood events were considered to be the largest flows in the historic period dating back to 1897. **Figure 8-7** shows the adopted

discharge/frequency curve that was graphically fitted to the 25 years of systematic record with the adjusted median plotting positions for the 107-year historic period. Rating curves for the outlet structure were used with the adopted elevation/frequency curve as an aid for graphically constructing the discharge probability relationship. The 1-percent flood event reaches a peak elevation of 957.9 feet with a total outflow of approximately 11,700 cfs of which about 8,600 cfs flows over the service spillway and about 3,100 cfs passes over the emergency spillway. For consistency with the annual peak mean daily inflow frequency curve and the annual peak pool elevation frequency curve, the peak outflow frequency relationship was not extended beyond the 200-year recurrence interval.

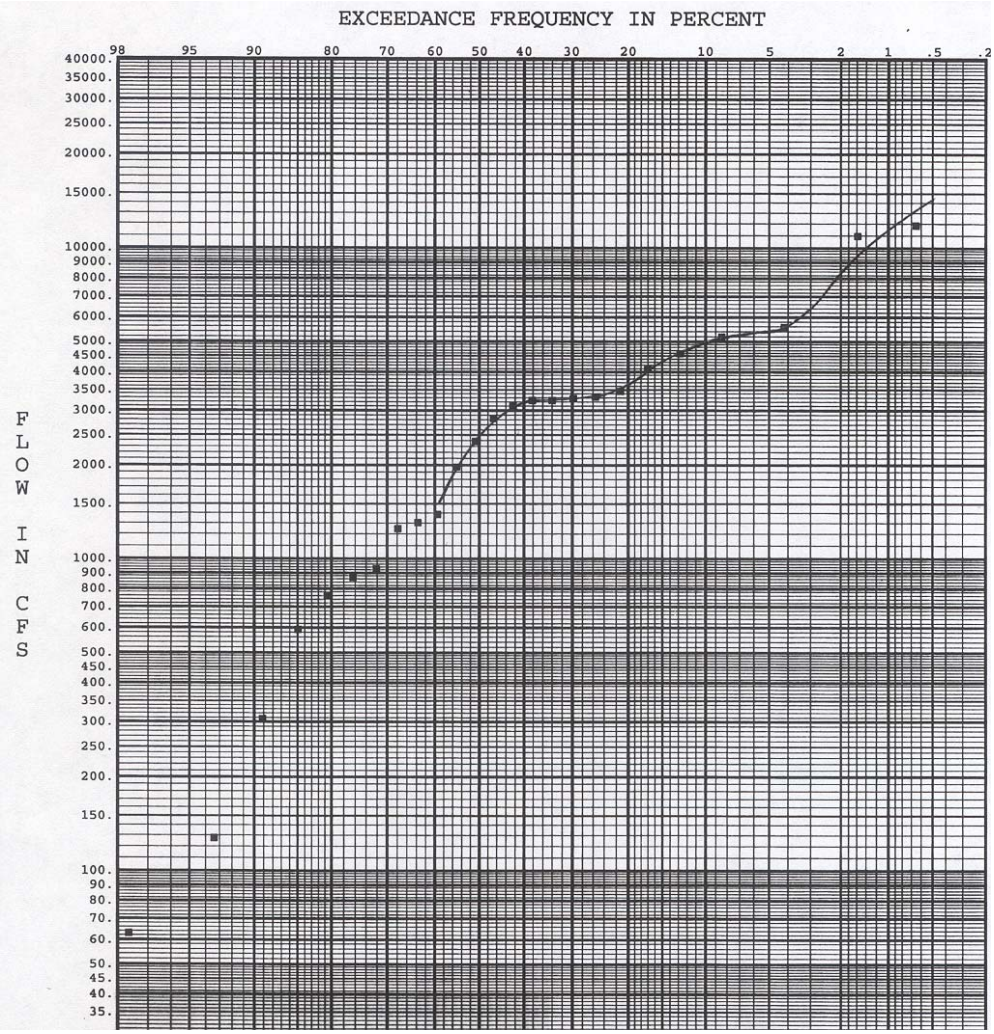


Figure 8-7. Annual Peak Outflow Probability – Highway 75

h. Yellow Bank River near Odessa. The US Geological Survey maintains a continuous stream flow gage on the Yellow Bank River near Odessa, Minnesota. The gage is a water-stage recorder and is located on the left bank 1,200 feet upstream of the highway bridge, 2.5 miles southwest of Odessa, and 4.5 miles upstream from the mouth. The gage has a datum of 953.34 feet above mean sea level (1929 NGVD), drains an area of 459 square miles, and has a period of record from October 1939 to September 1999, October 1999 to the current year. Shown on **Figure 8-8** is the annual instantaneous peak discharge frequency relationship for the Yellow Bank River near Odessa that was developed using the available published period of record flows for the water years of 1940 to 2002.

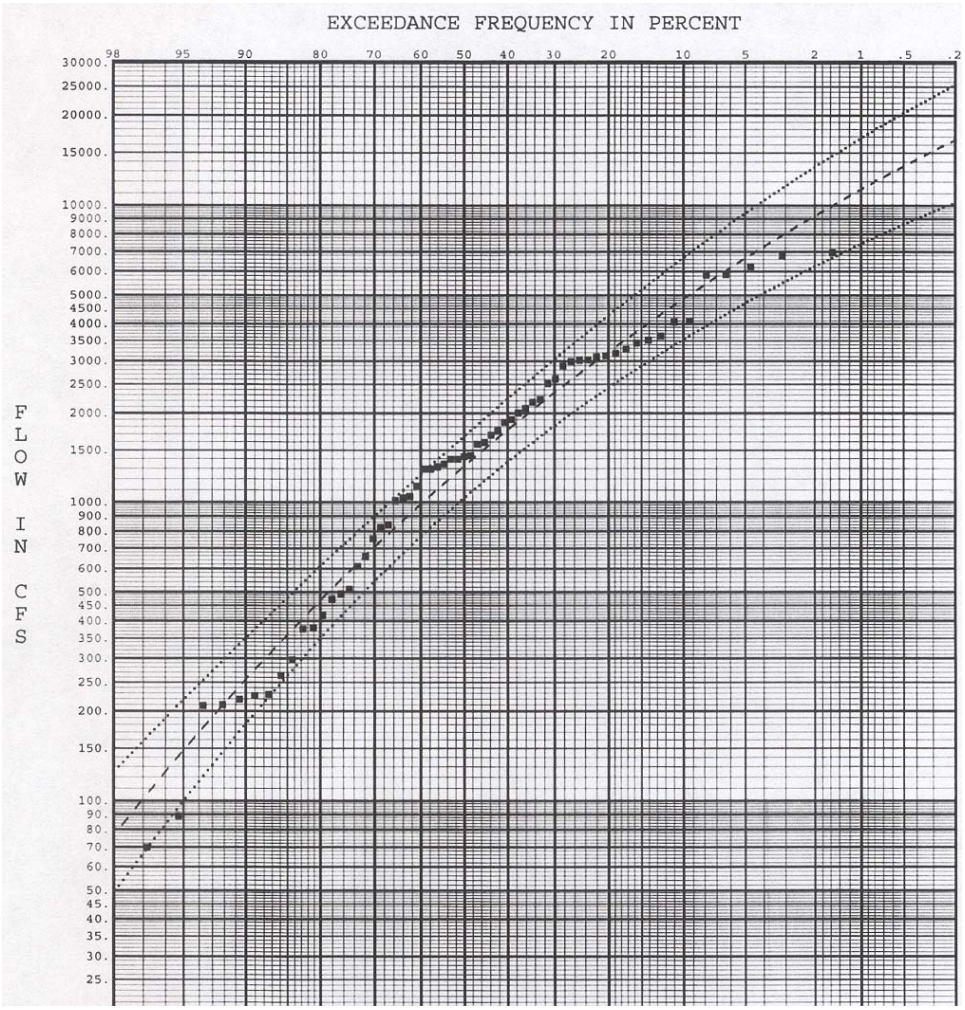


Figure 8-8. Yellow Bank River near Odessa – Discharge/Frequency

8-11. Other Studies.

a. Flood Forecasting. The University of Minnesota, St. Anthony Falls Hydraulic Lab, published Report No. 151 on June 1974. The title of the repot was *Forecasting Rainfall and Snowmelt Runoff on Floods on Upper Midwest Watersheds*. This report used SSARR (Streamflow Synthesis and Reservoir Regulation), HEC-1 (Flood Hydrograph Package), and the National Weather Service's River Forecast model to compare various flood forecasting techniques. The entire Minnesota River basin was modeled.

b. Low Flow Simulation. Barr Engineering was contracted by the Corps of Engineers to simulate low flow conditions in the Minnesota River. The title of the report was *Computer Simulation of Low Flow Conditions, Minnesota River*, 1980. This report discusses an HEC-3 model (Reservoir System Analysis for Conservation) that was developed to examine the effects of low flows in the Minnesota River valley.

IX - WATER CONTROL MANAGEMENT

9-01. Responsibilities and Organization. There are several federal, state, and county agencies that have an interest in the regulation of the Big Stone Lake-Whetstone River Project. The following is a description of the responsibilities of the larger organizations.

a. Corps of Engineers. The Corps of Engineers owns, operates, and maintains Highway 75 Dam. The Lac qui Parle Flood Control Project Office has responsibility for the actual operation and maintenance of the dam. Regulation of the reservoir is under the direction of the St. Paul District, Water Control Section. "Prior to spring runoff, the bascule gate on the service spillway will be lowered to the spillway crest and the conservation pool will be at elevation. 947.3" as prescribed by paragraph 1.b. of the Memorandum of Understanding between the Corps of Engineers and the US Fish and Wildlife Service (**Appendix C**, Exhibit 3). Following spring runoff, regulation of the reservoir follows the operating plan developed by the US Fish and Wildlife Service (USFWS).

The Corps of Engineers owns the project, which includes approximately 254 acres encompassing the embankment, main service spillway, emergency spillway and low flow outlet works. Also, included in this acreage is a 150-foot wide trans-basin channel within the reservoir that extends from the Minnesota River channel, transects the former Yellow Bank River channel and ends just upstream of the service spillway area.

b. Fish and Wildlife Service. The US Fish and Wildlife Service (USFWS) owns the Highway 75 Reservoir that includes approximately 10,540 acres of project lands and water upstream of the Highway 75 Dam. The USFWS manages the lake level, through a cooperative agreement with the Corps of Engineers following spring runoff. A Cooperative Agreement (**Appendix C**, Exhibit 1) allows for an annual operating plan to be prepared by the US Fish and Wildlife Service and the Corps of

Engineers with particular consideration given to the reservoir water levels desired for waterfowl production and management at various times of the year.

c. Other Federal Agencies. The National Weather Service has the responsibility for all hydrologic forecasts within the Minnesota River Basin. The nearest forecast point to the project is Montevideo. The US Geological Survey collects and publishes stage and discharge data at Whetstone River near Big Stone City, Minnesota River at Ortonville, and the Yellow Bank River near Odessa. The Natural Resource Conservation Service and the US Environmental Protection Agency all have an ongoing interest in the regulation of the Big Stone Lake-Whetstone River Project.

9-02. Interagency Coordination.

a. Local Press and Corps Bulletins. Water Control Section works with the Public Affairs Office (PAO) to provide news releases to the local news media of an advisory nature regarding important aspects of project regulation. Because Highway 75 plays a minor role in flood protection and essentially regulated by the US Fish and Wildlife Service, a public news release is rarely ever needed.

b. National Weather Service. Water Control provides operational information regarding Highway 75 Dam and Reservoir to the National Weather Service (NWS) through the World Wide Web, e-mail, facsimile, and telephone. Because it is standard operating procedure to lower the bascule leaf gate prior to spring runoff, little coordination with the NWS is needed regarding project regulation during spring runoff.

c. US Geological Survey. Water Control enters into a cooperative agreement with the US Geological Survey (USGS) every year regarding the operation and maintenance of the stream gages on the Minnesota River at Ortonville and the Yellow Bank River near Odessa. While the Corps does not fund the Whetstone River near Big Stone City, the equipment at this site belongs to Water Control. All

three of these sites are Data Collection Platforms and therefore hourly stage data are available. Discharge values for these sites are published on the USGS web site.

d. Other Agencies. The Upper Minnesota River Watershed District owns, operates and maintains Big Stone Lake Dam, which is an integral part of the Big Stone Lake-Whetstone River Flood Control Project. Operation of Highway 75 Dam and Reservoir is correlated with that of Big Stone Lake Dam. The original operating plan for Big Stone Lake Dam is provided as **Appendix F**.

9-03. Interagency Agreements.

a. Upper Minnesota River Partnership Group. The St. Paul District is a participant in the Upper Minnesota River Partnership Group, which consists of representatives from the St. Paul District, U S Fish and Wildlife Service, Natural Resource Conservation Service, Minnesota Department of Natural Resources, Minnesota Pollution Control Agency, and the Minnesota Board of Water and Soil Resources. Its two main objectives are to provide a mechanism for participating state and federal agencies to facilitate the coordination of their programs and activities, and to provide an opportunity for other interested parties to express their concerns and receive guidance. Each participating agency, including the St. Paul District, functions within the partnership according to its own authorities, programs, funding, and management or regulatory responsibilities.

b. US Fish and Wildlife Service. There exist several formal agreements between the Department of the Army through the Corps of Engineers and the Department of Interior through the US Fish and Wildlife Service including a Cooperative Agreement, a General Plan for use of Project Lands and Waters, and a Memorandum of Understanding. These agreements are shown in **Appendix C**, Exhibits 1 through 3 respectively.

9-04. Commissions, River Authorities, Compacts & Committees. In addition to the federal, state, and local government agencies previously discussed, other interest groups include the Area II Minnesota River Basin Projects Group, Citizens for Big Stone Lake, Clean Up Our River Environment (CURE), Coalition for a Clean Minnesota River, and Friends of the Minnesota Valley.

9-05. Reports. Table 9-1 presents a listing of reports compiled by or for the Water Control Section regarding the regulation of the Big Stone Lake-Whetstone River Project.

Table 9-1
Highway 75 Dam and Reservoir Reports

Report Name	Compiled	Form Number
Compiled by Water Control		
Reservoir Bulletin	Daily	Water Control Web Site
Compiled by Field Office for the Water Control Center		
Weekly Log Sheet	Weekly	CEMVP-405B
Snow Reports and Frost Reports	Weekly During Season	CEMVP-430 CEMVP-58
Other		
Climatological and River Records	Monthly	NWS B-91

APPENDIX A
SUPPLEMENTAL PERTINENT DATA

Highway 75 Dam and Reservoir

GENERAL INFORMATION

Full Project Name:	Big Stone Lake-Whetstone River Project
Reservoir Project Name:	Highway 75 Dam and Reservoir
Location:	Minnesota River, River Mile 316 Nine miles D/S of Big Stone Lake Four miles D/S of Odessa, Minnesota
Type of Project:	Dam and Reservoir
Regulation Objectives:	Primary: Flood Mitigation Secondary: Wildlife Enhancement and Recreation
Project Owner:	United States Government
Dam and Appurtenant Works:	Corps of Engineers
Reservoir Lands, Water Areas:	US Fish and Wildlife Service
Operating Agency:	Corps of Engineers
Regulating Agency:	Corps of Engineers and US Fish and Wildlife Service
Construction:	
Cost:	$3,092,000
Initiated:	July 1971
Completed:	July 1974

Formal Agreements: Corps of Engineers/US Fish and Wildlife Service
No. 1 Cooperative Agreement
No. 2 General Plan for use of Project Lands and Water
No. 3 Memorandum of Understanding

RESERVOIR

	Elevation Feet	Area Acres	Storage Acre-Feet
Emergency Spillway Design	961.4	7,900	84,000
Crest of Emergency Spillway	956.5	6,100	34,000
Raised Bascule Leaf Gate	952.3	2,800	9,000
Lowered Bascule Leaf Gate	947.3	950	300

Real Estate

US Fish and Wildlife Service:	10,540 acres
Corps of Engineers:	254 acres
Total Purchased:	10,794 acres
Corps Acquired Easements:	105 acres
Taking Line Elevation:	959.5 feet

Emergency Drawdown

Culvert Diameter:	42 inches
Intake Invert:	940.0 feet
Outlet Invert:	939.0 feet
Low Flow Control:	Sluice Gate

Reservoir

Length:	7.5 miles @ Elev. 952.3 feet
Shoreline:	23 miles @ Elev. 952.3 feet
Range of Clearing:	None

HYDROLOGY

Drainage Areas

Big Stone Lake Dam:	1,160 square miles
Yellow Bank River:	470 square miles
Local:	260 square miles
Total at Highway 75 Dam:	1,890 square miles

Standard Project Flood

Peak Inflow:	44,400 cfs	Peak Pool Elevation:	961.4 feet
Peak Outflow:	32,800 cfs	Freeboard:	3.1 feet

Maximum Pool Elevation:	957.89 feet	(April 14, 2001)
Minimum Pool Elevation:	946.08 feet	(January 1, 1985)
Maximum Peak Outflow:	11,900 cfs	(April 14, 2001)
Minimum Daily Outflow:	2 cfs	(1 Aug 1987 to 17 Feb 1988) (3 Jun 1988 to 27 Mar 1989)
Maximum Monthly Flow:	6,362 cfs	(April 1997)
Minimum Monthly Flow:	2 cfs	(several occasions)
Key Streamflow Stations	Upstream:	Minnesota River at Ortonville
	Mid Pool:	Yellow Bank River near Odessa

Data Recorded at Lac qui Parle:

Pool Elevation	Low Flow Head Differential
Tailwater Elevation	Computed Flow - Leaf Gate
Minnesota River at Ortonville Stage	Computed Flow - Low Flow Culvert
Yellow Bank River near Odessa	Total Computed Outflow
Leaf Gate Elevation	24-Precipatation (from DCP)
Low Flow Gate Opening	

EMBANKMENT

Location: Highway 75
Purpose: Impoundment of Flood Waters
Type: Compacted Earth Impervious Fill

Design Flood: Standard Project Flood (SPF)
Freeboard: 3.1 feet

Crest Elevation: 964.5 feet
Length: 16,250 feet including spillway sections
Maximum Height: 25 feet
Top Width: 20 feet (with roadway)
Side Slopes

Upstream Face:	1V:2.5H	Protection: 18 inch Riprap
Downstream Face:	1V:3H	Protection: 12 inch Riprap below 956.0 ft

SERVICE SPILLWAY

Location: Near South End of Dam,
450 feet upstream of Highway 75
Type: Re-inforced Concrete Gravity Weir
Crest Elevation: 947.3 feet
Length: 65 feet

Gate:
Type: Bascule Leaf Gate
Height: 5 feet in raised position
Length: 65 feet

Stilling Basin:
Type: Re-inforced Concrete
Length: 68 feet
Width: 65 feet
Floor Elevation: 934.0 feet
Baffle Blocks: 5 blocks, top elevation of 938.6 feet
End Sill Elevation: 936.9 feet

EMERGENCY SPILLWAY

Location:	Near North End of Dam
Type:	Uncontrolled Broad Crest, Grass-lined
Crest:	
Elevation:	956.5 feet
Length:	715 feet
Width:	50 feet
Side Slopes:	1V:3H training dike 30-inch Rip Rap
Discharge Channel	
Length:	310 feet to 350 feet, varies
Slope:	1.5 percent
Geometry:	1-foot deep "V" shaped depression
Maximum Discharge:	19,300 cfs for SPF, Pool Elevation at 961.4 feet

LOW FLOW CONTROL

Location:	Near North End of Embankment
Purpose:	Low Flow
Type	Circular Re-inforced Concrete Pipe
Diameter:	42 inches
Length:	117 feet
Intake Invert:	940.0 feet
Discharge Invert:	939.0 feet
Gates	
Service:	42-inch Sluice Gate
Emergency:	42-inch Sluice Gate, upstream
Maintenance:	Stop Logs

Big Stone Lake Dam

GENERAL INFORMATION

Project Name:	Big Stone Lake Dam
Location:	Minnesota River, River Mile 330 Nine Miles U/S of Highway 75 Dam
Type of Project:	Dam and Reservoir

Regulation Objective: Flood Control for Big Stone Lake
Improve Water Quality of Big Stone Lake
Provide Minimum Flows in the Minnesota River

Project Owner: Original Owner: State of Minnesota
Present Owner: Upper Minnesota River Watershed
Operating Agency: Upper Minnesota River Watershed
Regulating Agency: Upper Minnesota River Watershed

Construction: Original Structure: 1937
Modified as Part of the
Big Stone Lake - Whetstone River Project
Initiated 1971/Completed 1974
Adjustment to Limit Torque Switches: 1999

Formal Agreements: Operation and Maintenance Manual, March 1987
Maintain elevation 968.0 feet during the Summer
Drawdown to elevation 967.0 feet, 1 Nov to 1 Dec

RESERVOIR

Length: About 25 miles
Width: About 1.5 miles at the lower end
About 1 mile at the upper end

Maximum Pool Elevation: 973.2 feet on 7 April 1997 (period of record 1937 to 2005)
Maximum Discharge: 5,070 cfs on 10 April 1997

Drainage Area: 1,160 square miles

CONTROL STRUCTURE

Top of Embankment: Elevation 972.7 feet to 975.0 feet
Top of Abutment: Elevation 972.7 feet

Service Spillway
Type: Concrete with Ogee Crest
Crest Elevation: 960.70 feet

Slide Gates
Number and Size: 8 gates: 7 feet high, 10 feet 10 inches wide
Vertical Lift: Design: 12.25 feet
1974 to 1999: Approximately 7 feet
1999 to 2005: 11.5 feet

Low Flow Conduits	No. 1	No.2
Shape:	Square	Circular
Size:	4 feet by 4 feet	18-inch
Invert Elevation:	961.4 feet	961.4 feet
Control:	Sluice Gate	Sluice Gate

Silt Barrier

Type:	Steel Sheet Pile with Concrete Cap
Length of Spillway:	200 feet
Crest Elevation:	964.7 feet
Low Flow Control:	30-inch Corrugated Metal Pipe Sluice Gate Controlled

APPENDIX B

RELATED MANUALS AND REPORTS

Prior reports for flood control and navigation aids date from about 1874 and include a number of printed documents and annual reports of the Chief of Engineers. These reports deal with investigations into the advisability of dredging, removal of obstructions, and construction of locks and dams on the Minnesota River, Lake Traverse, and the Red River of the North and tributary streams. In general, these early reports were favorable to dredging and the removal of obstructions but were unfavorable to the construction of locks and dams as aids to navigation.

a. *Report of an Exploration of the Territory of Minnesota in 1849,* Ex. Document No. 42, 31st Congress, Corps of Topographical Engineers, Captain John Pope, 1850.
b. *Examination and Survey of the Minnesota River,* Ex. Document No. 76, 43rd Congress, 2nd Session, Corps of Engineers, Major G. K. Warren, 1866 - 1867.
c. *Survey of Minnesota River, Big Stone Lake, and Lake Traverse,* House Document No. 75, 44th Congress, 1st Session, Corps of Engineers, Colonel T. N. Macomb, 1872.
d. *Report on Reservoir at Foot of Big Stone Lake,* Senate Document No. 30, 48th Congress, 1st Session. Provided unfavorable recommendations, as commerce did not justify cost of reservoir for navigation.
e. *Preliminary Examination of Big Stone Lake and Lake Traverse*. House Document No. 71, 48th Congress, 2nd Session, (Unfavorable). Examined the possibility of connecting the two lakes.
f. *Red River of the North and Big Stone Lake,* House Document No. 127, 52nd Congress, 1st Session. Concluded that a reservoir at Big Stone Lake could aid navigation on the Mississippi River by increasing low flows.
g. *Preliminary Examination of Big Stone Lake,* House Ex. Document No. 256, 53rd Congress, 3rd Session. Recommended a survey of Big Stone Lake and Lake Traverse for reservoirs.
h. *Survey of Big Stone Lake and Lake Traverse for Reservoirs,* House Document No. 134, 55th Congress, 2nd Session, 1897. (unfavorable, recommended further study) Includes plans for reservoir and estimates of cost.
i. *Preliminary Report on Survey of Big Stone Lake and Lake Traverse for Reservoirs*, House Document No. 675, 56th Congress, 1st Session, Progress Report. Recommended a final report to be completed in 3 years.
j. *Survey Report on Reservoirs at Big Stone and Lake Traverse,* House Document No. 539, 58th Congress, 2nd Session, 1904. Provided an unfavorable recommendation.
k. *Examination of the Bois de Sioux River, Lakes Traverse and Big Stone Lake,* House Document No. 493, 60th Congress, 1st Session, 1908. (unfavorable) Examined the possibility of diverting floodwaters from the Red River of the North basin into the Minnesota River.

l. *Survey of Minnesota River for Upper Valley Navigation Reservoirs*, House Document No. 700, 62nd Congress 2nd Session. Recommended the construction of a 45-foot dam at Lac qui Parle with water power development to be operated as a navigation reservoir.
m. *Examination of Lake Traverse and Big Stone Lake*. House Document No. 199, 65th Congress, 1st Session, 1917. Looked at flood control, waterpower, and the possibility of connecting and extending navigation on and between the lakes.
n. *First Biennial Report of the Commissioner of Drainage and Waters to the Governor of the State of Minnesota and the Legislature*, 1921. Presents plans of improvement for control of floods on the Minnesota River by means of 3 main stem reservoirs.
o. *Second Biennial Report of the Commissioner of Drainage and Waters to the Governor of the State of Minnesota and the Legislature*, 1923. Provides results of continuation of studies on plan in 1st Biennial Report.
p. *Minnesota River, Minnesota (Navigation, water power, flood control, and irrigation)*, House Document No. 230, 74th Congress, 1st Session. The prospective flood control benefits from three reservoirs (Big Stone Lake, Lac qui Parle, New Ulm) were generally not sufficient in character to warrant Federal participation. The report proposed the Mendota Reservoir.
q. *Big Stone Lake Reservoir Project and Lac qui Parle Reservoir Project*, House Document No. 669, 76th Congress, 3rd Session. Proposed reservoirs to reduce the frequency of flooding in the upper portions of the Minnesota River Valley. A future reservoir is proposed near New Ulm, Minnesota in a tabulation of a comprehensive flood control plan.
r. *Report on Diversion of Flood Waters of Little Minnesota River into Lake Traverse*, Review of House Document No. 230, 74th Congress, 1st Session. Includes a study of flood problems on the Minnesota River from Browns Valley to Lac qui Parle Dam.

EXHIBIT 1

DRAFT

COOPERATIVE AGREEMENT
BETWEEN THE U.S. DEPARTMENT OF THE ARMY
AND THE U.S. DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF SPORT FISHERIES AND WILDLIFE

THIS AGREEMENT, between the Department of the Army and the Department of the Interior through the Fish and Wildlife Service, Bureau of Sport Fisheries and Wildlife, witnesseth that:

WHEREAS, the Act of 27 October 1965 (79 Stat. 1093-1096) provides that "The project for the Big Stone Lake and Whetstone River, Minnesota and South Dakota, is hereby authorized substantially as recommended by the Chief of Engineers in House Document Numbered 579, Eighty-seventh Congress, and House Document Numbered 193, Eighty-eighth Contress,...: and,

WHEREAS, approximately 82 per cent of the Federal first cost will be cost-shared for wildlife in recognition of the National interest in conservation benefits (National Wildlife Refuge) and,

WHEREAS, the Bureau of Sport Fisheries and Wildlife has indicated that approximately 10,100 acres of project lands and waters will be needed for a National Wildlife Refuge, and,

WHEREAS THE UNITED STATES, throught the Department of the Army, has acquired certain lands in fee-title for purposes of the Big Stone Lake-Whetstone River Project, and

WHEREAS, pursuant to the authority contained in the Act of 10 March 1934 (48 Stat. 401, as amended; 16 U.S.C. 661-666e), there has been formulated a "General Plan for use of Project Lands and Waters for Wildlife Conservation and Management, Big Stone Lake-Whetstone River Project", and said plan has been approved by the Secretary of the Army, the Secretary of the Interior, and the Commissioner of the Minnesota Department of Conservation.

NOW, THEREFORE, in accordance with the aforesaid Section 3 of Public Law 732, and the aforesaid General Plan, the former two parties hereto enter into this Cooperative Agreement.

THE DEPARTMENT OF THE ARMY hereby makes available to the Bureau of Sport Fisheries and Wildlife the land and water areas of the Big Stone Lake-Whetstone River Project as shown substantially in red on the attached drawing labeled Exhibit "A", for the purposes of development, conservation and management of wildlife resources thereon in accordance with said General Plan. Said exhibit is attached hereto and made a part hereof. This Cooperative Agreement shall be subject to the provisions and conditions of the said General Plan and to the following additional conditions:

1. The use and occupation of the said premises shall be without cost or expense to the Department of the Army, under the general supervision of the District Engineer, Corps of Engineers, St. Paul District, hereinafter referred to as the "District Engineer", except that that agency will be responsible for major repair and maintenance of the dam and associated structures, including funding of this work.

2. It is understood and agreed that the ownership of the United States in the area described in Exhibit "A" is subject to certain outstanding rights in third parties, such as easements for public roads and highways, access roads, pipelines, transmission lines, sheep and cattle watering locations and similar matters. It is therefore agreed that the uses and administration of the area described herein shall be subject to all such existing rights.

3. As of the commencement date of this agreement, an inventory and condition report of all property and improvements of the Department of the Army included in this agreement shall be made by a representative of the Department of the Army and a representative of the Bureau of Sport Fisheries and Wildlife to reflect the then present condition of said property. A copy of said inventory and condition report shall be attached hereto as Exhibit "B" and become a part hereof as fully as if originally incorporated herein. Upon the expiration, revocation, or termination of this agreement, a similar inventory and condition report shall be prepared and submitted to the said officer, said inventory and condition report to constitute the basis for settlement by the Bureau of Sport Fisheries and Wildlife with said

officer for property shown to be lost, damaged, or destroyed, any such property to be either replaced or restored to the condition required by Condition No. 8 hereof, or at the election of the Department of the ARmy reimbursement made therefore by the Bureau of Sport Fisheries and Wildlife at the then current market value thereof.

4. An annual operating plan will be prepared by the U.S. Corps of Engineers and the Bureau of Sport Fisheries and Wildlife. Particular consideration will be given to the reservoir water levels desired for waterfowl production and management at various times of the year.

5. The Bureau of Sport Fisheries and Wildlife shall administer and maintain the premises in accordance with an annual management program prepared and submitted to the District Engineer each year on or before 1 March. Such annual management program shall include information as to all areas designated for public hunting, wildlife refuges, the production of food for wildlife, or other purposes; nature, site, and layout of proposed construction and improvements; estimated cost of construction of planned improvements; and plans for other such activities, on lands made available under this agreement. The annual management program may be amended from time to time as may be necessary, but the District Engineer shall be informed thereof prior to the effective date of any change. The Bureau of Sport Fisheries and Wildlife will also furnish statistical data and other information to the District Engineer relative to the magnitude of benefits being realized by the public from operation of the premises as a wildlife management area.

6. This agreement may be revoked at the discretion of the Department of the Army in case of national emergency declared by the President, or in event of violation of any of the terms and conditions of this agreement, which ciolation is continued for a period of thirty (30) days after notice in writing by the District Engineer, or for nonuse for a period of two consecutive years.

7. This agreement may be relinquished by the Service at any time by giving to the District Engineer at least thirty (30) days' notice in writing.

8. If this agreement is relinquished or revoked as provided above, the Service shall vacate the said premises, remove all property of the Service therefrom, and restore the premises to a condition as reflected in Exhibit "B", ordinary wear and tear and damage beyond the control of the Service excepted, within such time as the Secretary of the Army may designate.

Date	Director, Bureau of Sport Fisheries and Wildlife, U.W. Fish and Wildlife Service
Date	Chief of Engineers U.S. Corps of Engineers

EXHIBIT 2

General Plan
For use of Project Lands and Waters
For Wildlife Conservation and Management
Big Stone Lake-Whetstone River Project, Minn. and So. Dak.

The Department of the Army, acting through the Corps of Engineers, under the authority of 79 Stat. 1073-1096 is acquiring certain lands in the State of Minnesota for the construction, operation and maintenance of the Big Stone Lake-Whetstone River Project for flood control and fish and willdife purposes; and the Secretary of the Army has determined that approximately 10,100 acres of the project land and water areas, as shown on Exhibit A, attached hereto, are available for fish and wildlife conservation and management purposes, consistent with the primary and collateral purposes of the project.

The Secretary of the Interior finds that the project land and water areas shown on the exhibit attached hereto, do have value in carrying out the National Migratory Bird Management Program.

THEREFORE, IN ACCORDANCE WITH THE PROVISIONS OF AND UNDER THE AUTHROITY OF THE FISH AND WILDLIFE COORDINATION ACT (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.) THE SECRETARY OF THE ARMY, THE SECRETARY OF THE INTERIOR AND THE COMMISSIONER, MINNESOTA DEPARTMENT OF CONSERVATION, DO HEREBY APPROVE THIS DOCUMENT AS A GENERAL PLAN AND AGREE THAT:

1. All land and water areas shown on Exhibit A, dated (May, 1967) attached hereto and by this reference made a part hereof will be made available by the Secretary of the Army to the Department of the Interior for primary administration and management.

2. Necessary details of agreement between the two agencies shall be covered in a cooperative agreement to be mutually agreed to and signed by the Director of the Bureau of Sport Fisheries and Wildlife and the Chief of Engineers without amendment to this General Plan. Such adjustments will be made by amendment of the aforementioned agreement.

IN WITNESS WHEREOF, the parties hereto have affixed their signature and date thereof an triplicate copies hereof, as follows:

Date_____ _____

Commissioner, Minnesota Department of Conservation

Date_____ _____

Secretary of the Army

Date_____ _____

Acting Secretary of the Interior

EXHIBIT 3

MEMORANDUM OF UNDERSTANDING
BIG STONE LAKE - WHETSTONE RIVER PROJECT

WHEREAS, the United States Fish and Wildlife Service will cooperate with the Corps of Engineers in the operation of the Highway No. 75 dam and reservoir; with the water area and surrounding land to be utilized as a wildlife refuge; now, therefore, the following agreements between the Corps of Engineers and the United States Fish and Wildlife Service are hereby entered into.

RESERVOIR OPERATING PLAN

1. Operation of the gates of the Highway 75 dam and the low flow conduit structure will be the responsibility of the Corps of Engineers through its Reservoir Regulating Section in accordance with the following plan.

a. During the critical waterfowl use period, May through October, the gates will be operated to maintain the reservoir pool at high conservation pool elevation 952.3. If heavy flows should occur during this period, the service spillway bascule gate will be lowered at the rate required to control the level within a half-foot range above or below elevation 952.3. During low flow periods, small releases, as required, will be made through the gated low flow conduit provided in the dam. Pool levels normally will be in accordance with the following schedule.

Month	Pool elevation
May 1 -- October 31	952.3
December 1	951.1
January 1	950.4
February 1	949.6
March 1	948.4
Prior to spring runoff	947.3

b. Prior to spring run-off, the bascule gate on the service spillway will be lowered to the spillway crest and the conservation pool will be at elevation 947.3. During spring periods, the runoff from major floods will pass over the service spillway and the bascule gate will be raised during the recession of the high flow to obtain the normal summer high conservation pool level of elevation 952.3.

c. The hydrologic operation of this reservoir at all times will be under the direction of the Reservoir Regulation Section and will be correlated with the operation of the control structure at Big Stone Lake.

d. In the event the reservoir has to be drawn down for management or maintenance purposes, such action will be fully coordinated between the Corps of Engineers, the United States Fish and Wildlife Service, and the Minnesota Department of Natural Resources. The discharge during drawdown will be set to minimize high water conditions along the river and in the reservoirs downstream of the dam.

e. A daily log of low flow and spillway gate setting will be maintained by the Reservoir Regulating Section and a copy furnished monthly to the United States Fish and Wildlife Service.

f. The Reservoir Regulating Section will develop a Reservoir Regulating Manual detailing specifics of operation and coordination with the United States Fish and Wildlife Service.

DATA COLLECTION

2. Visitation data for the project will be collected by the United States Fish and Wildlife Service and furnished by mail to the Corps of Engineers monthly.

3. Additional work at the Highway 75 dam may be handled by the United States Fish and Wildlife Service on a reimbursement basis. This could include data collection, operation of the service spillway, low flow structure, and minor maintenance work. Work to be done by the United States Fish and Wildlife Service would be determined on a annual basis.

3 July 1975
Date

District Engineer
Corps of Engineers

7/16/75
Date

Regional Director
Fish and Wildlife Service

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Big Stone National Wildlife Refuge
R.R. 1, Box 25
Odessa, MN 56276

COMMERCIAL: 320/273-2191
TTY:1-800-735-2966
FAX: 320/273-2231

March 12, 2001

Ferris Chamberlin
St. Paul District, Corps of Engineers
Attention: CEMVP-ED-H
190 5th St. East
St. Paul, MN 55101-1638

Dear Ferris,

The following is our request for the operation of the Highway 75 dam and levels in the East Conservation Pool for the calendar year 2001 according to the FWS-COE Cooperative Agreement 14-16-000381-902, Big Stone Lake-Whetstone River Project.

We request that water levels be drawn down to 949.0 after the spring crest has passed. If possible, we would like to reach this level by April 10 and maintain through May 1. Surveys have shown that mid-April is the peak of the shorebird migration as the birds are utilizing the shallow waters and mudflats in West Conservation Pool exposed by draw-down. After May 1, gradually raise the water level back to 950.0 and maintain through June 15. Precipitation permitting, these water levels should provide breeding water-birds adequate foraging opportunity and access to cover while concurrently setting back succession of annual and perennial wetland plants that have colonized mudflat fringes in recent years.

After June 15 gradually de-water to 948.0 by July 9 in preparation for the onset of fall shorebird migration. Continue to slowly de-water to 947.3 by August 15 to maximize mudflats in East Pool for the peak of migration. Maintain this level until August 31. After August 31 we request a gradual raising of the water (approximately .25 feet/week) to a level no higher than 949.5 by October 15. After October 15 continue to raise water-levels through late fall until 951.0 is attained. Maintain this level throughout the late fall and winter period.

As always, we appreciate your continued cooperation in achieving our water-level management goals to maximize benefits to all waterbirds.

Sincerely,

Bridget Olson

for Ron Cole, Project Leader

EXPANDED RATING TABLE TYPE: LOG

5290000 DATE PROCESSED: 02-09-1999 @ 13:32 BY mcnellis

LITTLE MINNESOTA RIVER NEAR PEEVER, SD DD: 2 TYPE 001 RATING NO: 25.0

OFFSET: 1.90 BREAK,OFFEST: (2.44,2.20) START DATE/TIME: 10-01-1996 (0001)

GAGE HEIGHT (FEET)	DISCHARGE IN CUBIC FEET PER SECOND (EXPANDED PRECISION) 0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	DIFF IN Q PER TENTH FT
1.90	.000*	0.020	0.040	0.060	0.080	0.100	0.120	0.140	0.160	0.180	0.200
2.00	.200*	0.220	0.240	0.260	0.280	0.3000	0.320	0.340	0.360	0.380	0.200
2.10	.400*	0.445	0.492	0.542	0.595	.650*	0.705	0.763	0.823	0.885	0.550
2.20	.950*	1.016	1.083	1.153	1.226	1.300*	1.408	1.522	1.642	1.768	0.950
2.30	1.900*	2.053	2.214	2.384	2.563	2.750*	2.942	3.143	3.352	3.572	1.900
2.40	3.800*	4.035	4.280	4.535	4.800*	5.148*	5.507	5.876	6.254	6.642	3.240
2.50	7.04	7.45	7.87	8.29	8.73	9.17	9.63	10.09	10.56	11.05	4.50
2.60	11.54	12.04	12.54	13.06	13.59	14.12	14.66	15.22	15.78	16.34	5.38
2.70	16.92	17.51	18.10	18.70*	19.49	20.29	21.11	21.95	22.80	23.68	7.65
2.80	24.57	25.48	26.41	27.36	28.32	29.31	30.31	31.33	32.37	33.42	9.93
2.90	34.50	35.59	36.71	37.84	38.99	40.16	41.34	42.55	43.78	45.02	11.79
3.00	46.29	47.57	48.87	50.19	51.53	52.89	54.27	55.67	57.09	58.53	13.70
3.10	59.99	61.46	62.96	64.48	66.01	67.57	69.14	70.74	72.35	73.99	15.65
3.20	75.64	77.32	79.02	80.73	82.47	84.22	86.00	87.79	89.61	91.45	17.66
3.30	93.30	95.18	97.08	99.00	100.90	102.90	104.90	106.90	108.90	110.90	19.70
3.40	113.0*	115.00	117.00	119.10	121.20	123.30	125.40	127.50	129.60	131.80	21.00
3.50	134.0	136.1	138.3	140.4	142.6	144.8	147.0	149.2	151.5	153.7	22.0
3.60	156.0	158.2	160.4	162.6	164.8	167.0	169.3	171.5	173.8	176.1	22.4
3.70	178.4	180.7	183.1	185.4	187.8	190.2	192.6	195.0	197.4	199.8	23.9
3.80	202.3	204.8	207.2	209.7	212.2	214.8	217.3	219.9	222.4	225.0	25.3
3.90	227.6	230.2	232.8	235.5	238.1	240.8	243.5	246.2	248.9	251.6	26.8

EXPANDED RATING TABLE TYPE: LOG

5290000 DATE PROCESSED: 02-09-1999 @ 13:32 BY mcnellis

LITTLE MINNESOTA RIVER NEAR PEEVER, SD DD: 2 TYPE 001 RATING NO: 25.0

OFFSET: 1.90 BREAK,OFFEST: (2.44,2.20) START DATE/TIME: 10-01-1996 (0001)

GAGE HEIGHT (FEET)	DISCHARGE IN CUBIC FEET PER SECOND (EXPANDED PRECISION) 0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	DIFF IN Q PER TENTH FT
4.00	254.4	257.1	259.9	262.7	265.5	268.3	271.1	274.0	276.8	279.7	28.2
4.10	282.6	285.5	288.4	291.4	294.3	297.3	300.2	303.2	306.2	309.2	29.7
4.20	312.3	315.3	318.4	321.4	324.5	327.6	330.8	333.9	337.0	340.2	31.1
4.30	343.4	346.6	349.8	353.0	356.2	359.4	362.7	366.0	369.3	372.6	32.5
4.40	375.9	379.2	382.6	385.9	389.3	392.7	396.1	399.5	402.9	406.4	33.9
4.50	409.8	413.3	416.8	420.3	423.8	427.4	430.9	434.5	438.0	441.6	35.4
4.60	445.2	448.9	452.5	456.1	459.8	463.5	467.1	470.9	474.6	478.3	36.8
4.70	482.0	485.8	489.6	493.4	497.2	501.0	504.8	508.7	512.5	516.4	38.3
4.80	520.3	524.2	528.1	532.0	536.0	539.9	543.9	547.9	551.9	555.9	39.6
4.90	559.9	564.0	568.0	572.1	576.2	580.3	584.4	588.5	592.6	596.8	41.1
5.00	601.0	605.1	609.3	613.6	617.8	622.0	626.3	630.5	634.8	639.1	42.4
5.10	643.4	647.8	652.1	656.4	660.8	665.2	669.6	674.0	678.4	682.9	43.9
5.20	687.3	691.8	696.2	700.7	705.2	709.8	714.3	718.9	723.4	728.0	45.3
5.30	732.6	737.2	741.8	746.4	751.1	755.8	760.4	765.1	769.8	774.5	46.7
5.40	779.3	784.0	788.8	793.5	798.3	803.1	807.9	812.8	817.6	822.5	48.0
5.50	827.3	832.2	837.1	842.0	847.0	851.9	856.9	861.8	866.8	871.8	49.5
5.60	876.8	881.9	886.9	891.9	897.0	902.1	907.2	912.3	917.4	922.6	50.9
5.70	927.7	932.9	938.0	943.2	948.4	953.7	958.9	964.1	969.4	974.7	52.3
5.80	980.0	985.3	990.6	995.9	1001.0	1007.0	1012.0	1017.0	1023.0	1028.0	54.0
5.90	1034.0	1039.0	1045.0	1050.0	1055.0	1061.0	1067.0	1072.0	1078.0	1083.0	55.0

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GAGE HEIGHT (FEET)	DISCHARGE IN CUBIC FEET PER SECOND (EXPANDED PRECISION) 0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	DIFF IN Q PER TENTH FT
6.00	1089	1094	1100	1105	1111	1117	1122	1128	1134	1139	56
6.10	1145	1151	1157	1162	1168	1174	1180	1185	1191	1197	58
6.20	1203	1209	1215	1221	1226	1232	1238	1244	1250	1256	59
6.30	1262	1268	1274	1280	1286	1292	1298	1304	1311	1317	61
6.40	1323	1329	1335	1341	1347	1354	1360	1366	1372	1378	62
6.50	1385	1391	1397	1404	1410	1416	1423	1429	1435	1442	63
6.60	1448	1454	1461	1467	1474	1480	1487	1493	1500	1506	65
6.70	1513	1519	1526	1532	1539	1546	1552	1559	1566	1572	66
6.80	1579	1586	1592	1599	1606	1612	1619	1626	1633	1640	67
6.90	1646	1653	1660	1667	1674	1681	1687	1694	1701	1708	69
7.00	1715	1722	1729	1736	1743	1750	1757	1764	1771	1778	70
7.10	1785	1793	1800	1807	1814	1821	1828	1835	1843	1850	72
7.20	1857	1864	1871	1879	1886	1893	1901	1908	1915	1923	73
7.30	1930	1937	1945	1952	1959	1967	1974	1982	1989	1997	74
7.40	2004	2012	2019	2027	2034	2042	2049	2057	2065	2072	76
7.50	2080	2088	2095	2103	2111	2118	2126	2134	2141	2149	77
7.60	2157	2165	2173	2180	2188	2196	2204	2212	2220	2227	78
7.70	2235	2243	2251	2259	2267	2275	2283	2291	2299	2307	80
7.80	2315	2323	2331	2339	2347	2356	2364	2372	2380	2388	81
7.90	2396	2404	2413	2421	2429	2437	2446	2454	2462	2470	83

EXPANDED RATING TABLE TYPE: LOG

5290000 DATE PROCESSED: 02-09-1999 @ 13:32 BY mcnellis

LITTLE MINNESOTA RIVER NEAR PEEVER, SD DD: 2 TYPE 001 RATING NO: 25.0

OFFSET: 1.90 BREAK,OFFEST: (2.44,2.20) START DATE/TIME: 10-01-1996 (0001)

GAGE HEIGHT (FEET)	DISCHARGE IN CUBIC FEET PER SECOND (EXPANDED PRECISION) 0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	DIFF IN Q PER TENTH FT
8.00	2479	2487	2495	2504	2512	2520	2529	2537	2546	2554	84
8.10	2563	2571	2579	2588	2596	2605	2614	2622	2631	2639	85
8.20	2648	2656	2665	2674	2682	2691	2699	2708	2717	2726	86
8.30	2734	2743	2752	2761	2769	2778	2787	2796	2804	2813	88
8.40	2822	2831	2840	2849	2858	2867	2876	2884	2893	2902	89
8.50	2911	2920	2929	2938	2947	2957	2966	2975	2984	2993	91
8.60	3002	3011	3020	3029	3039	3048	3057	3066	3075	3085	92
8.70	3094	3103	3112	3122	3131	3140	3150	3159	3168	3178	93
8.80	3187	3197	3206	3215	3225	3234	3244	3253	3263	3272	95
8.90	3282	3291	3301	3311	3320	3330	3339	3349	3359	3368	96
9.00	3378	3388	3397	3407	3417	3426	3436	3446	3456	3465	97
9.10	3475	3485	3495	3505	3514	3524	3534	3544	3554	3564	99
9.20	3574	3584	3594	3604	3614	3624	3634	3644	3654	3664	100
9.30	3674	3684	3694	3704	3714	3724	3735	3745	3755	3765	101
9.40	3775	3785	3796	3806	3816	3826	3837	3847	3857	3868	103
9.50	3878	3888	3899	3909	3919	3930	3940	3951	3961	3971	104
9.60	3982	3992	4003	4013	4024	4034	4045	4056	4066	4077	105
9.70	4087	4098	4109	4119	4130	4140	4151	4162	4173	4183	107
9.80	4194	4205	4216	4226	4237	4248	4259	4269	4280	4291	108
9.90	4302	4313	4324	4335	4346	4357	4368	4378	4389	4400	109

EXPANDED RATING TABLE TYPE: LOG

5290000 DATE PROCESSED: 02-09-1999 @ 13:32 BY mcnellis

LITTLE MINNESOTA RIVER NEAR PEEVER, SD DD: 2 TYPE 001 RATING NO: 25.0

OFFSET: 1.90 BREAK,OFFEST: (2.44,2.20) START DATE/TIME: 10-01-1996 (0001)

GAGE HEIGHT (FEET)	DISCHARGE IN CUBIC FEET PER SECOND (EXPANDED PRECISION) 0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	DIFF IN Q PER TENTH FT
10.00	4411	4422	4433	4444	4456	4467	4478	4489	4500	4511	111
10.10	4522	4533	4544	4556	4567	4578	4589	4600	4612	4623	112
10.20	4634	4645	4657	4668	4679	4691	4702	4713	4725	4736	114
10.30	4748	4759	4770	4782	4793	4805	4816	4828	4839	4851	114
10.40	4862	4874	4885	4897	4909	4920	4932	4943	4955	4967	116
10.50	4978	4990	5002	5013	5025	5037	5049	5060	5072	5084	118
10.60	5096	5107	5119	5131	5143	5155	5167	5179	5191	5202	118
10.70	5214	5226	5238	5250	5262	5274	5286	5298	5310	5322	120
10.80	5334	5346	5359	5371	5383	5395	5407	5419	5431	5444	122
10.90	5456	5468	5480	5492	5505	5517	5529	5541	5554	5566	122
11.00	5578	5591	5603	5615	5628	5640	5653	5665	5678	5690	124
11.10	5702	5715	5727	5740	5752	5765	5777	5790	5803	5815	126
11.20	5828	5840	5853	5866	5878	5891	5904	5916	5929	5942	126
11.30	5954	5967	5980	5993	6005	6018	6031	6044	6057	6070	128
11.40	6082	6095	6108	6121	6134	6147	6160	6173	6186	6199	130
11.50	6212	6225	6238	6251	6264	6277	6290	6303	6316	6329	130
11.60	6342	6355	6369	6382	6395	6408	6421	6435	6448	6461	132
11.70	6474	6488	6501	6514	6527	6541	6554	6567	6581	6594	134
11.80	6608	6621	6634	6648	6661	6675	6688	6702	6715	6729	134
11.90	6742	6756	6769	6783	6796	6810	6823	6837	6851	6864	136

EXPANDED RATING TABLE TYPE: LOG

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LITTLE MINNESOTA RIVER NEAR PEEVER, SD DD: 2 TYPE 001 RATING NO: 25.0

OFFSET: 1.90 BREAK,OFFEST: (2.44,2.20) START DATE/TIME: 10-01-1996 (0001)

GAGE HEIGHT (FEET)	DISCHARGE IN CUBIC FEET PER SECOND (EXPANDED PRECISION) 0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	DIFF IN Q PER TENTH FT
12.00	6878	6892	6905	6919	6933	6946	6960	6974	6988	7001	137
12.10	7015	7029	7043	7057	7070	7084	7098	7112	7126	7140	139
12.20	7154	7168	7182	7196	7210	7224	7238	7252	7266	7280	140
12.30	7294	7308	7322	7336	7350	7364	7378	7392	7406	7421	141
12.40	7435	7449	7463	7477	7492	7506	7520	7534	7549	7563	142
12.50	7577	7592	7606	7620	7635	7649	7663	7678	7692	7707	144
12.60	7721	7736	7750	7764	7779	7793	7808	7822	7837	7852	145
12.70	7866	7881	7895	7910	7925	7939	7954	7969	7983	7998	147
12.80	8013	8027	8042	8057	8072	8086	8101	8116	8131	8145	147
12.90	8160	8175	8190	8205	8220	8235	8250	8265	8279	8294	149
13.00	8309	8324	8339	8354	8369	8384	8399	8414	8430	8445	151
13.10	8460	8475	8490	8505	8520	8535	8551	8566	8581	8596	151
13.20	8611	8627	8642	8657	8672	8688	8703	8718	8734	8749	153
13.30	8764	8780	8795	8811	8826	8841	8857	8872	8888	8903	155
13.40	8919	8934	8950	8965	8981	8996	9012	9027	9043	9059	155
13.50	9074	9090	9106	9121	9137	9153	9168	9184	9200	9215	157
13.60	9231	9247	9263	9278	9294	9310	9326	9342	9358	9373	158
13.70	9389	9405	9421	9437	9453	9469	9485	9501	9517	9533	160
13.80	9549	9565	9581	9597	9613	9629	9645	9661	9677	9694	161
13.90	9710	9726	9742	9758	9774	9791	9807	9823	9839	9856	162
14.00	9872	9888	9904	9921	9937	9953	9970	9986	10000	10020	168
14.10	10040	10050	10070	10080	10100	10120	10130	10150	10170	10180	160.0*
14.20	10200*										

EXPANDED RATING TABLE TYPE: LOG

5291000 DATE PROCESSED: 02-14-2002 @ 07:12 BY JJCOPA

WHETSTONE RIVER NEAR BIG STONE CITY, SD DD: 7 TYPE: 001 RATING NO: 38

OFFSET: .00 START DATE/TIME: 01-01-2001 (0001)

GAGE HEIGHT (FEET)	DISCHARGE IN CUBIC FEET PER SECOND (EXPANDED PRECISION) 0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	DIFF IN Q PER TENTH FT
0.50	.800*	0.855	0.914	0.975	1.038	1.105	1.174	1.247	1.322	1.401	0.683
0.60	1.483	1.569	1.658	1.750	1.846	1.945	2.048	2.155	2.266	2.381	1.017
0.70	2.500*	2.619	2.742	2.868	2.999	3.134	3.273	3.416	3.564	3.716	1.372
0.80	3.872	4.033	4.198	4.368	4.543	4.723	4.907	5.097	5.291	5.491	1.823
0.90	5.695	5.905	6.121	6.341	6.568	6.799	7.037	7.280	7.528	7.783	2.348
1.00	8.04	8.31	8.58	8.86	9.15	9.44	9.74	10.04	10.35	10.67	2.95
1.10	10.99	11.32	11.66	12.00	12.36	12.71	13.08	13.45	13.83	14.22	3.63
1.20	14.62	15.02	15.43	15.85	16.27	16.71	17.15	17.60	18.06	18.53	4.38
1.30	19.00*	19.42	19.85	20.28	20.72	21.17	21.62	22.08	22.54	23.01	4.49
1.40	23.49	23.97	24.46	24.96	25.46	25.97	26.48	27.01	27.53	28.07	5.12
1.50	28.61	29.16	29.72	30.28	30.85	31.43	32.01	32.60	33.20	33.80	5.80
1.60	34.41	35.03	35.66	36.29	36.93	37.58	38.24	38.90	39.57	40.25	6.52
1.70	40.93	41.62	42.32	43.03	43.75	44.47	45.20	45.94	46.69	47.44	7.27
1.80	48.20	48.97	49.75	50.54	51.33	52.13	52.94	53.76	54.59	55.42	8.07
1.90	56.27	57.12	57.98	58.85	59.72	60.61	61.50	62.40	63.31	64.23	8.89
2.00	65.16	66.10	67.04	68.00	68.96	69.93	70.91	71.90	72.90	73.90	9.76
2.10	74.92	75.95	76.98	78.02	79.08	80.14	81.21	82.29	83.38	84.48	10.67
2.20	85.59	86.70	87.83	88.97	90.11	91.27	92.43	93.61	94.79	95.99	11.60
2.30	97.19	98.41	99.63	100.90	102.10	103.40	104.60	105.90	107.20	108.50	12.61
2.40	109.80	111.10	112.40	113.70	115.10	116.40	117.80	119.20	120.60	122.00	13.60

EXPANDED RATING TABLE TYPE: LOG

5291000 DATE PROCESSED: 02-14-2002 @ 07:12 BY JJCOPA

WHETSTONE RIVER NEAR BIG STONE CITY, SD DD: 7 TYPE: 001 RATING NO: 38

OFFSET: .00 START DATE/TIME: 01-01-2001 (0001)

GAGE HEIGHT (FEET)	DISCHARGE IN CUBIC FEET PER SECOND (EXPANDED PRECISION)										DIFF IN Q PER TENTH FT
	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	
2.50	123.4	124.8	126.2	127.7	129.1	130.6	132.0	133.5	135.0	136.5	14.6
2.60	138.0	139.5	141.1	142.6	144.2	145.8	147.3	148.9	150.5	152.1	15.8
2.70	153.8	155.4	157.0	158.7	160.4	162.0	163.7	165.4	167.2	168.9	16.8
2.80	170.6	172.4	174.1	175.9	177.7	179.5	181.3	183.1	184.9	186.8	18.0
2.90	188.6	190.5	192.4	194.3	196.2	198.1	200.0	202.0	203.9	205.9	19.3
3.00	207.9	209.8	211.8	213.9	215.9	217.9	220.0	222.0	224.1	226.2	20.4
3.10	228.3	230.4	232.5	234.7	236.8	239.0	241.2	243.4	245.6	247.8	21.7
3.20	250.0*	251.5	253.1	254.6	256.1	257.7	259.2	260.8	262.3	263.9	15.4
3.30	265.4	267.0	268.6	270.2	271.7	273.3	274.9	276.5	278.1	279.7	15.9
3.40	281.3	282.9	284.5	286.2	287.8	289.4	291.1	292.7	294.3	296.0	16.3
3.50	297.6	299.3	301.0	302.6	304.3	306.0	307.7	309.3	311.0	312.7	16.8
3.60	314.4	316.1	317.8	319.6	321.3	323.0	324.7	326.4	328.2	329.9	17.3
3.70	331.7	333.4	335.2	336.9	338.7	340.4	342.2	344.0	345.8	347.5	17.6
3.80	349.3	351.1	352.9	354.7	356.5	358.3	360.1	362.0	363.8	365.6	18.2
3.90	367.5	369.3	371.1	373.0	374.8	376.7	378.5	380.4	382.3	384.1	18.5
4.00	386.0	387.9	389.8	391.7	393.6	395.5	397.4	399.3	401.2	403.1	19.0
4.10	405.0	407.0	408.9	410.8	412.8	414.7	416.6	418.6	420.6	422.5	19.5
4.20	424.5	426.4	428.4	430.4	432.4	434.4	436.4	438.4	440.4	442.4	19.9
4.30	444.4	446.4	448.4	450.4	452.5	454.5	456.5	458.6	460.6	462.7	20.3
4.40	464.7	466.8	468.8	470.9	473.0	475.1	477.1	479.2	481.3	483.4	20.8

EXPANDED RATING TABLE TYPE: LOG

5291000 DATE PROCESSED: 02-14-2002 @ 07:12 BY JJCOPA

WHETSTONE RIVER NEAR BIG STONE CITY, SD DD: 7 TYPE: 001 RATING NO: 38

OFFSET: .00 START DATE/TIME: 01-01-2001 (0001)

GAGE HEIGHT (FEET)	DISCHARGE IN CUBIC FEET PER SECOND (EXPANDED PRECISION) 0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	DIFF IN Q PER TENTH FT
4.50	485.5	487.6	489.7	491.8	493.9	496.1	498.2	500.3	502.4	504.6	21.2
4.60	506.7	508.9	511.0	513.2	515.3	517.5	519.7	521.8	524.0	526.2	21.7
4.70	528.4	530.6	532.8	535.0	537.2	539.4	541.6	543.8	546.0	548.3	22.1
4.80	550.5	552.7	555.0	557.2	559.5	561.7	564.0	566.2	568.5	570.8	22.5
4.90	573.0	575.3	577.6	579.9	582.2	584.5	586.8	589.1	591.4	593.7	23.0
5.00	596.0	598.4	600.7	603.0	605.3	607.7	610.0	612.4	614.7	617.1	23.5
5.10	619.5	621.8	624.2	626.6	629.0	631.3	633.7	636.1	638.5	640.9	23.8
5.20	643.3	645.7	648.1	650.6	653.0	655.4	657.9	660.3	662.7	665.2	24.3
5.30	667.6	670.1	672.5	675.0	677.5	679.9	682.4	684.9	687.4	689.9	24.8
5.40	692.4	694.9	697.4	699.9	702.4	704.9	707.4	710.0	712.5	715.0	25.1
5.50	717.5	720.1	722.6	725.2	727.7	730.3	732.9	735.4	738.0	740.6	25.7
5.60	743.2	745.8	748.3	750.9	753.5	756.1	758.7	761.4	764.0	766.6	26.0
5.70	769.2	771.9	774.5	777.1	779.8	782.4	785.1	787.7	790.4	793.0	26.5
5.80	795.7	798.4	801.1	803.7	806.4	809.1	811.8	814.5	817.2	819.9	26.9
5.90	822.6	825.4	828.1	830.8	833.5	836.3	839.0	841.7	844.5	847.2	27.4
6.00	850.0	853.6	857.2	860.7	864.3	867.9	871.6	875.2	878.8	882.5	36.1
6.10	886.1	889.8	893.5	897.1	900.8	904.5	908.2	911.9	915.7	919.4	37.1
6.20	923.2	926.9	930.7	934.4	938.2	942.0	945.8	949.6	953.4	957.3	37.9
6.30	961.1	964.9	968.8	972.7	976.5	980.4	984.3	988.2	992.1	996.0	38.9
6.40	1000.0	1004.0	1008.0	1012.0	1016.0	1020.0	1024.0	1028.0	1032.0	1036.0	40.0

EXPANDED RATING TABLE TYPE: LOG

5291000 DATE PROCESSED: 02-14-2002 @ 07:12 BY JJCOPA

WHETSTONE RIVER NEAR BIG STONE CITY, SD DD: 7 TYPE: 001 RATING NO: 38

OFFSET: .00 START DATE/TIME: 01-01-2001 (0001)

GAGE HEIGHT (FEET)	DISCHARGE IN CUBIC FEET PER SECOND (EXPANDED PRECISION)										DIFF IN Q PER TENTH FT
	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	
6.50	1040	1044	1048	1052	1056	1060	1064	1068	1072	1076	41
6.60	1081	1085	1089	1093	1097	1101	1105	1110	1114	1118	41
6.70	1122	1126	1131	1135	1139	1143	1148	1152	1156	1161	43
6.80	1165	1169	1174	1178	1182	1187	1191	1195	1200	1204	43
6.90	1208	1213	1217	1222	1226	1231	1235	1240	1244	1249	45
7.00	1253	1258	1262	1267	1271	1276	1280	1285	1289	1294	46
7.10	1299	1303	1308	1312	1317	1322	1326	1331	1336	1340	46
7.20	1345	1350	1355	1359	1364	1369	1374	1378	1383	1388	48
7.30	1393	1398	1402	1407	1412	1417	1422	1427	1431	1436	48
7.40	1441	1446	1451	1456	1461	1466	1471	1476	1481	1486	50
7.50	1491	1496	1501	1506	1511	1516	1521	1526	1531	1536	50
7.60	1541	1546	1552	1557	1562	1567	1572	1577	1583	1588	52
7.70	1593	1598	1603	1609	1614	1619	1624	1630	1635	1640	53
7.80	1646	1651	1656	1661	1667	1672	1678	1683	1688	1694	53
7.90	1699	1705	1710	1715	1721	1726	1732	1737	1743	1748	55
8.00	1754	1759	1765	1770	1776	1782	1787	1793	1798	1804	56
8.10	1810	1815	1821	1826	1832	1838	1843	1849	1855	1861	56
8.20	1866	1872	1878	1884	1889	1895	1901	1907	1912	1918	58
8.30	1924	1930	1936	1942	1948	1953	1959	1965	1971	1977	59
8.40	1983	1989	1995	2001	2007	2013	2019	2025	2031	2037	60

EXPANDED RATING TABLE TYPE: LOG

5291000 DATE PROCESSED: 02-14-2002 @ 07:12 BY JJCOPA

WHETSTONE RIVER NEAR BIG STONE CITY, SD DD: 7 TYPE: 001 RATING NO: 38

OFFSET: .00 START DATE/TIME: 01-01-2001 (0001)

GAGE HEIGHT (FEET)	DISCHARGE IN CUBIC FEET PER SECOND (EXPANDED PRECISION)										DIFF IN Q PER TENTH FT
	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	
8.50	2043	2049	2055	2061	2067	2073	2080	2086	2092	2098	61
8.60	2104	2110	2116	2123	2129	2135	2141	2147	2154	2160	62
8.70	2166	2172	2179	2185	2191	2198	2204	2210	2217	2223	63
8.80	2229	2236	2242	2249	2255	2261	2268	2274	2281	2287	65
8.90	2294	2300	2307	2313	2320	2326	2333	2339	2346	2353	65
9.00	2359	2366	2372	2379	2386	2392	2399	2406	2412	2419	67
9.10	2426	2433	2439	2446	2453	2459	2466	2473	2480	2487	67
9.20	2493	2500	2507	2514	2521	2528	2535	2542	2548	2555	69
9.30	2562	2569	2576	2583	2590	2597	2604	2611	2618	2625	70
9.40	2632	2639	2646	2653	2660	2668	2675	2682	2689	2696	71
9.50	2703	2710	2718	2725	2732	2739	2746	2754	2761	2768	72
9.60	2775	2783	2790	2797	2805	2812	2819	2827	2834	2841	74
9.70	2849	2856	2864	2871	2879	2886	2893	2901	2908	2916	74
9.80	2923	2931	2938	2946	2954	2961	2969	2976	2984	2991	76
9.90	2999	3007	3014	3022	3030	3037	3045	3053	3060	3068	77
10.00	3076	3084	3091	3099	3107	3115	3123	3130	3138	3146	78
10.10	3154	3162	3170	3178	3186	3193	3201	3209	3217	3225	79
10.20	3233	3241	3249	3257	3265	3273	3281	3289	3297	3305	81
10.30	3314	3322	3330	3338	3346	3354	3362	3371	3379	3387	81
10.40	3395	3403	3412	3420	3428	3436	3445	3453	3461	3470	83

EXPANDED RATING TABLE TYPE: LOG

5291000 DATE PROCESSED: 02-14-2002 @ 07:12 BY JJCOPA

WHETSTONE RIVER NEAR BIG STONE CITY, SD DD: 7 TYPE: 001 RATING NO: 38

OFFSET: .00 START DATE/TIME: 01-01-2001 (0001)

GAGE HEIGHT (FEET)	DISCHARGE IN CUBIC FEET PER SECOND (EXPANDED PRECISION) 0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	DIFF IN Q PER TENTH FT
10.50	3478	3486	3495	3503	3511	3520	3528	3537	3545	3554	84
10.60	3562	3570	3579	3587	3596	3604	3613	3621	3630	3639	85
10.70	3647	3656	3664	3673	3682	3690	3699	3708	3716	3725	87
10.80	3734	3742	3751	3760	3769	3777	3786	3795	3804	3812	87
10.90	3821	3830	3839	3848	3857	3866	3874	3883	3892	3901	89
11.00	3910	3919	3928	3937	3946	3955	3964	3973	3982	3991	90
11.10	4000	4009	4018	4028	4037	4046	4055	4064	4073	4082	92
11.20	4092	4101	4110	4119	4128	4138	4147	4156	4166	4175	92
11.30	4184	4194	4203	4212	4222	4231	4240	4250	4259	4269	94
11.40	4278	4288	4297	4306	4316	4325	4335	4345	4354	4364	95
11.50	4373	4383	4392	4402	4412	4421	4431	4441	4450	4460	97
11.60	4470	4479	4489	4499	4508	4518	4528	4538	4548	4557	97
11.70	4567	4577	4587	4597	4607	4617	4626	4636	4646	4656	99
11.80	4666	4676	4686	4696	4706	4716	4726	4736	4746	4756	100
11.90	4766	4776	4787	4797	4807	4817	4827	4837	4847	4858	102
12.00	4868	4878	4888	4899	4909	4919	4929	4940	4950	4960	103
12.10	4971	4981	4991	5002	5012	5022	5033	5043	5054	5064	104
12.20	5075	5085	5096	5106	5117	5127	5138	5148	5159	5169	105
12.30	5180	5191	5201	5212	5223	5233	5244	5255	5265	5276	107
12.40	5287	5297	5308	5319	5330	5341	5351	5362	5373	5384	108

EXPANDED RATING TABLE TYPE: LOG

5291000 DATE PROCESSED: 02-14-2002 @ 07:12 BY JJCOPA

WHETSTONE RIVER NEAR BIG STONE CITY, SD DD: 7 TYPE: 001 RATING NO: 38

OFFSET: .00 START DATE/TIME: 01-01-2001 (0001)

GAGE HEIGHT (FEET)	DISCHARGE IN CUBIC FEET PER SECOND (EXPANDED PRECISION)										DIFF IN Q PER TENTH FT
	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	
12.50	5395	5406	5416	5427	5438	5449	5460	5471	5482	5493	109
12.60	5504	5515	5526	5537	5548	5559	5570	5581	5592	5604	111
12.70	5615	5626	5637	5648	5659	5671	5682	5693	5704	5715	112
12.80	5727	5738	5749	5761	5772	5783	5794	5806	5817	5829	113
12.90	5840	5851	5863	5874	5886	5897	5909	5920	5932	5943	115
13.00	5955	5966	5978	5989	6001	6012	6024	6036	6047	6059	116
13.10	6071	6082	6094	6106	6117	6129	6141	6153	6164	6176	117
13.20	6188	6200	6212	6223	6235	6247	6259	6271	6283	6295	119
13.30	6307	6319	6331	6343	6355	6367	6379	6391	6403	6415	120
13.40	6427	6439	6451	6463	6475	6487	6499	6512	6524	6536	121
13.50	6548	6560	6573	6585	6597	6609	6622	6634	6646	6659	123
13.60	6671	6683	6696	6708	6721	6733	6745	6758	6770	6783	124
13.70	6795	6808	6820	6833	6845	6858	6870	6883	6896	6908	126
13.80	6921	6933	6946	6959	6971	6984	6997	7010	7022	7035	127
13.90	7048	7061	7073	7086	7099	7112	7125	7137	7150	7163	128
14.00	7176	7189	7202	7215	7228	7241	7254	7267	7280	7293	130
14.10	7306	7319	7332	7345	7358	7371	7384	7398	7411	7424	131
14.20	7437	7450	7463	7477	7490	7503	7516	7530	7543	7556	133
14.30	7570	7583	7596	7610	7623	7636	7650	7663	7677	7690	134
14.40	7704	7717	7731	7744	7758	7771	7785	7798	7812	7825	135

EXPANDED RATING TABLE TYPE: LOG

5291000 DATE PROCESSED: 02-14-2002 @ 07:12 BY JJCOPA

WHETSTONE RIVER NEAR BIG STONE CITY, SD DD: 7 TYPE: 001 RATING NO: 38

OFFSET: .00 START DATE/TIME: 01-01-2001 (0001)

GAGE HEIGHT (FEET)	DISCHARGE IN CUBIC FEET PER SECOND (EXPANDED PRECISION) 0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	DIFF IN Q PER TENTH FT
14.50	7839	7853	7866	7880	7894	7907	7921	7935	7948	7962	137
14.60	7976	7990	8003	8017	8031	8045	8059	8072	8086	8100	138
14.70	8114	8128	8142	8156	8170	8184	8198	8212	8226	8240	140
14.80	8254	8268	8282	8296	8310	8324	8338	8352	8367	8381	141
14.90	8395	8409	8423	8437	8452	8466	8480	8495	8509	8523	142
15.00	8537	8552	8566	8580	8595	8609	8624	8638	8653	8667	144
15.10	8681	8696	8710	8725	8739	8754	8769	8783	8798	8812	146
15.20	8827	8842	8856	8871	8886	8900	8915	8930	8944	8959	147
15.30	8974	8989	9003	9018	9033	9048	9063	9078	9092	9107	148
15.40	9122	9137	9152	9167	9182	9197	9212	9227	9242	9257	150
15.50	9272	9287	9302	9317	9333	9348	9363	9378	9393	9408	152
15.60	9424	9439	9454	9469	9484	9500	9515	9530	9546	9561	152
15.70	9576	9592	9607	9622	9638	9653	9669	9684	9700	9715	155
15.80	9731	9746	9762	9777	9793	9808	9824	9840	9855	9871	155
15.90	9886	9902	9918	9934	9949	9965	9981	9996	10010	10030	154
16.00	10040	10060	10080	10090	10110	10120	10140	10150	10170	10190	160
16.10	10200	10220	10230	10250	10270	10280	10300	10310	10330	10350	160
16.20	10360	10380	10400	10410	10430	10440	10460	10480	10490	10510	160
16.30	10520	10540	10560	10570	10590	10610	10620	10640	10660	10670	170
16.40	10690	10700	10720	10740	10750	10770	10790	10800	10820	10840	160

EXPANDED RATING TABLE TYPE: LOG

5291000 DATE PROCESSED: 02-14-2002 @ 07:12 BY JJCOPA

WHETSTONE RIVER NEAR BIG STONE CITY, SD DD: 7 TYPE: 001 RATING NO: 38

OFFSET: .00 START DATE/TIME: 01-01-2001 (0001)

GAGE HEIGHT (FEET)	DISCHARGE IN CUBIC FEET PER SECOND (EXPANDED PRECISION) 0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	DIFF IN Q PER TENTH FT
16.50	10850	10870	10890	10900	10920	10940	10950	10970	10990	11000	170
16.60	11020	11040	11050	11070	11090	11100	11120	11140	11150	11170	170
16.70	11190	11200	11220	11240	11250	11270	11290	11310	11320	11340	170
16.80	11360	11370	11390	11410	11420	11440	11460	11480	11490	11510	170
16.90	11530	11540	11560	11580	11600	11610	11630	11650	11670	11680	170.0*
17.00	11700*										

STATION NUMBER 05292000 MINNESOTA RIVER AT ORTONVILLE, MN SOURCE AGENCY USGS STATE 27 COUNTY 011

LATITUDE 451744 DRAINAGE AREA: 1160 CONTRIBUTING DATUM 956.38 NGVD 1929

LONGITUDE 0962638 Date Processed: 2003-06-13 06:55 By ddaly

OFFSET: 0.80 Rating for DISCHARGE, IN CFS

EXPANDED RATING TABLE

GAGE HEIGHT (FEET)	DISCHARGE IN CFS (STANDARD PRECISION) 0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	DIFF IN Q PER .1 UNITS
0.80						0.25*	0.30*	0.36*	0.43*	0.51*	0.68
0.90	0.59*	0.71	0.83	0.97	1.10	1.30	1.40	1.60	1.80	2.00	1.60
1.00	2.2	2.4	2.6	2.8	3.1	3.3	3.6	3.9	4.1	4.4	2.5
1.10	4.7	5.0	5.3	5.6	6.0	6.3	6.6	7.0	7.4	7.7	3.4
1.20	8.1	8.5	8.9	9.3	9.7	10.1	10.5	11.0	11.4	11.9	4.2
1.30	12.3	12.8	13.3	13.8	14.3	14.8	15.3	15.8	16.3	16.9	5.1
1.40	17.4	18.0	18.5	19.1	19.7	20.3	20.9	21.5	22.1	22.7	5.9
1.50	23.3	23.9	24.6	25.2	25.9	26.6	27.2	27.9	28.6	29.3	6.7
1.60	30.0*	30.8	31.6	32.5	33.3	34.2	35.1	35.9	36.8	37.8	8.7
1.70	38.7	39.6	40.6	41.5	42.5	43.5	44.4	45.5	46.5	47.5	9.8
1.80	48.5	49.6	50.7	51.7	52.8	53.9	55.0	56.2	57.3	58.4	11.1
1.90	59.6	60.8	62.0	63.2	64.4	65.6	66.8	68.1	69.4	70.6	12.3
2.00	71.9	73.2	74.5	75.8	77.2	78.5	79.9	81.3	82.6	84	13.6
2.10	85.5	86.9	88.3	89.8	91.2	92.7	94.2	95.7	97.2	98.7	14.5
2.20	100	102	103	105	107	108	110	111	113	115	16
2.30	116	118	120	121	123	125	127	128	130	132	18
2.40	134	136	137	139	141	143	145	147	149	150	18
2.50	152	154	156	158	160	162	164	166	168	170	20
2.60	172	174	177	179	181	183	185	187	189	191	22
2.70	194	196	198	200	203	205	207	209	212	214	22
2.80	216	219	221	223	226	228	231	233	235	238	24
2.90	240	243	245	248	250	253	255	258	261	263	26

STATION NUMBER 05292000 MINNESOTA RIVER AT ORTONVILLE, MN SOURCE AGENCY USGS STATE 27 COUNTY 011

LATITUDE 451744 DRAINAGE AREA: 1160 CONTRIBUTING DATUM 956.38 NGVD 1929

LONGITUDE 0962638 Date Processed: 2003-06-13 06:55 By ddaly

OFFSET: 0.80 Rating for DISCHARGE, IN CFS

EXPANDED RATING TABLE

GAGE HEIGHT (FEET)	DISCHARGE IN CFS (STANDARD PRECISION) 0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	DIFF IN Q PER .1 UNITS
3.00	266	268	271	274	276	279	282	284	287	290	26
3.10	292	295	298	301	303	306	309	312	315	318	29
3.20	321	323	326	329	332	335	338	341	344	347	29
3.30	350*	353	355	358	360	363	365	368	370	373	25
3.40	375	378	381	383	386	388	391	394	396	399	27
3.50	402	404	407	410	412	415	418	420	423	426	27
3.60	429	431	434	437	440	442	445	448	451	453	27
3.70	456	459	462	465	468	470	473	476	479	482	29
3.80	485	488	491	493	496	499	502	505	508	511	29
3.90	514	517	520	523	526	529	532	535	538	541	30
4.00	544	547	550	553	556	559	562	565	568	572	31
4.10	575	578	581	584	587	590	593	597	600	603	31
4.20	606	609	613	616	619	622	625	629	632	635	32
4.30	638	642	645	648	651	655	658	661	665	668	33
4.40	671	675	678	681	685	688	691	695	698	702	34
4.50	705	708	712	715	719	722	726	729	732	736	34
4.60	739	743	746	750	753	757	760	764	767	771	35
4.70	774	778	782	785	789	792	796	799	803	807	36
4.80	810	814	818	821	825	828	832	836	839	843	37
4.90	847	851	854	858	862	865	869	873	877	880	37

STATION NUMBER 05292000 MINNESOTA RIVER AT ORTONVILLE, MN SOURCE AGENCY USGS STATE 27 COUNTY 011

LATITUDE 451744 DRAINAGE AREA: 1160 CONTRIBUTING DATUM 956.38 NGVD 1929

LONGITUDE 0962638 Date Processed: 2003-06-13 06:55 By ddaly

OFFSET: 0.80 Rating for DISCHARGE, IN CFS

EXPANDED RATING TABLE

GAGE HEIGHT (FEET)	DISCHARGE IN CFS (STANDARD PRECISION) 0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	DIFF IN Q PER .1 UNITS
OFFSET: 0.80											
5.00	884	888	892	895	899	903	907	911	914	918	38
5.10	922	926	930	934	937	941	945	949	953	957	39
5.20	961	965	968	972	976	980	984	988	992	996	39
5.30	1000*	1000	1010	1010	1010	1020	1020	1020	1030	1030	30
5.40	1030	1040	1040	1040	1050	1050	1050	1060	1060	1060	40
5.50	1070	1070	1070	1080	1080	1080	1090	1090	1090	1100	30
5.60	1100	1110	1110	1110	1120	1120	1120	1130	1130	1130	40
5.70	1140	1140	1140	1150	1150	1150	1160	1160	1160	1170	30
5.80	1170	1170	1180	1180	1190	1190	1190	1200	1200	1200	40
5.90	1210	1210	1210	1220	1220	1220	1230	1230	1230	1240	30
6.00	1240	1250	1250	1250	1260	1260	1260	1270	1270	1270	40
6.10	1280	1280	1290	1290	1290	1300	1300	1300	1310	1310	30
6.20	1310	1320	1320	1330	1330	1330	1340	1340	1340	1350	40
6.30	1350	1350	1360	1360	1370	1370	1370	1380	1380	1380	40
6.40	1390	1390	1400	1400	1400	1410	1410	1410	1420	1420	40
6.50	1430	1430	1430	1440	1440	1440	1450	1450	1460	1460	30
6.60	1460	1470	1470	1470	1480	1480	1490	1490	1490	1500	40
6.70	1500	1510	1510	1510	1520	1520	1520	1530	1530	1540	40
6.80	1540	1540	1550	1550	1550	1560	1560	1570	1570	1570	40
6.90	1580	1580	1590	1590	1590	1600	1600	1610	1610	1610	40

STATION NUMBER 05292000 MINNESOTA RIVER AT ORTONVILLE, MN SOURCE AGENCY USGS STATE 27 COUNTY 011

LATITUDE 451744 DRAINAGE AREA: 1160 CONTRIBUTING DATUM 956.38 NGVD 1929

LONGITUDE 0962638 Date Processed: 2003-06-13 06:55 By ddaly

OFFSET: 0.80 Rating for DISCHARGE, IN CFS

EXPANDED RATING TABLE

GAGE HEIGHT (FEET)	DISCHARGE IN CFS (STANDARD PRECISION) 0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	DIFF IN Q PER .1 UNITS
7.00	1620	1620	1620	1630	1630	1640	1640	1640	1650	1650	40
7.10	1660	1660	1660	1670	1670	1680	1680	1680	1690	1690	40
7.20	1700	1700	1700	1710	1710	1720	1720	1720	1730	1730	40
7.30	1740	1740	1740	1750	1750	1760	1760	1760	1770	1770	40
7.40	1780	1780	1780	1790	1790	1800	1800	1800	1810	1810	40
7.50	1820	1820	1820	1830	1830	1840	1840	1850	1850	1850	40
7.60	1860	1860	1870	1870	1870	1880	1880	1890	1890	1890	40
7.70	1900	1900	1910	1910	1920	1920	1920	1930	1930	1940	40
7.80	1940	1940	1950	1950	1960	1960	1960	1970	1970	1980	40
7.90	1980	1990	1990	1990	2000	2000	2010	2010	2020	2020	40
8.00	2020	2030	2030	2040	2040	2040	2050	2050	2060	2060	50
8.10	2070	2070	2070	2080	2080	2090	2090	2100	2100	2100	40
8.20	2110	2110	2120	2120	2130	2130	2130	2140	2140	2150	40
8.30	2150	2160	2160	2160	2170	2170	2180	2180	2190	2190	40
8.40	2190	2200	2200	2210	2210	2220	2220	2220	2230	2230	50
8.50	2240	2240	2250	2250	2260	2260	2260	2270	2270	2280	40
8.60	2280	2290	2290	2290	2300	2300	2310	2310	2320	2320	50
8.70	2330	2330	2330	2340	2340	2350	2350	2360	2360	2370	40
8.80	2370	2370	2380	2380	2390	2390	2400	2400	2410	2410	40
8.90	2410	2420	2420	2430	2430	2440	2440	2450	2450	2450	50

STATION NUMBER 05292000 MINNESOTA RIVER AT ORTONVILLE, MN SOURCE AGENCY USGS STATE 27 COUNTY 011

LATITUDE 451744 DRAINAGE AREA: 1160 CONTRIBUTING DATUM 956.38 NGVD 1929

LONGITUDE 0962638 Date Processed: 2003-06-13 06:55 By ddaly

OFFSET: 0.80 Rating for DISCHARGE, IN CFS

EXPANDED RATING TABLE

GAGE HEIGHT (FEET)	DISCHARGE IN CFS (STANDARD PRECISION) 0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	DIFF IN Q PER .1 UNITS
9.00	2460	2460	2470	2470	2480	2480	2490	2490	2500	2500	40
9.10	2500	2510	2510	2520	2520	2530	2530	2540	2540	2550	50
9.20	2550*	2560	2560	2570	2580	2580	2590	2600	2600	2610	70
9.30	2620	2620	2630	2640	2640	2650	2660	2660	2670	2680	60
9.40	2680	2690	2700	2700	2710	2720	2730	2730	2740	2750	70
9.50	2750	2760	2770	2770	2780	2790	2790	2800	2810	2810	70
9.60	2820	2830	2840	2840	2850	2860	2860	2870	2880	2890	70
9.70	2890	2900	2910	2910	2920	2930	2930	2940	2950	2960	70
9.80	2960	2970	2980	2980	2990	3000	3010	3010	3020	3030	80
9.90	3040	3040	3050	3060	3060	3070	3080	3090	3090	3100	70
10.00	3110	3120	3120	3130	3140	3150	3150	3160	3170	3180	70
10.10	3180	3190	3200	3210	3210	3220	3230	3240	3240	3250	80
10.20	3260	3270	3270	3280	3290	3300	3300	3310	3320	3330	70
10.30	3330	3340	3350	3360	3360	3370	3380	3390	3400	3400	80
10.40	3410	3420	3430	3430	3440	3450	3460	3460	3470	3480	80
10.50	3490	3500	3500	3510	3520	3530	3540	3540	3550	3560	80
10.60	3570	3580	3580	3590	3600	3610	3610	3620	3630	3640	80
10.70	3650	3650	3660	3670	3680	3690	3700	3700	3710	3720	80
10.80	3730	3740	3740	3750	3760	3770	3780	3780	3790	3800	80
10.90	3810	3820	3830	3830	3840	3850	3860	3870	3880	3880	80

STATION NUMBER 05292000 MINNESOTA RIVER AT ORTONVILLE, MN SOURCE AGENCY USGS STATE 27 COUNTY 011

LATITUDE 451744 DRAINAGE AREA: 1160 CONTRIBUTING DATUM 956.38 NGVD 1929

LONGITUDE 0962638 Date Processed: 2003-06-13 06:55 By ddaly

OFFSET: 0.80 Rating for DISCHARGE, IN CFS

EXPANDED RATING TABLE

GAGE HEIGHT (FEET)	DISCHARGE IN CFS (STANDARD PRECISION) 0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	DIFF IN Q PER .1 UNITS
11.00	3890	3900	3910	3920	3930	3930	3940	3950	3960	3970	90
11.10	3980	3980	3990	4000	4010	4020	4030	4030	4040	4050	80
11.20	4060	4070	4080	4090	4090	4100	4110	4120	4130	4140	90
11.30	4150	4150	4160	4170	4180	4190	4200	4210	4210	4220	80
11.40	4230	4240	4250	4260	4270	4280	4280	4290	4300	4310	90
11.50	4320	4330	4340	4350	4350	4360	4370	4380	4390	4400	90
11.60	4410	4420	4430	4430	4440	4450	4460	4470	4480	4490	90
11.70	4500	4510	4520	4520	4530	4540	4550	4560	4570	4580	90
11.80	4590	4600	4610	4610	4620	4630	4640	4650	4660	4670	90
11.90	4680	4690	4700	4710	4720	4720	4730	4740	4750	4760	90
12.00	4770	4780	4790	4800	4810	4820	4830	4840	4850	4850	90
12.10	4860	4870	4880	4890	4900	4910	4920	4930	4940	4950	100
12.20	4960	4970	4980	4990	5000	5010	5020	5020	5030	5040	90
12.30	5050	5060	5070	5080	5090	5100	5110	5120	5130	5140	100
12.40	5150	5160	5170	5180	5190	5200	5210	5220	5230	5240	100
12.50	5250	5260	5270	5280	5290	5300	5310	5320	5330	5340	100
12.60	5350	5350	5360	5370	5380	5390	5400	5410	5420	5430	90
12.70	5440	5450	5460	5470	5480	5490	5500	5510	5520	5530	100
12.80	5540	5550	5560	5570	5580	5590	5600	5610	5630	5640	110
12.90	5650	5660	5670	5680	5690	5700	5710	5720	5730	5740	100

STATION NUMBER 05292000 MINNESOTA RIVER AT ORTONVILLE, MN SOURCE AGENCY USGS STATE 27 COUNTY 011

LATITUDE 451744 DRAINAGE AREA: 1160 CONTRIBUTING DATUM 956.38 NGVD 1929

LONGITUDE 0962638 Date Processed: 2003-06-13 06:55 By ddaly

OFFSET: 0.80 Rating for DISCHARGE, IN CFS

EXPANDED RATING TABLE

GAGE HEIGHT (FEET)	DISCHARGE IN CFS (STANDARD PRECISION) 0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	DIFF IN Q PER .1 UNITS
13.00	5750	5760	5770	5780	5790	5800	5810	5820	5830	5840	100
13.10	5850	5860	5870	5880	5890	5900	5910	5920	5930	5940	100
13.20	5950	5970	5980	5990	6000	6010	6020	6030	6040	6050	110
13.30	6060	6070	6080	6090	6100	6110	6120	6130	6140	6160	110
13.40	6170	6180	6190	6200	6210	6220	6230	6240	6250	6260	100
13.50	6270	6280	6290	6310	6320	6330	6340	6350	6360	6370	110
13.60	6380	6390	6400	6410	6420	6440	6450	6460	6470	6480	110
13.70	6490	6500	6510	6520	6530	6540	6560	6570	6580	6590	110
13.80	6600*										

EXPANDED RATING TABLE TYPE: LOG

5293000 DATE PROCESSED 02-14-2002 @ 06:18 BY ddaly

YELLOW BANK RIVER NEAR ODESSA, MN DD: 7 TYPE: 001 RATING NO: 28

OFFSET: .40 START DATE/TIME: 04-01-2001 (0001)

GAGE HEIGHT (FEET)	DISCHARGE IN CUBIC FEET PER SECOND (EXPANDED PRECISION)										DIFF IN Q PER TENTH FT
	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	
1.50	1.730	1.847	1.970	2.100	2.238	2.383	2.536	2.698	2.869	3.049	1.508
1.60	3.238	3.437	3.647	3.868	4.101	4.345	4.602	4.871	5.155	5.452	2.526
1.70	5.764	6.091	6.434	6.793	7.170	7.550	7.947	8.361	8.794	9.246	3.954
1.80	9.718	10.210	10.720	11.260	11.820	12.400	13.010	13.640	14.290	14.980	5.972
1.90	15.690	16.430	17.200	18.000	18.830	19.700	20.600	21.220	21.850	22.500	7.480
2.00	23.170	23.850	24.540	25.250	25.980	26.720	27.480	28.250	29.050	29.860	7.520
2.10	30.690	31.530	32.400	33.280	34.180	35.100	36.040	37.000	37.980	38.980	9.310
2.20	40.000	40.890	41.800	42.730	43.670	44.620	45.590	46.580	47.580	48.600	9.640
2.30	49.640	50.690	51.750	52.840	53.940	55.060	56.190	57.350	58.520	59.710	11.270
2.40	60.910	62.140	63.380	64.640	65.920	67.220	68.540	69.880	71.240	72.610	13.100
2.50	74.01	75.43	76.87	78.32	79.80	81.30	82.82	84.36	85.92	87.51	15.10
2.60	89.11	90.74	92.39	94.07	95.76	97.48	99.22	101.00	102.80	104.60	17.29
2.70	106.40	108.30	110.20	112.10	114.0*	115.20	116.40	117.60	118.80	120.00	14.90
2.80	121.30	122.50	123.70	125.00	126.30	127.50	128.80	130.10	131.40	132.70	12.70
2.90	134.00	135.30	136.60	137.90	139.30	140.60	141.90	143.30	144.70	146.00	13.40
3.00	147.4	148.8	150.2	151.6	153.0	154.4	155.8	157.3	158.7	160.2	14.2
3.10	161.6	163.1	164.6	166.0	167.5	169.0	170.5	172.0	173.6	175.1	15.0
3.20	176.6	178.2	179.7	181.3	182.8	184.4	186.0	187.6	189.2	190.8	15.8
3.30	192.4	194.0	195.7	197.3	198.9	200.6	202.3	203.9	205.6	207.3	16.6
3.40	209.0*	210.4	211.8	213.1	214.5	215.9	217.3	218.7	220.1	221.6	14.0

EXPANDED RATING TABLE TYPE: LOG

5293000 DATE PROCESSED 02-14-2002 @ 06:18 BY ddaly

YELLOW BANK RIVER NEAR ODESSA, MN DD: 7 TYPE: 001 RATING NO: 28

OFFSET: .40 START DATE/TIME: 04-01-2001 (0001)

GAGE HEIGHT (FEET)	DISCHARGE IN CUBIC FEET PER SECOND (EXPANDED PRECISION)										DIFF IN Q PER TENTH FT
	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	
3.50	223.0	224.4	225.8	227.3	228.7	230.1	231.6	233.0	234.5	235.9	14.4
3.60	237.4	238.9	240.3	241.8	243.3	244.8	246.3	247.8	249.3	250.8	14.9
3.70	252.3	253.8	255.3	256.8	258.4	259.9	261.4	263.0	264.5	266.0	15.3
3.80	267.6	269.2	270.7	272.3	273.9	275.4	277.0	278.6	280.2	281.8	15.8
3.90	283.4	285.0	286.6	288.2	289.8	291.4	293.0	294.7	296.3	297.9	16.2
4.00	299.6	301.2	302.9	304.5	306.2	307.8	309.5	311.2	312.9	314.5	16.6
4.10	316.2	317.9	319.6	321.3	323.0	324.7	326.4	328.1	329.9	331.6	17.1
4.20	333.3	335.1	336.8	338.5	340.3	342.0	343.8	345.6	347.3	349.1	17.6
4.30	350.9	352.6	354.4	356.2	358.0	359.8	361.6	363.4	365.2	367.0	18.0
4.40	368.9	370.7	372.5	374.3	376.2	378.0	379.9	381.7	383.6	385.4	18.4
4.50	387.3	389.2	391.0	392.9	394.8	396.7	398.6	400.5	402.4	404.3	18.9
4.60	406.2	408.1	410.0	411.9	413.8	415.8	417.7	419.6	421.6	423.5	19.3
4.70	425.5	427.4	429.4	431.4	433.3	435.3	437.3	439.3	441.3	443.2	19.7
4.80	445.2	447.2	449.2	451.3	453.3	455.3	457.3	459.3	461.4	463.4	20.2
4.90	465.4	467.5	469.5	471.6	473.6	475.7	477.8	479.8	481.9	484.0	20.7
5.00	486.1	488.2	490.3	492.4	494.5	496.6	498.7	500.8	502.9	505.0	21.1
5.10	507.2	509.3	511.4	513.6	515.7	517.9	520.0	522.2	524.4	526.5	21.5
5.20	528.7	530.9	533.1	535.2	537.4	539.6	541.8	544.0	546.2	548.5	22.0
5.30	550.7	552.9	555.1	557.4	559.6	561.8	564.1	566.3	568.6	570.8	22.4
5.40	573.1	575.4	577.6	579.9	582.2	584.5	586.7	589.0	591.3	593.6	22.8

EXPANDED RATING TABLE TYPE: LOG

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YELLOW BANK RIVER NEAR ODESSA, MN DD: 7 TYPE: 001 RATING NO: 28

OFFSET: .40 START DATE/TIME: 04-01-2001 (0001)

GAGE HEIGHT (FEET)	DISCHARGE IN CUBIC FEET PER SECOND (EXPANDED PRECISION)										DIFF IN Q PER TENTH FT
	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	
5.50	595.9	598.2	600.6	602.9	605.2	607.5	609.9	612.2	614.5	616.9	23.3
5.60	619.2	621.6	623.9	626.3	628.7	631.0	633.4	635.8	638.2	640.6	23.8
5.70	643.0	645.4	647.8	650.2	652.6	655.0	657.4	659.8	662.3	664.7	24.1
5.80	667.1	669.6	672.0	674.5	676.9	679.4	681.9	684.3	686.8	689.3	24.7
5.90	691.8	694.2	696.7	699.2	701.7	704.2	706.7	709.3	711.8	714.3	25.0
6.00	716.8	719.3	721.9	724.4	727.0	729.5	732.1	734.6	737.2	739.7	25.5
6.10	742.3	744.9	747.5	750.0	752.6	755.2	757.8	760.4	763.0	765.6	25.9
6.20	768.2	770.9	773.5	776.1	778.7	781.4	784.0	786.7	789.3	792.0	26.4
6.30	794.6	797.3	800.0	802.6	805.3	808.0	810.7	813.3	816.0	818.7	26.8
6.40	821.4	824.1	826.9	829.6	832.3	835.0	837.7	840.5	843.2	845.9	27.3
6.50	848.7	851.4	854.2	857.0	859.7	862.5	865.3	868.0	870.8	873.6	27.7
6.60	876.4	879.2	882.0	884.8	887.6	890.4	893.2	896.0	898.9	901.7	28.1
6.70	904.5	907.4	910.2	913.0	915.9	918.7	921.6	924.5	927.3	930.2	28.6
6.80	933.1	936.0	938.9	941.7	944.6	947.5	950.4	953.3	956.3	959.2	29.0
6.90	962.1	965.0	968.0	970.9	973.8	976.8	979.7	982.7	985.6	988.6	29.4
7.00	992	995	998	1000	1003	1006	1009	1012	1015	1018	30
7.10	1021	1024	1027	1030	1034	1037	1040	1043	1046	1049	31
7.20	1052	1055	1058	1061	1064	1067	1070	1073	1076	1079	31
7.30	1083	1086	1089	1092	1095	1098	1101	1104	1107	1111	31
7.40	1114	1117	1120	1123	1126	1129	1133	1136	1139	1142	31

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YELLOW BANK RIVER NEAR ODESSA, MN DD: 7 TYPE: 001 RATING NO: 28

OFFSET: .40 START DATE/TIME: 04-01-2001 (0001)

GAGE HEIGHT (FEET)	DISCHARGE IN CUBIC FEET PER SECOND (EXPANDED PRECISION)										DIFF IN Q PER TENTH FT
	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	
7.50	1145	1149	1152	1155	1158	1161	1165	1168	1171	1174	32
7.60	1177	1181	1184	1187	1190	1194	1197	1200	1203	1207	33
7.70	1210	1213	1216	1220	1223	1226	1230	1233	1236	1240	33
7.80	1243	1246	1250	1253	1256	1260	1263	1266	1270	1273	33
7.90	1276	1280	1283	1286	1290	1293	1296	1300	1303	1307	34
8.00	1310	1313	1317	1320	1324	1327	1331	1334	1337	1341	34
8.10	1344	1348	1351	1355	1358	1362	1365	1369	1372	1376	35
8.20	1379	1383	1386	1390	1393	1397	1400	1404	1407	1411	35
8.30	1414	1418	1421	1425	1428	1432	1435	1439	1443	1446	36
8.40	1450	1453	1457	1460	1464	1468	1471	1475	1478	1482	36
8.50	1486	1489	1493	1497	1500	1504	1508	1511	1515	1519	36
8.60	1522	1526	1530	1533	1537	1541	1544	1548	1552	1555	37
8.70	1559	1563	1566	1570	1574	1578	1581	1585	1589	1593	37
8.80	1596	1600	1604	1608	1611	1615	1619	1623	1627	1630	38
8.90	1634	1638	1642	1645	1649	1653	1657	1661	1665	1668	38
9.00	1672	1676	1680	1684	1688	1692	1695	1699	1703	1707	39
9.10	1711	1715	1719	1723	1726	1730	1734	1738	1742	1746	39
9.20	1750	1754	1758	1762	1766	1770	1774	1778	1781	1785	39
9.30	1789	1793	1797	1801	1805	1809	1813	1817	1821	1825	40
9.40	1829	1833	1837	1841	1845	1849	1853	1858	1862	1866	41

EXPANDED RATING TABLE TYPE: LOG

5293000 DATE PROCESSED 02-14-2002 @ 06:18 BY ddaly

YELLOW BANK RIVER NEAR ODESSA, MN DD: 7 TYPE: 001 RATING NO: 28

OFFSET: .40 START DATE/TIME: 04-01-2001 (0001)

GAGE HEIGHT (FEET)	DISCHARGE IN CUBIC FEET PER SECOND (EXPANDED PRECISION)										DIFF IN Q PER TENTH FT
	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	
9.50	1870	1874	1878	1882	1886	1890	1894	1898	1902	1906	40
9.60	1910	1915	1919	1923	1927	1931	1935	1939	1943	1948	42
9.70	1952	1956	1960	1964	1968	1972	1977	1981	1985	1989	41
9.80	1993	1998	2002	2006	2010	2014	2019	2023	2027	2031	42
9.90	2035	2040	2044	2048	2052	2057	2061	2065	2069	2074	43
10.00	2078	2082	2087	2091	2095	2099	2104	2108	2112	2117	43
10.10	2121	2125	2130	2134	2138	2143	2147	2151	2156	2160	43
10.20	2164	2169	2173	2177	2182	2186	2191	2195	2199	2204	44
10.30	2208	2213	2217	2221	2226	2230	2235	2239	2244	2248	44
10.40	2252	2257	2261	2266	2270	2275	2279	2284	2288	2293	45
10.50	2297	2302	2306	2311	2315	2320	2324	2329	2333	2338	45
10.60	2342	2347	2351	2356	2360	2365	2370	2374	2379	2383	46
10.70	2388	2392	2397	2402	2406	2411	2415	2420	2425	2429	46
10.80	2434	2438	2443	2448	2452	2457	2462	2466	2471	2476	46
10.90	2480	2485	2490	2494	2499	2504	2508	2513	2518	2522	47
11.00	2527	2532	2537	2541	2546	2551	2555	2560	2565	2570	47
11.10	2574	2579	2584	2589	2593	2598	2603	2608	2613	2617	48
11.20	2622	2627	2632	2637	2641	2646	2651	2656	2661	2665	48
11.30	2670	2675	2680	2685	2690	2695	2699	2704	2709	2714	49
11.40	2719	2724	2729	2734	2738	2743	2748	2753	2758	2763	49

EXPANDED RATING TABLE TYPE: LOG

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YELLOW BANK RIVER NEAR ODESSA, MN DD: 7 TYPE: 001 RATING NO: 28

OFFSET: .40 START DATE/TIME: 04-01-2001 (0001)

GAGE HEIGHT (FEET)	DISCHARGE IN CUBIC FEET PER SECOND (EXPANDED PRECISION)										DIFF IN Q PER TENTH FT
	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	
11.50	2768	2773	2778	2783	2788	2793	2797	2802	2807	2812	49
11.60	2817	2822	2827	2832	2837	2842	2847	2852	2857	2862	50
11.70	2867	2872	2877	2882	2887	2892	2897	2902	2907	2912	51
11.80	2918	2923	2928	2933	2938	2943	2948	2953	2958	2963	50
11.90	2968	2973	2978	2984	2989	2994	2999	3004	3009	3014	51
12.00	3019	3025	3030	3035	3040	3045	3050	3056	3061	3066	52
12.10	3071	3076	3081	3087	3092	3097	3102	3107	3113	3118	52
12.20	3123	3128	3134	3139	3144	3149	3155	3160	3165	3170	53
12.30	3176	3181	3186	3191	3197	3202	3207	3213	3218	3223	53
12.40	3229	3234	3239	3244	3250	3255	3260	3266	3271	3277	53
12.50	3282	3287	3293	3298	3303	3309	3314	3319	3325	3330	54
12.60	3336	3341	3346	3352	3357	3363	3368	3374	3379	3384	54
12.70	3390	3395	3401	3406	3412	3417	3423	3428	3434	3439	54
12.80	3444	3450	3455	3461	3466	3472	3477	3483	3489	3494	56
12.90	3500	3505	3511	3516	3522	3527	3533	3538	3544	3549	55
13.00	3555	3561	3566	3572	3577	3583	3589	3594	3600	3605	56
13.10	3611	3617	3622	3628	3633	3639	3645	3650	3656	3662	56
13.20	3667	3673	3679	3684	3690	3696	3701	3707	3713	3718	57
13.30	3724	3730	3736	3741	3747	3753	3758	3764	3770	3776	57
13.40	3781	3787	3793	3799	3804	3810	3816	3822	3827	3833	58

EXPANDED RATING TABLE TYPE: LOG

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YELLOW BANK RIVER NEAR ODESSA, MN DD: 7 TYPE: 001 RATING NO: 28

OFFSET: .40 START DATE/TIME: 04-01-2001 (0001)

GAGE HEIGHT (FEET)	DISCHARGE IN CUBIC FEET PER SECOND (EXPANDED PRECISION)										DIFF IN Q PER TENTH FT
	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	
13.50	3839	3845	3851	3856	3862	3868	3874	3880	3885	3891	58
13.60	3897	3903	3909	3915	3920	3926	3932	3938	3944	3950	59
13.70	3956	3961	3967	3973	3979	3985	3991	3997	4003	4009	59
13.80	4015	4020	4026	4032	4038	4044	4050	4056	4062	4068	59
13.90	4074	4080	4086	4092	4098	4104	4110	4116	4122	4128	60
14.00	4134	4140	4146	4152	4158	4164	4170	4176	4182	4188	60
14.10	4194	4200	4206	4212	4218	4224	4230	4236	4242	4249	61
14.20	4255	4261	4267	4273	4279	4285	4291	4297	4303	4310	61
14.30	4316	4322	4328	4334	4340	4346	4353	4359	4365	4371	61
14.40	4377	4383	4390	4396	4402	4408	4414	4421	4427	4433	62
14.50	4439	4445	4452	4458	4464	4470	4477	4483	4489	4495	63
14.60	4502	4508	4514	4520	4527	4533	4539	4546	4552	4558	62
14.70	4564	4571	4577	4583	4590	4596	4602	4609	4615	4621	64
14.80	4628	4634	4640	4647	4653	4659	4666	4672	4679	4685	63
14.90	4691	4698	4704	4710	4717	4723	4730	4736	4743	4749	64
15.00	4755	4762	4768	4775	4781	4788	4794	4801	4807	4813	65
15.10	4820	4826	4833	4839	4846	4852	4859	4865	4872	4878	65
15.20	4885	4891	4898	4904	4911	4918	4924	4931	4937	4944	65
15.30	4950	4957	4963	4970	4977	4983	4990	4996	5003	5010	66
15.40	5016	5023	5029	5036	5043	5049	5056	5062	5069	5076	66

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YELLOW BANK RIVER NEAR ODESSA, MN DD: 7 TYPE: 001 RATING NO: 28

OFFSET: .40 START DATE/TIME: 04-01-2001 (0001)

GAGE HEIGHT (FEET)	DISCHARGE IN CUBIC FEET PER SECOND (EXPANDED PRECISION) 0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	DIFF IN Q PER TENTH FT
15.50	5082	5089	5096	5102	5109	5116	5122	5129	5136	5142	67
15.60	5149	5156	5162	5169	5176	5183	5189	5196	5203	5209	67
15.70	5216	5223	5230	5236	5243	5250	5257	5263	5270	5277	68
15.80	5284	5290	5297	5304	5311	5318	5324	5331	5338	5345	68
15.90	5352	5358	5365	5372	5379	5386	5393	5399	5406	5413	68
16.00	5420	5427	5434	5441	5448	5454	5461	5468	5475	5482	69
16.10	5489	5496	5503	5510	5517	5523	5530	5537	5544	5551	69
16.20	5558	5565	5572	5579	5586	5593	5600	5607	5614	5621	70
16.30	5628	5635	5642	5649	5656	5663	5670	5677	5684	5691	70
16.40	5698	5705	5712	5719	5726	5733	5740	5747	5754	5761	70
16.50	5768	5776	5783	5790	5797	5804	5811	5818	5825	5832	71
16.60	5839	5847	5854	5861	5868	5875	5882	5889	5896	5904	72
16.70	5911	5918	5925	5932	5939	5947	5954	5961	5968	5975	72
16.80	5983	5990	5997	6004	6011	6019	6026	6033	6040	6048	72
16.90	6055	6062	6069	6077	6084	6091	6098	6106	6113	6120	73
17.00	6128	6135	6142	6149	6157	6164	6171	6179	6186	6193	73
17.10	6201	6208	6215	6223	6230	6237	6245	6252	6259	6267	73
17.20	6274	6282	6289	6296	6304	6311	6318	6326	6333	6341	74
17.30	6348	6356	6363	6370	6378	6385	6393	6400	6408	6415	75
17.40	6423	6430	6437	6445	6452	6460	6467	6475	6482	6490	74

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OFFSET: .40 START DATE/TIME: 04-01-2001 (0001)

GAGE HEIGHT (FEET)	DISCHARGE IN CUBIC FEET PER SECOND (EXPANDED PRECISION) 0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	DIFF IN Q PER TENTH FT
17.50	6497	6505	6512	6520	6527	6535	6542	6550	6557	6565	76
17.60	6573	6580	6588	6595	6603	6610	6618	6626	6633	6641	75
17.70	6648	6656	6663	6671	6679	6686	6694	6701	6709	6717	76
17.80	6724	6732	6740	6747	6755	6763	6770	6778	6786	6793	77
17.90	6801	6809	6816	6824	6832	6839	6847	6855	6862	6870	77
18.00	6878	6886	6893	6901	6909	6916	6924	6932	6940	6947	77
18.10	6955	6963	6971	6979	6986	6994	7002	7010	7017	7025	78
18.20	7033	7041	7049	7056	7064	7072	7080	7088	7096	7103	78
18.30	7111	7119	7127	7135	7143	7151	7158	7166	7174	7182	79
18.40	7190	7198	7206	7214	7221	7229	7237	7245	7253	7261	79
18.50	7269	7277	7285	7293	7301	7309	7317	7325	7333	7341	80
18.60	7349	7356	7364	7372	7380	7388	7396	7404	7412	7420	79
18.70	7428	7436	7444	7453	7461	7469	7477	7485	7493	7501	81
18.80	7509	7517	7525	7533	7541	7549	7557	7565	7573	7582	81
18.90	7590	7598	7606	7614	7622	7630	7638	7646	7655	7663	81
19.00	7671	7679	7687	7695	7703	7712	7720	7728	7736	7744	81
19.10	7752	7761	7769	7777	7785	7793	7802	7810	7818	7826	83
19.20	7835	7843	7851	7859	7868	7876	7884	7892	7901	7909	82
19.30	7917	7925	7934	7942	7950	7958	7967	7975	7983	7992	83.00*
19.40	8000*										

Table 7-2 Low Flow Outlet - Tailwater Rating Table							
TW Elev	**Q cfs**	**TW Elev**	**Q cfs**	**TW Elev**	**Q cfs**	**TW Elev**	**Q cfs**
940.6	2	941.4	20	942.2	62	943.0	134
940.7	4	941.5	24	942.3	69	943.1	146
940.8	5	941.6	28	942.4	77	943.2	158
940.9	7	941.7	32	942.5	85	943.3	170
941.0	9	941.8	37	942.6	94	943.4	183
941.1	11	941.9	43	942.7	103	943.5	197
941.2	14	942.0	49	942.8	113		
941.3	17	942.1	55	942.9	123		

Table 7-3 Low Flow Outlet Discharge Rating							
Head Pool-TW (feet)	**Discharge in cfs**						
	Gate Opening (ft) / Flow Area (sq ft)						
	0.5	1.0	1.5	2.0	2.5	3.0	3.5
	0.843	2.27	3.94	5.68	7.34	8.77	9.62
6.8	14	39	68	97	126	150	165
7.0	15	40	69	99	128	153	167
7.2	15	40	70	100	130	155	170
7.4	15	41	71	102	131	157	172
7.6	15	41	71	103	133	159	175
7.8	15	42	72	104	135	161	177
8.0	16	42	73	106	137	163	179
8.2	16	43	74	107	138	165	181
8.4	16	43	75	108	140	167	183
8.6	16	44	76	110	142	169	186
8.8	16	44	77	111	143	171	188
9.0	17	45	78	112	145	173	190
9.2	17	45	79	113	147	175	192
9.4	17	46	79	115	148	177	194
9.6	17	46	80	116	150	179	196
9.8	17	47	81	117	151	181	198
10.0	18	47	82	118	153	182	200
10.2	18	48	83	119	154	184	202
10.4	18	48	84	121	156	186	204

Table 7-4 Service Spillway Rating based on Head							
Head (feet)	**Q (cfs)**	**Head (feet)**	**Q (cfs)**	**Head (feet)**	**Q (cfs)**	**Head (feet)**	**Q (cfs)**
0.1	8	2.3	870	4.6	2,470	6.8	4,435
0.2	20	2.4	930	4.7	2,550	6.9	4,535
0.3	40	2.5	990	4.8	2,630	7.0	4,635
0.4	60	2.6	1,050	4.9	2,715	7.1	4,735
0.5	90	2.7	1,110	5.0	2,800	7.2	4,835
0.6	115	2.8	1,170	5.1	2,880	7.3	4,935
0.7	145	2.9	1,235	5.2	2,965	7.4	5,040
0.8	180	3.0	1,300	5.3	3,055	7.5	5,140
0.9	215	3.1	1,365	5.4	3,140	7.6	5,245
1.0	250	3.2	1,430	5.5	3,230	7.7	5,345
1.1	290	3.4	1,570	5.6	3,315	7.8	5,450
1.2	330	3.5	1,640	5.7	3,405	7.9	5,555
1.3	370	3.6	1,710	5.8	3,495	8.0	5,665
1.4	415	3.7	1,780	5.9	3,585	8.1	5,770
1.5	460	3.8	1,855	6.0	3,680	8.2	5,875
1.6	505	3.9	1,925	6.1	3,770	8.3	5,985
1.7	555	4.0	2,000	6.2	3,865	8.4	6,090
1.8	605	4.1	2,080	6.3	3,955	8.5	6,200
1.9	655	4.2	2,130	6.4	4,050	8.6	6,310
2.0	710	4.3	2,230	6.5	4,145	8.7	6,420
2.1	760	4.4	2,310	6.6	4,245	8.8	6,530
2.2	815	4.5	2,390	6.7	4,340	8.9	6,645

Table 7-5
Bascule Leaf Gate in the Lowered Position (Elev. 947.3 feet)
Service Spillway Rating based on Pool Elevation

Pool Elev.	Q (cfs)	Pool Elev.	Q (cfs)	Pool Elev.	Q (cfs)	Pool Elev.	Q (cfs)
947.3	0	950.2	1,235	953.1	3,490	956.0	6,420
947.4	8	950.3	1,300	953.2	3,585	956.1	6,530
947.5	22	950.4	1,365	953.3	3,680	956.2	6,640
947.6	40	950.5	1,430	953.4	3,770	956.3	6,750
947.7	63	950.6	1,500	953.5	3,860	956.4	6,870
947.8	88	950.7	1,570	953.6	3,960	956.5	6,980
947.9	115	950.8	1,640	953.7	4,050	956.6	7,100
948.0	150	950.9	1,710	953.8	4,150	956.7	7,210
948.1	180	951.0	1,780	953.9	4,240	956.8	7,325
948.2	215	951.1	1,850	954.0	4,340	956.9	7,440
948.3	250	951.2	1,930	954.1	4,440	957.0	7,560
948.4	290	951.3	2,000	954.2	4,540	957.1	7,680
948.5	330	951.4	2,075	954.3	4,640	957.2	7,800
948.6	370	951.5	2,150	954.4	4,740	957.3	7,910
948.7	415	951.6	2,230	954.5	4,840	957.4	8,030
948.8	460	951.7	2,310	954.6	4,940	957.5	8,150
948.9	510	951.8	2,390	954.7	5,040	957.6	8,270
949.0	555	951.9	2,470	954.8	5,140	957.7	8,400
949.1	605	952.0	2,550	954.9	5,240	957.8	8,520
949.2	655	952.1	2,630	955.0	5,350	957.9	8,640
949.3	710	952.2	2,710	955.1	5,450	958.0	8,760
949.4	760	952.3	2,800	955.2	5,560	958.1	8,880
949.5	820	952.4	2,880	955.3	5,660	958.2	9,005
949.6	875	952.5	2,970	955.4	5,770	958.3	9,130
949.7	930	952.6	3,055	955.5	5,880	958.4	9,250
949.8	990	952.7	3,140	955.6	5,990	958.5	9,380
949.9	1,050	952.8	3,230	955.7	6,090	958.6	9,500
950.0	1,110	952.9	3,315	955.8	6,200	958.7	9,630
950.1	1,175	953.0	3,400	955.9	6,310	958.8	9,760

Table 7-6 Emergency Spillway Rating Table					
Pool Elevation (feet)	**Discharge (cfs)**	**Pool Elevation (feet)**	**Discharge (cfs)**	**Pool Elevation (feet)**	**Discharge (cfs)**
956.5	20	958.1	3,780	959.7	10,660
956.6	80	958.2	4,140	959.8	11,160
956.7	190	958.3	4,510	959.9	11,670
956.8	325	958.4	4,890	960.0	12,190
956.9	490	958.5	5,280	960.1	12,720
957.0	675	958.6	5,675	960.2	13,250
957.1	880	958.7	6,085	960.3	13,790
957.2	1,110	958.8	6,505	960.4	14,340
957.3	1,350	958.9	6,930	960.5	14,890
957.4	1,610	959.0	7,350	960.6	15,450
957.5	1,880	959.1	7,815	960.7	16,020
957.6	2,165	959.2	8,270	960.8	16,600
957.7	2,465	959.3	8,730	960.9	17,180
957.8	2,775	959.4	9,200	961.0	17,770
957.9	3,100	959.5	9,680	961.2	18,360
958.0	3,435	959.6	10,170	961.3	19,570

Highway 75 Reservoir

Elevation in Feet (1929 NGVD) with Storage Capacity in Acre-Feet

	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
944.0	500	495	499	503	507	511	514	518	522	526
944.1	530	534	538	542	546	550	554	558	563	567
944.2	571	575	579	583	587	591	596	600	604	608
944.3	612	617	621	625	629	634	638	642	647	651
944.4	655	660	664	669	673	677	682	686	691	695
944.5	700	704	709	713	718	722	727	732	736	741
944.6	745	750	755	759	764	769	774	778	783	788
944.7	793	797	802	807	812	817	821	826	831	836
944.8	841	846	851	856	861	866	871	876	881	886
944.9	891	896	901	906	911	916	921	927	932	937
945.0	942	947	953	958	963	968	974	979	984	989
945.1	995	1000	1005	1011	1016	1022	1027	1032	1038	1043
945.2	1049	1054	1060	1065	1071	1076	1082	1087	1093	1099
945.3	1104	1110	1116	1121	1127	1133	1138	1144	1150	1155
945.4	1161	1167	1173	1178	1184	1190	1196	1202	1208	1214
945.5	1219	1225	1231	1237	1243	1249	1255	1261	1267	1273
945.6	1279	1285	1291	1297	1304	1310	1316	1322	1328	1334
945.7	1341	1347	1353	1359	1366	1372	1378	1384	1391	1397
945.8	1403	1410	1416	1423	1429	1436	1442	1448	1455	1461
945.9	1468	1475	1481	1488	1494	1501	1508	1514	1521	1528
946.0	1534	1541	1548	1554	1561	1568	1575	1581	1588	1595
946.1	1602	1609	1616	1623	1630	1637	1644	1650	1657	1664
946.2	1672	1679	1686	1693	1700	1707	1714	1721	1728	1736
946.3	1743	1750	1757	1764	1772	1779	1786	1794	1801	1808
946.4	1816	1823	1830	1838	1845	1853	1860	1868	1875	1883
946.5	1890	1898	1905	1913	1921	1928	1936	1943	1951	1959
946.6	1967	1974	1982	1990	1998	2005	2013	2021	2029	2037

Highway 75 Reservoir

Elevation in Feet (1929 NGVD) with Storage Capacity in Acre-Feet

	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
946.7	2045	2052	2060	2068	2076	2084	2092	2100	2108	2116
946.8	2124	2132	2140	2149	2157	2165	2173	2181	2189	2197
946.9	2206	2214	2222	2230	2239	2247	2255	2264	2272	2280
947.0	2289	2297	2306	2314	2323	2331	2340	2348	2357	2365
947.1	2374	2382	2391	2400	2408	2417	2426	2434	2443	2452
947.2	2461	2470	2478	2487	2496	2505	2514	2523	2532	2541
947.3	2550	2559	2568	2577	2586	2595	2604	2613	2622	2631
947.4	2641	2650	2659	2668	2678	2687	2696	2705	2715	2724
947.5	2734	2743	2752	2762	2771	2781	2790	2800	2809	2819
947.6	2829	2838	2848	2858	2867	2877	2887	2896	2906	2916
947.7	2926	2936	2946	2955	2965	2975	2985	2995	3005	3015
947.8	3025	3035	3045	3056	3066	3076	3086	3096	3106	3117
947.9	3127	3137	3148	3158	3168	3179	3189	3199	3210	3220
948.0	3231	3241	3252	3262	3273	3284	3294	3305	3316	3326
948.1	3337	3348	3359	3369	3380	3391	3402	3413	3424	3435
948.2	3446	3457	3468	3479	3490	3501	3512	3523	3534	3546
948.3	3557	3568	3579	3591	3602	3613	3625	3636	3648	3659
948.4	3671	3682	3694	3705	3717	3728	3740	3752	3763	3775
948.5	3787	3799	3810	3822	3834	3846	3858	3870	3882	3894
948.6	3905	3917	3930	3942	3954	3966	3978	3990	4002	4014
948.7	4027	4039	4051	4064	4076	4088	4101	4113	4125	4138
948.8	4150	4163	4175	4188	4201	4213	4226	4238	4251	4264
948.9	4277	4289	4302	4315	4328	4341	4353	4366	4379	4392
949.0	4405	4418	4431	4444	4457	4471	4484	4497	4510	4523
949.1	4537	4550	4563	4577	4590	4604	4617	4630	4644	4658
949.2	4671	4685	4698	4712	4726	4739	4753	4767	4781	4795
949.3	4809	4822	4836	4850	4864	4878	4892	4906	4921	4935

Highway 75 Reservoir

Elevation in Feet (1929 NGVD) with Storage Capacity in Acre-Feet

	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
949.4	4949	4963	4977	4992	5006	5020	5035	5049	5063	5078
949.5	5092	5107	5121	5136	5151	5165	5180	5195	5210	5224
949.6	5239	5254	5269	5284	5299	5314	5329	5344	5359	5374
949.7	5389	5405	5420	5435	5451	5466	5481	5497	5512	5528
949.8	5543	5559	5575	5590	5606	5622	5637	5653	5669	5685
949.9	5701	5717	5733	5749	5765	5781	5797	5813	5829	5846
950.0	5862	5878	5895	5911	5927	5944	5960	5977	5994	6010
950.1	6027	6044	6060	6077	6094	6111	6128	6145	6162	6179
950.2	6196	6213	6230	6247	6264	6281	6299	6316	6333	6351
950.3	6368	6386	6403	6421	6438	6456	6474	6491	6509	6527
950.4	6545	6563	6581	6598	6616	6635	6653	6671	6689	6707
950.5	6725	6744	6762	6780	6799	6817	6836	6854	6873	6891
950.6	6910	6929	6947	6966	6985	7004	7023	7042	7061	7080
950.7	7099	7118	7137	7157	7176	7195	7215	7234	7254	7273
950.8	7293	7312	7332	7352	7371	7391	7411	7431	7451	7471
950.9	7491	7511	7531	7551	7571	7592	7612	7632	7653	7673
951.0	7693	7714	7735	7755	7776	7797	7817	7838	7859	7880
951.1	7901	7922	7943	7964	7985	8006	8028	8049	8070	8092
951.2	8113	8135	8156	8178	8200	8221	8243	8265	8287	8309
951.3	8331	8353	8375	8397	8419	8441	8463	8486	8508	8530
951.4	8553	8575	8598	8621	8643	8666	8689	8712	8734	8757
951.5	8780	8803	8826	8850	8873	8896	8919	8943	8966	8990
951.6	9013	9037	9061	9084	9108	9132	9156	9180	9204	9228
951.7	9252	9276	9301	9325	9349	9374	9398	9423	9447	9472
951.8	9497	9522	9547	9571	9596	9622	9647	9672	9697	9722
951.9	9748	9773	9799	9824	9850	9875	9901	9927	9953	9979
952.0	10005	10031	10057	10083	10109	10135	10162	10188	10214	10241

Highway 75 Reservoir

Elevation in Feet (1929 NGVD) with Storage Capacity in Acre-Feet

	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
952.1	10268	10294	10321	10348	10374	10401	10428	10455	10482	10509
952.2	10536	10564	10591	10618	10646	10673	10701	10728	10756	10783
952.3	10811	10839	10867	10895	10923	10951	10979	11007	11035	11064
952.4	11092	11120	11149	11177	11206	11235	11263	11292	11321	11350
952.5	11379	11408	11437	11466	11496	11525	11554	11584	11614	11643
952.6	11673	11703	11733	11763	11793	11823	11853	11884	11914	11945
952.7	11975	12006	12037	12068	12099	12130	12161	12192	12223	12255
952.8	12286	12317	12349	12381	12413	12444	12476	12508	12541	12573
952.9	12605	12637	12670	12702	12735	12768	12801	12834	12867	12900
953.0	12933	12966	12999	13033	13066	13100	13133	13167	13201	13235
953.1	13269	13303	13337	13371	13406	13440	13475	13509	13544	13579
953.2	13614	13648	13683	13719	13754	13789	13824	13860	13895	13931
953.3	13967	14003	14038	14074	14110	14147	14183	14219	14255	14292
953.4	14329	14365	14402	14439	14476	14513	14550	14587	14624	14662
953.5	14699	14737	14744	14812	14851	14889	14927	14966	15005	15044
953.6	15083	15122	15162	15201	15241	15281	15321	15362	15402	15443
953.7	15484	15525	15566	15607	15649	15691	15733	15775	15817	15860
953.8	15903	15945	15988	16032	16075	16119	16163	16206	16251	16295
953.9	16340	16384	16429	16474	16520	16565	16611	16656	16702	16749
954.0	16795	16842	16888	16935	16982	17029	17076	17123	17170	17217
954.1	17264	17312	17359	17407	17454	17502	17550	17598	17646	17694
954.2	17742	17790	17839	17887	17936	17984	18033	18082	18130	18179
954.3	18228	18277	18327	18376	18425	18475	18524	18574	18624	18673
954.4	18723	18773	18823	18873	18924	18974	19024	19075	19125	19176
954.5	19227	19278	19329	19380	19431	19482	19533	19584	19635	19687
954.6	19738	19790	19841	19893	19945	19996	20048	20100	20152	20204
954.7	20256	20308	20361	20413	20465	20518	20570	20623	20676	20728

Highway 75 Reservoir

Elevation in Feet (1929 NGVD) with Storage Capacity in Acre-Feet

	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
954.8	20781	20834	20887	20940	20993	21046	21099	21153	21206	21259
954.9	21313	21366	21420	21474	21527	21581	21635	21689	21743	21797
955.0	21851	21906	21960	22014	22069	22123	22178	22232	22287	22341
955.1	22396	22451	22506	22560	22615	22670	22725	22780	22836	22891
955.2	22946	23001	23057	23112	23168	23223	23279	23334	23390	23446
955.3	23501	23557	23613	23669	23725	23781	23837	23893	23950	24006
955.4	24062	24119	24175	24232	24288	24345	24401	24458	24515	24572
955.5	24629	24686	24742	24799	24857	24914	24971	25028	25085	25142
955.6	25200	25257	25314	25372	25429	25487	25544	25602	25660	25717
955.7	25775	25833	25890	25948	26006	26064	26122	26180	26238	26296
955.8	26354	26413	26471	26529	26587	26646	26704	26763	26821	26879
955.9	26938	26997	27055	27114	27173	27231	27290	27349	27408	27467
956.0	27526	27585	27644	27703	27762	27821	27881	27940	27999	28059
956.1	28118	28178	28237	28297	28356	28416	28476	28535	28595	28655
956.2	28715	28775	28835	28895	28955	29015	29075	29135	29195	29256
956.3	29316	29376	29437	29497	29558	29618	29679	29740	29800	29861
956.4	29922	29983	30043	30104	30165	30226	30287	30348	30410	30471
956.5	30532	30593	30655	30716	30777	30839	30900	30962	31023	31085
956.6	31146	31208	31270	31332	31393	31455	31517	31579	31641	31703
956.7	31765	31827	31889	31951	32013	32075	32138	32200	32262	32325
956.8	32387	32449	32512	32574	32637	32700	32762	32825	32888	32950
956.9	33013	33076	33139	33202	33265	33328	33391	33454	33517	33580
957.0	33643	33706	33770	33833	33896	33960	34023	34086	34150	34213
957.1	34277	34340	34404	34468	34531	34595	34659	34723	34787	34850
957.2	34914	34978	35042	35106	35170	35234	35298	35363	35427	35491
957.3	35555	35620	35684	35748	35813	35877	35942	36006	36071	36135
957.4	36200	36264	36329	36394	36459	36523	36588	36653	36718	36783

MINNESOTA RIVER HEADWATERS
WEEKLY LOG SHEET

CORPS OF ENGINEERS
ST. PAUL DISTRICT

DATE: 11-JUN-2004

LOCATION		SAT. 05	SUN. 06	MON. 07	TUES. 08	WED. 09	THUR. 10	FRI. 11
MN RIVER @ MONTEVIDEO (FT)		6.88 D	6.81 D	6.68 U	6.27 U	6.09 U	6.49 U	8.31 D
MN RIVER FLOW (CFS)		1495 D	1469 D	1420 U	1270 U	1210 U	1350 U	2073
POMME DE TERRE RIVER @ APPLETON (FT)		5.77 D	5.69 D	5.64 U	5.57 U	5.71 U	5.89 U	6.15 D
PDT RIVER FLOW (CFS)		293 D	275 D	261 U	248 U	274 U	308 U	390 D
LAC QUI PARLE RIVER @ LAC QUI PARLE (FT)		5.95 D	5.85 D	5.75 U	5.66 U	5.67 U	5.61 U	5.69 D
LQP RIVER FLOW (CFS)		134 D	119 D	90 U	79 U	80 U	71 U	90 D
MARSH LAKE DAM (900.00) -POOL		938.40 D	938.39 D	938.36 D	938.46 D	938.51 D	938.46 D	938.55 D
MARSH LAKE DAM (900.00) -T.W.		933.48 D	933.49 D	933.60 D	933.52 D	933.64 D	933.74 D	933.15 D
MARSH LAKE DAM TOTAL DISCHARGE								
MARSH LAKE CONDUIT OPENING (FT)		1.0						1.0
HWY. 40 BRIDGE @ MILAN (900.00)		933.23 D	933.24 D	933.17 D	933.15 D	933.26 D	933.45 D	933.69 D
LAC QUI PARLE DAM (900.00) -POOL		932.91 D	932.90 D	932.75 D	932.98 D	933.13 D	933.18 D	933.15 D
LAC QUI PARLE DAM (900.00) -T.W.		924.06 D	924.04 D	923.99 U	923.34 U	934.06 U	934.39 U	296.04 D
LQP DAM TW (CFS) TOTAL DISCHARGE		998 D	993 D	980 U	819 U	751 U	831 U	1532 D
LQP GATE SETTINGS GATE (FT)	BAY							
1	1	0.0						0.0
2	1	0.0						0.0
3, 4, 5	2	0.0						0.0
6	3	0.0						4.0
7	3	3.0			1.0			4.0
8	4	4.0						5.0
9	4	5.0				4.0	5.0	5.0
15 BULKHEADS		DOWN						DOWN
CHIPPEWA RIVER @ MILAN (FT)		3.22 D	3.07 D	2.99 U	2.99 U	3.19 U	5.14 U	4.96 D
CHIPP. R. FLOW (CFS)		1037 D	942 D	817 U	817 U	920 U	2120 U	2132 D
SAG WEIR –POOL(900.00) CHIPPEWA RIVER DAMS		939.81 D	939.80 D	939.71 D	939.64 D	939.65 D	941.39 D	940.89 D
SAG WEIR - T.W. (900.00) CHIPPEWA RIVER DAMS		937.80 D	937.62 D	937.37 D	937.24 D	937.79 D	941.43 D	940.86 D
TOTAL FLOW POOL READING (CFS)		614	524	408	414	499	1452	1354
CHIPP. TAINTER GATE -POOL (900.00)		939.73 D	939.65 D	939.56 D	939.51 D	939.78 D	941.74 D	941.18 D
CHIPP. TAINTER GATE -T.W. (900.00)		937.95 D	937.92 D	937.87 U	937.84 U	937.94 U	939.13 U	939.60 D
TOTAL DISCHARGE T.W. READING (CFS)		423 D	418 D	409 D	403 D	421 D	668 D	778 D
TAINTER GATE OPENING (FT)		2.5					3.0	4.0
LOW FLOW GATE OPENING (FT)		.20						.20

CEMVP FORM 405B REVISED 10-01-99

SIGNATURE Thurlyn Bahl

MINNESOTA RIVER HEADWATERS
WEEKLY LOG SHEET

CORPS OF ENGINEERS
ST. PAUL DISTRICT

DATE: 11-JUN-2004

LOCATION	SAT. 05	SUN. 06	MON. 07	TUES. 08	WED. 09	THUR. 10	FRI. 11
MN RIVER @ ORTONVILLE (FT)	1.85 D	1.77 D	1.78 D	2.99 U	2.99 U	2.96 U	2.29 D
YELLOW BANK RIVER @ ODESSA (FT)	2.10 D	2.09 D	2.01 U	1.98 D	2.18 U	2.41 U	2.45 U
HWY. 75 LOW FLOW GATE OPENING (FT)	.10						.10
SERVICE SPILLWAY LEAF GATE ELEVATION	951.50					951.00	950.50
LOW FLOW – POOL HWY. 75 (900.00)	951.41 D	951.45 D	951.47 D	951.53 D	951.70 D	951.76 D	951.75 D
LOW FLOW – T.W. HWY. 75 (900.00)	941.04 D	941.03 D	941.04 D	941.04 D	941.06 D	941.08 D	941.52
LOW FLOW – HEAD HWY 75 (FT)	10.37	10.42	10.43	10.49	10.64	10.68	10.23
-DISCHARGE (CFS) LOW FLOW – HWY 75	5	5	5	5	5	5	5
SERVICE SPILLWAY HEAD - HWY 75 (FT)	0	0	0	.03	.20	.76	1.25
DISCHARGE (CFS) SERVICE SPILLWAY	0	0	0	4	22	168	350
TOTAL DISCHARGE (CFS) LEAF GATE/LOW FLOW	5	5	5	9	27	173	355
PRECIPATION HWY. 75 LAST 24 HRS. (INCHES)	0	0	0	.55	1.15	0	0
PRECIPATION LQP-P LAST 24 HRS. (INCHES)	0	0	0	.21	.90	0	0
WIND SPEED/DIRECTION			17 SW	8 NE	14 E	12 E	
TEMPERATURES (MIN/MAX/0800)			57/84/77	72.93/68	57/68/57	55/68/55	

WINTER WEATHER REPORT	FROST TUBE:	SNOW ON GROUND:	WATER CONTENT:	ICE ON LQP LAKE:

NOTES:

METHOD USED:
W = WIRE WEIGHT
M = VOICE MODEM
D = DCP (DATA COLLECTION PLATFORM)
V = TAPE/STAFF VISUAL
U= USGS WEB

MEASUREMENTS USED:
FT = FOOT
CFS = CUBIC FEET PER SECOND

Pool and tailwater readings begin at 900.00 elevation as noted in ( ), 1929 NGVD.

LQP DAM BULKHEADS IN BAYS 8, 9, 10, 11, 12

READINGS TAKEN AT 8AM UNLESS NOTED.

COMMENTS:

07-JUN-LQP DAM-closed gate #7 2FT. 0945 Hrs.
08-JUN-LQP DAM -closed gate #9 1 ft at 1000 hrs.
09-JUN-LQP DAM-opened gate #9 1 Ft. at 0930 Hrs.
CHIP. DIV.-OPENED TAINTER GATE .50 FT. 0900 HRS
HWY 75 - Lowered LG to 951.00 at 1130 hrs.
10-JUN LQP DAM-opened gate #6 4 Ft at 0900 hrs.
LQP DAM-opened gate #7 3 Ft at 1530 Hrs.
LQP DAM-opened gate #8 1 Ft. at 1530 Hrs.
10-JUN CHIP.DIV.-Opened TG 1 FT. at 0830 Hrs..
HWY 75 -Lowered Leaf Gate to 950.50 at 1300 Hrs.

CEMVP FORM 405A REVISED 10-01-99

SIGNATURE

US Army Corps
of Engineers
St. Paul District

OPERATION AND MAINTENANCE MANUAL

BIG STONE LAKE - WHETSTONE RIVER
FLOOD CONTROL
UPSTREAM WORKS - MINNESOTA RIVER
BIG STONE COUNTY, MINNESOTA

MARCH 1987

Revised 8/87

U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
WITH THE
SOUTH DAKOTA-MINNESOTA BOUNDARY WATERS COMMISSION
AND THE
UPPER MINNESOTA RIVER WATERSHED DISTRICT

Big Stone Lake Control Works at
Ortonville, Big Stone County, Minnesota

PROPOSED OPERATION OF CONTROL WORKS

A. Introduction.

The Big Stone Lake/Whetstone River project was designed chiefly as a conservation/recreational use project and was built under Minnesota state auspices with federal contributions. The need for additional flood control storage in this area is met by the Highway 75 dam (USACE) which is immediately downstream of Big Stone Lake. To provide maximum benefits and to meet the goals of the Big Stone/Whetstone project, the dam at Big Stone Lake shall be operated as provided hereinafter.

B. Objectives.

The operation of the control works in the outlet structure at Big Stone Lake as set forth in paragraph E below shall be conducted as a demonstration project for the period of one year following installation of the gates by the U.S. Army Corps of Engineers. The goal of the demonstration project is the successful accomplishment of the following purposes:

(1) To maintain the water surface of Big Stone Lake within one foot above elevation 964.6 feet NGVD 1929 (lake gage 6.9) during the period from May 1 to September 30 each year.

(2) To prevent excessive discharge of water over the spillway of the dam, when such discharge is due to the action of wind and waves, and while the water surface of the lake is at or below elevation 964.6 feet NGVD.

(3) To provide for minimum flows in the Minnesota River for the use of riparian owners downstream, for stock-watering, for the dilution of effluent from the sewage plant, and for protection and improvement of fish and wildlife habitat.

(4) To improve the water quality of Big Stone Lake by maximizing the diversion of the Whetstone River flood flows away from the lake and by increasing the export of accumulated sediment through the selective release of lake water between elevations 964.9 and 965.9 feet NGVD (lake gage 7.2 to 8.2).

Following the one year demonstration project, the "Operation of Control Works" document shall be approved or modified, based on an evaluation of the reported data, in order to provide for permanent operating guidelines which best accomplish the above-stated purposes.

C. Operating Gates.

The control structure located at the outlet of Big Stone Lake contains eight bays with underflow slide gates, which are 10'-10' wide and 7'-0" high. These gates are all operated by electric motors. Hereinafter, they are terms "spillway gates".

The control works also includes one 4'x4' gate and one 18" diameter gate for low flow operation. Both of these gates are operated with electric motors. Hereinafter, these gates are referred to as "sluice gates".

The silt barrier, located in the Minnesota River on the downstream side of the Milwaukee Railroad bridge crossing, has a 30"x30" wheel-operated gate in the left (looking downstream) abutment. Hereinafter, this gate is called the "silt barrier gate".

D. Gages.

Various water surface measuring gages have been installed on and near Big Stone Lake. Measurements on these gages are determining factors for operation of the control gates. For operating purposes, the pertinent gages are designated and described as follows:

(1) Whetstone River near Big Stone City, South Dakota (USGS 05291000).

This gage is a water-stage recorder located on the right bank, 1.5 miles west of Big Stone City, and 4.5 miles upstream from Big Stone Lake. (Drainage Area 389 mi^2). This gage is also an active sediment gage from March 1 to August 31.

(2) Big Stone Lake at Ortonville, Minnesota (USGS 05291500).

This is a non-recording (staff) gage located at the Big Stone Power Plant water intake structure near Big Stone City, South Dakota. The

zero of the lake gage is at elevation 960.1 feet (project datum) or 957.69 feet National Geodetic Vertical Datum (NGVD) 1929. This gage is hereinafter referred to as the "lake level gage". All further references to "elevation" in this operation plan will be in reference to the NGVD 1929. In regard to operation of the structure, the reading of the lake gage shall be corrected to allow for wind set-up.

(3) Minnesota River at Ortonville, Minnesota (USGS 95292000).

This is a water-stage recorder located on the left bank 1,300 feet downstream of the outlet of the dam at Big Stone Lake at Ortonville, Minnesota. (Drainage Area 1,160 mi^2).

(4) Precipitation, air temperature, and wind gages at the Big Stone Power Plant.

E, Operation.

(1) Flood control storage in Big Stone Lake shall be only that storage which is above elevation 965.9 feet NGVD (lake gage 8.2) and shall be surcharge storage only; whenever the lake exceeds this level, all spillway gates shall be opened fully. Any water above this level shall be released as rapidly as possible.

(2) Big Stone Lake has a concrete-capped sheet-pile weir at its exit, just upstream of the gated structure. This weir usually called the "silt barrier", contains a sluice gate for low flows. All "lake gage"

elevations stated in this section are at the Big Stone Power Plant intake structure near Big Stone City, South Dakota, and are referred to a datum giving 964.6 feet as the elevation of the center section of the silt barrier crest (NGVD 1929).

(3) During the year when the level of Big Stone Lake is at or below the silt barrier the dam will be opened sufficiently to release Whetstone River flows; and if necessary, the silt barrier gate will be opened to provide a minimum flow of 5 cubic feet per second through the dam.

(4) In late winter when the lake has an ice cover and the weather warms to the point of creating runoff due to snowmelt, the dam will be operated as such:

(a) When a normal or above-normal snowpack* exists and the lake level reaches elevation 964.1 (lake gage 6.4) or above, the spillway gates shall be opened.

(b) When a below-normal snowpack* exists and the lake level reaches elevation 964.6 feet (lake gage 6.9) or above, the spillway gates shall be opened.

*Normal snowpack will be defined using National Weather Service snowfall records within the Big Stone Lake Watershed, and correlated to the historical flows of the other tributaries to determine the amount of snowfall normally needed to restore the lake level back to elevation 964.6 feet (lake gage 6.9) from the given end-of-year condition.

(5) During the period of May 1 through September 30, when the lake level is at or above elevation 965.6 feet (lake gage 7.9), the gates of the dam shall be opened sufficiently and adjusted daily so that the flows of the Minnesota River are approximately equal to the inflow from the Whetstone River, but not less than 90 cubic feet per second.

(6) During the period of May 1 through September 30, when the lake level is between elevation 964.6 feet (lake gage 6.9) and elevation 965.6 feet (lake gage 7.9) the gates of the dam shall be opened sufficiently and adjusted daily so that the flows to the Minnesota River are approximately equal to the inflow from the Whetstone River but not less than 20 cubic feet per second.

(7) During the period of May 1 through September 30, when the lake level is below elevation 964.6 feet (lake gage 6.9) the gates of the dam shall be opened sufficiently and adjusted daily so that the flows to the Minnesota River are approximately equal to the inflow from the Whetstone River but not less than 5 cubic feet per second. This may require that the silt barrier sluice gate be opened to supplement Whetstone River flow.

(8) During the period of October 1 through April 30, the gates of the dam shall be opened sufficiently and adjusted daily so that the flows to the Minnesota River are at least approximately equal to the inflow from the Whetstone River or 5 cubic feet per second whichever is greater. This may require that the silt barrier sluice gate be opened to supplement Whetstone River flow.

(9) Water Quality Releases:

(a) When the lake level is between elevation 965.4 and 965.9 feet (lake gage 7.7 to 8.2), water will be released selectively on days when the wind and waves create resuspension of sediment so that the water sampled at the dike road bridge contains more than (100 ppm suspended) solids. The crest gates shall then be opened but not to exceed _____ cubic feet per second greater than Whetstone River flows.

Ramping Rates

(b) When the lake level is between elevation 964.9 and 965.4 feet (lake gage 7.2 to 7.7), water will be released selectively on days when the wind and waves create resuspension of sediment so that the water sampled at the dike road bridge contains more than 200 ppm suspended solids. The crest gates shall then be opened, but not to exceed _____ cubic feet per second greater than Whetstone River flows.

Ramping Rates

The operator shall coordinate all such water-quality releases in advance with the Water Control Center, St. Paul District, Corps of Engineers. Water quality releases will not be made when downstream flooding conditions exist or will be cause by the additional releases.

Operation Chart. BIG STONE LAKE

Lake Elev. feet NGVD (corrected for wind effects)	Lake Condition: Snowmelt Period		May 1- September 30
	above elev. 965.9, all spillway gates open		
965.9 ft.	8.2 normal or above-normal snowpack	8.2 below-normal snowpack	8.2 release up to ____ cfs if s/s 100 ppm otherwise release larger of: 1) Whetstone inflow 2) 90 cfs
965.6			
965.4	service spillway fully open	service spillway fully open	release up to ____ cfs if s/s 200 ppm otherwise release large of: 1) Whetstone flow 2) 20 cfs
964.9			
964.6		6.9	
964.1	release Whetstone flow or 5 cubic feet per second (whichever is greater)		

Notes:

(1) Winter operation: release Whetstone flow or 5 cubic feet per second, whichever is greater.

(2) Normally, sluice gate shall be kept closed when larger gates are open, to reduce clogging by debris.

(3) Lake level readings will be adjusted to allow for the effects of wind, in regard to project operation.

(4) Rates of change in flow shall not exceed natural increase rates of the Whetstone River and decrease rates shall not be greater than ____/day/hour.

(5) Elevation 964.6 feet NGVD = lake gage of 6.9 feet.

F. Records and Reports.

The operator shall obtain the following data daily and shall record them, with the times of observations, in a record book provided for this purpose:

(1) The reading of the Whetstone River gage near Big Stone City, South Dakota [gage (1)].

(2) The reading of lake level gage [gage (2)].

(3) The reading of the Minnesota River gage at Ortonville, Minnesota [gage (3)].

(4) The position of all gates (service spillway, sluice and silt barrier gates).

(5) The time any changes are made in gate positions.

(6) Weather conditions (wind velocity and direction, air temperature, and precipitation) at the Big Stone Power Plant.

(7) Unusual occurrences which may affect the lake level, the safety of the dam, or the validity of these operating instructions.

All observations shall be made as far as possible at the same hour each day, at an hour to be agreed upon with the Commissioner, Minnesota Department of Natural Resources and with the Chief, Water Control Center, U.S. Army Engineer District, St. Paul.

Each week the operator shall send a copy of all observations so recorded to the Water Control Center, St. Paul District, Army Corps of Engineers. Under certain conditions, including flood or drought conditions, the Corps of Engineers may require additional observations or more frequent reports. The operation shall also send these observations monthly, including any comments he may consider to be pertinent, to the Commissioner, Minnesota Department of Natural Resources. Under certain conditions, the Commissioner may require additional observations and reports. In addition, when any water quality releases are planned, the operator shall coordinate such releases with the Corps of Engineers Water Control Center in advance.

EMERGENCY conditions shall be reported immediately to the Commissioner by telephone, charges reversed, and to the Water Control Center, U.S. Army Engineer District, St. Paul. The Commissioner shall supply a copy of such monthly or special reports to each member of the South Dakota-Minnesota Boundary Waters Commission.

Any changes in the plan of operation shall be agreed upon in writing by the U.S. Army Engineer District, St. Paul, the South Dakota-Minnesota Boundary Waters Commission and the Upper Minnesota River Watershed District.

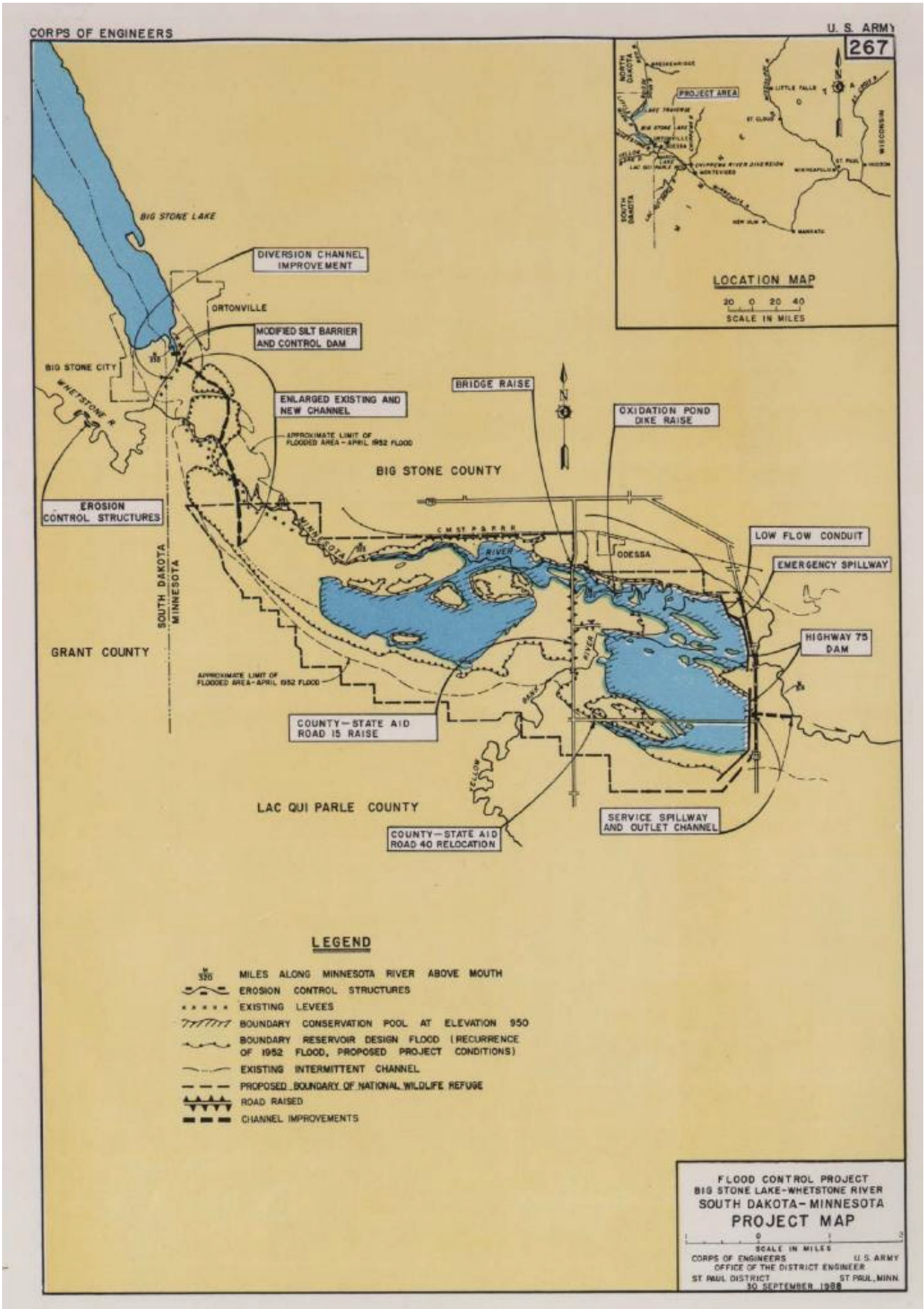
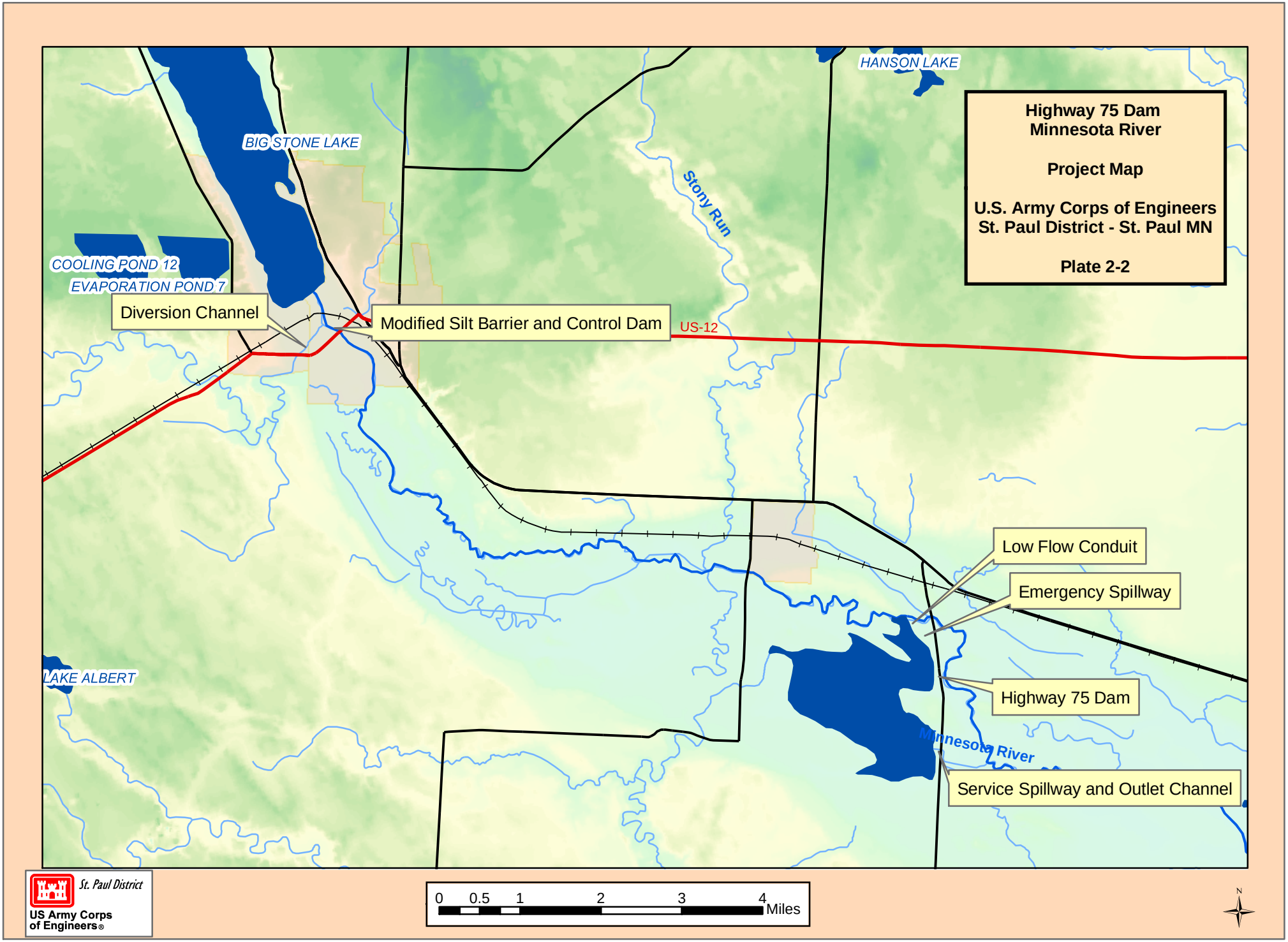

CORPS OF ENGINEERS
U. S. ARMY
267
PROJECT AREA
LOCATION MAP
20 0 20 40
SCALE IN MILES
BIG STONE LAKE
DIVERSION CHANNEL IMPROVEMENT
ORTONVILLE
MODIFIED SILT BARRIER AND CONTROL DAM
BIG STONE CITY
WHETSTONE R.
ENLARGED EXISTING AND NEW CHANNEL
APPROXIMATE LIMIT OF FLOODED AREA - APRIL 1952 FLOOD
BRIDGE RAISE
OXIDATION POND DIKE RAISE
BIG STONE COUNTY
EROSION CONTROL STRUCTURES
SOUTH DAKOTA
MINNESOTA
MINNESOTA RIVER
C M ST P & P R R
ODESSA
LOW FLOW CONDUIT
EMERGENCY SPILLWAY
HIGHWAY 75 DAM
GRANT COUNTY
APPROXIMATE LIMIT OF FLOODED AREA - APRIL 1952 FLOOD
COUNTY - STATE AID ROAD 15 RAISE
YELLOW
LAC QUI PARLE COUNTY
SERVICE SPILLWAY AND OUTLET CHANNEL
COUNTY - STATE AID ROAD 40 RELOCATION
LEGEND
320 MILES ALONG MINNESOTA RIVER ABOVE MOUTH
EROSION CONTROL STRUCTURES
EXISTING LEVEES
BOUNDARY CONSERVATION POOL AT ELEVATION 950
BOUNDARY RESERVOIR DESIGN FLOOD (RECURRENCE OF 1952 FLOOD, PROPOSED PROJECT CONDITIONS)
EXISTING INTERMITTENT CHANNEL
PROPOSED BOUNDARY OF NATIONAL WILDLIFE REFUGE
ROAD RAISED
CHANNEL IMPROVEMENTS
FLOOD CONTROL PROJECT
BIG STONE LAKE-WHETSTONE RIVER
SOUTH DAKOTA-MINNESOTA
PROJECT MAP
SCALE IN MILES
CORPS OF ENGINEERS U.S. ARMY
OFFICE OF THE DISTRICT ENGINEER
ST PAUL DISTRICT ST PAUL, MINN.
30 SEPTEMBER 1968

Plate 2-1


Highway 75 Dam
Minnesota River
Project Map
U.S. Army Corps of Engineers
St. Paul District - St. Paul MN
Plate 2-2
HANSON LAKE
BIG STONE LAKE
Stony Run
COOLING POND 12
EVAPORATION POND 7
Diversion Channel
Modified Silt Barrier and Control Dam
US-12
Low Flow Conduit
Emergency Spillway
LAKE ALBERT
Highway 75 Dam
Minnesota River
Service Spillway and Outlet Channel
St. Paul District
US Army Corps of Engineers
0 0.5 1 2 3 4 Miles
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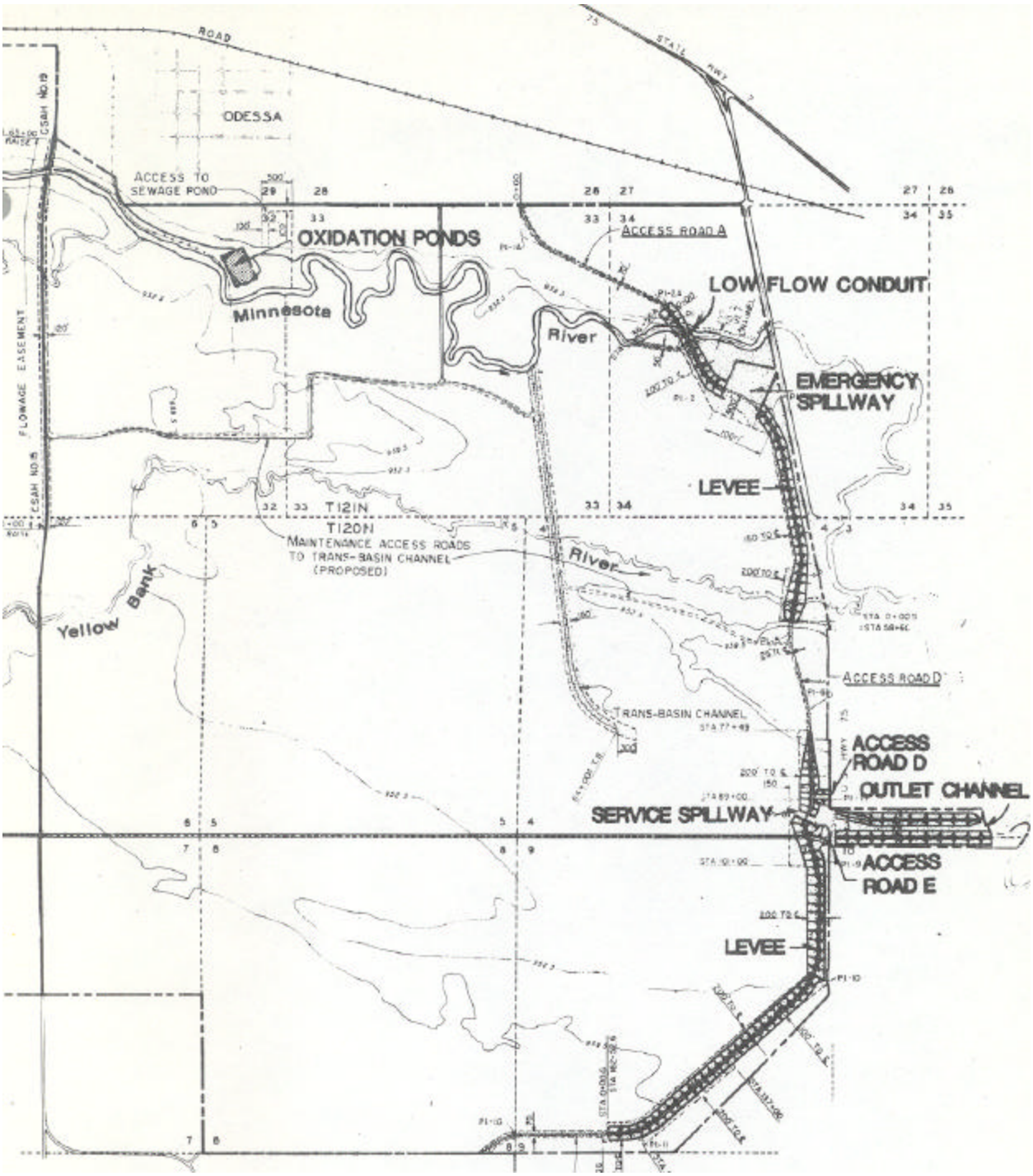
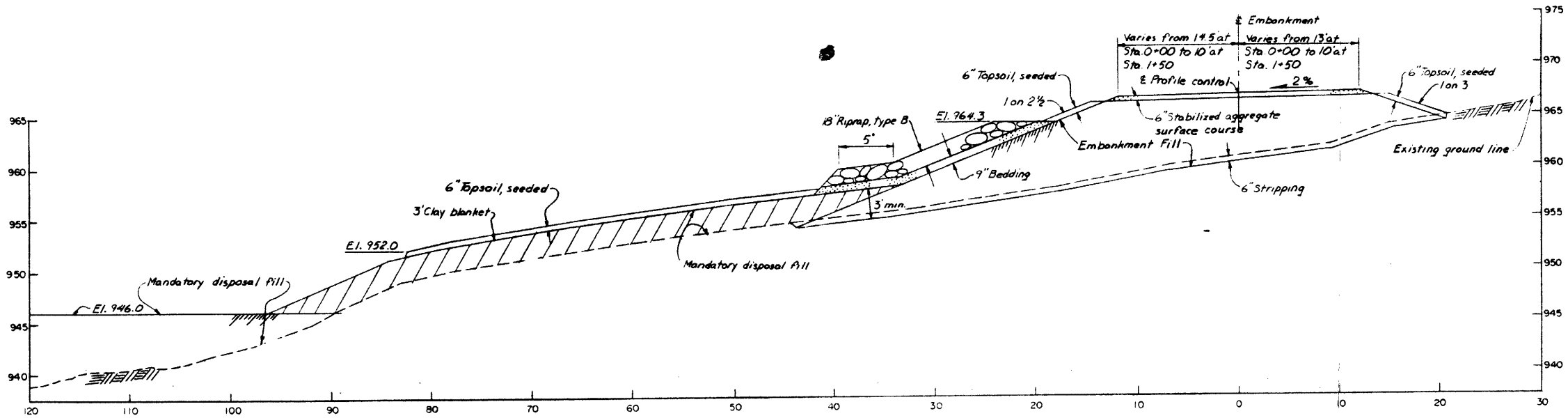


Big Stone Lake – Whetstone River Project
Highway 75 Dam and Reservoir

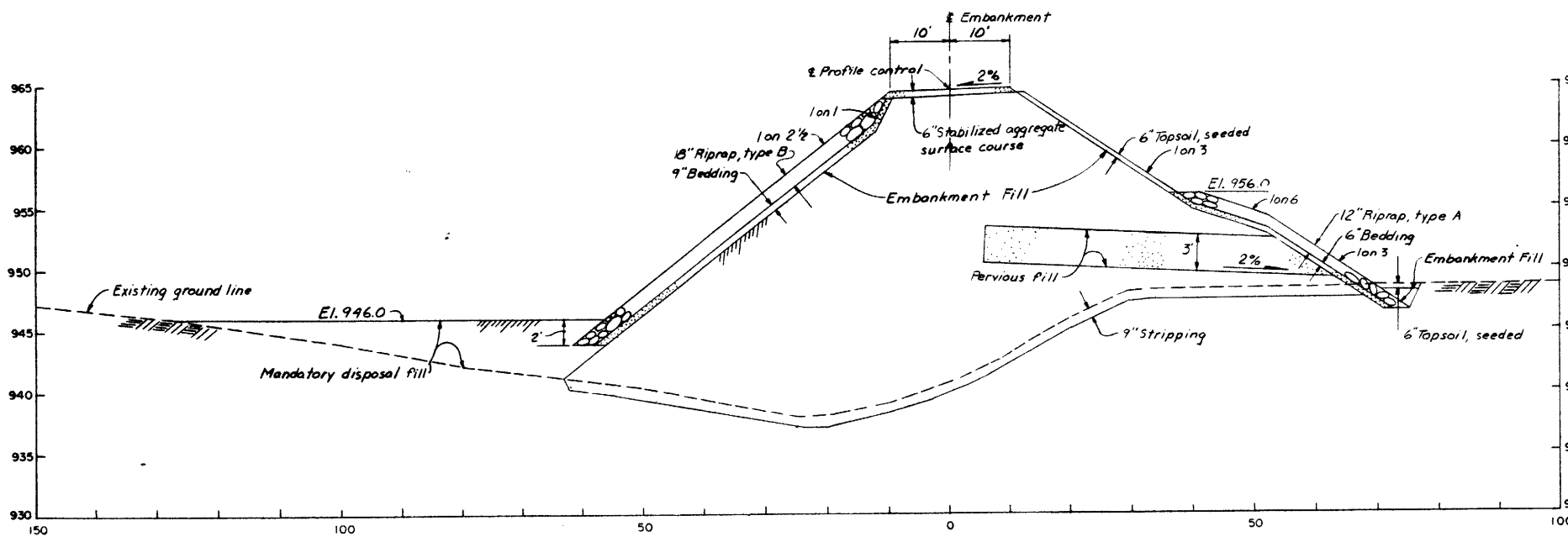
Project Plan

US Army Corps of Engineers
St. Paul District, St. Paul, MN

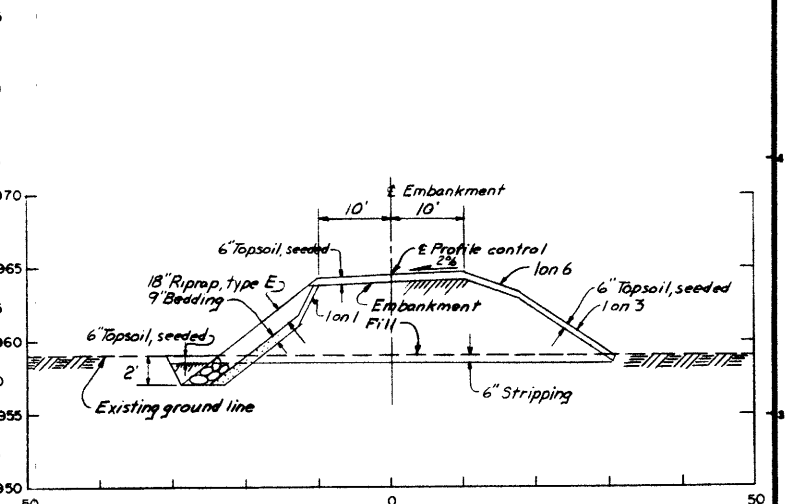
Plate 2-3



SECTION A

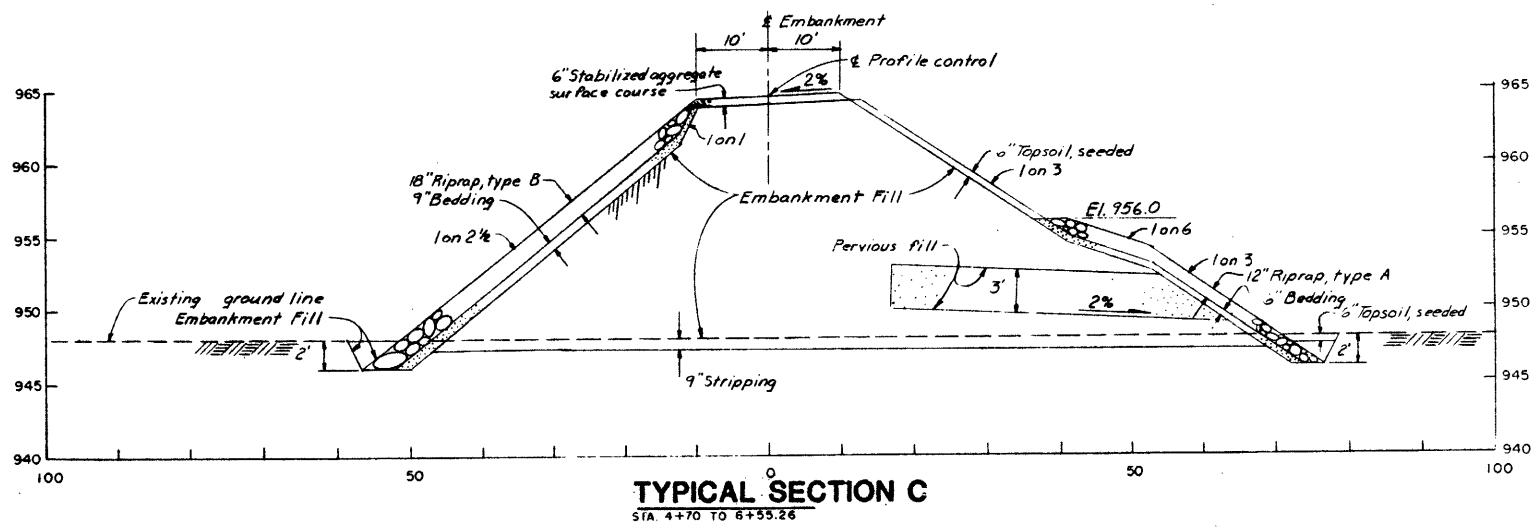


SECTION B



TYPICAL SECTION D

STA. 21+02.3 TO STA. 25+00



TYPICAL SECTION C

STA. 4+70 TO 6+55.26

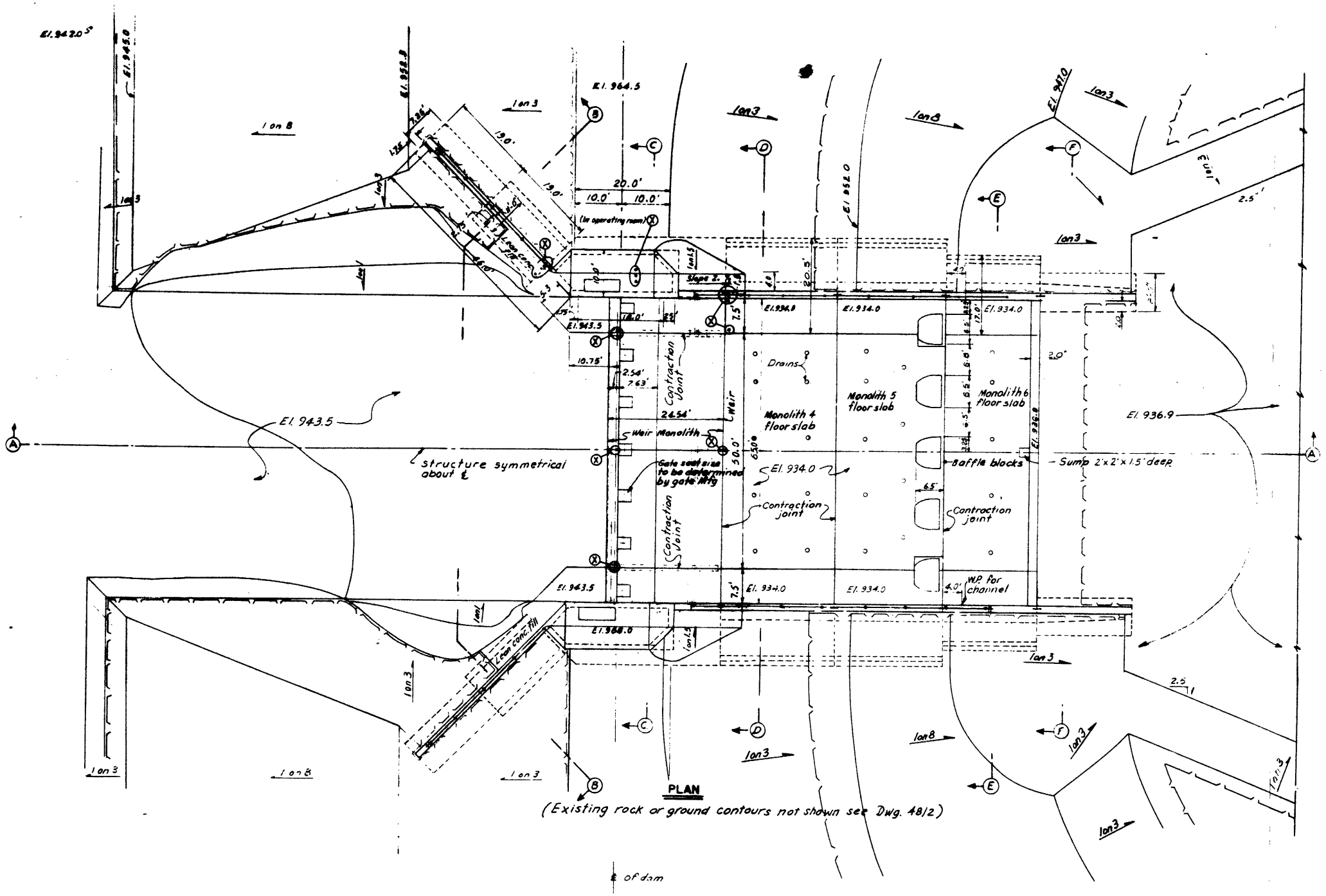
Big Stone Lake – Whetstone River Project
Highway 75 Dam
Water Control Manual

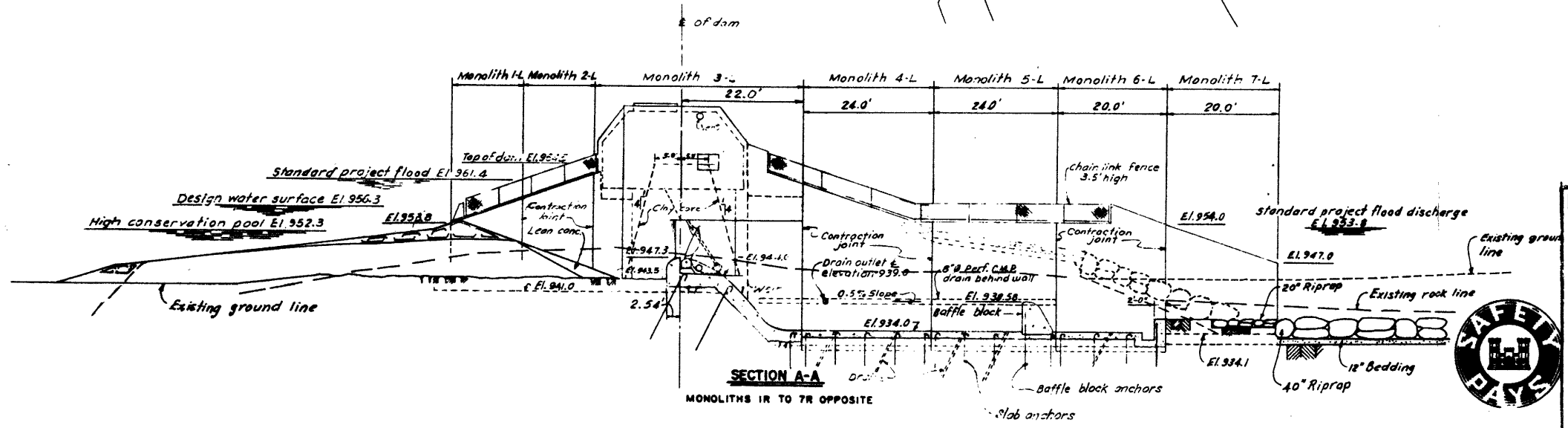
Typical Embankment Sections, Highway 75 Dam

U.S. Army Corps of Engineers
St. Paul District – St. Paul, MN

SAFETY PAYS

Plate 2-4





GENERAL CONCRETE NOTES:

1. ALL JOINTS AND EXPOSED EDGES SHALL BE CHAMFERED 3/4" EXCEPT THE SLAB JOINTS, WEIR JOINTS AND WALL JOINTS AGAINST WHICH BACKFILL WILL BE PLACED.
2. REINFORCING BARS NOT DETAILED AT OPENING AND EMBEDDED ITEMS SHALL BE SHIFTED BENT OR CUT AS DIRECTED BY THE CONTRACTING OFFICER.
3. THE CLEAR DISTANCE FROM THE FACE OF CONCRETE TO THE REINFORCEMENT SHALL BE AS FOLLOWS:
   THE SERVICE SPILLWAY SHALL HAVE A 4" CLEAR DISTANCE FOR ALL REINFORCEMENT EXCEPT FOR THE 1'-0" THICK WALLS THE CLEAR COVER SHALL BE 2" ON THE SMOOTH WALLS AND 3" FROM THE OUTER SURFACE FOR WALLS HAVING RUSTICATION.
   THE LOW FLOW CONTROL STRUCTURE, BRIDGE, BRIDGE ABUTMENTS AND ENERGY DISSIPATOR SHALL BE 2" CLEAR DISTANCE EXCEPT WHERE THE UNFORMED SURFACE IS IN CONTACT WITH THE FOUNDATION, THE CLEAR DISTANCE SHALL BE 4".
4. SPLICES IN REINFORCING BARS SHALL BE LAPPED A MINIMUM OF 30 BAR DIAMETERS OF THE SMALLER BARS.
5. ABBREVIATIONS
   F.F. - FAR FACE
   N.F. - NEAR FACE
   E.F. - EACH FACE
   ALT./W - ALTERNATE WITH

REFERENCES:

	DWG. NO.
1. LOCATION SERVICE SPILLWAY	48/4
2. FOUNDATION EXCAVATION	48/2 & 48/3
3. SECTIONS B-B, C-C, D-D, E-E & F-F	48/8
4. MONOLITH 1 & 2	48/9
5. MONOLITH 3	48/10-48/16
6. MONOLITH 4 & 5	48/17
7. MONOLITH 6 & 7	48/18
8. WEIR MONOLITH	48/19
9. MONOLITH 4,5 & 6 FLOOR SLABS	48/20
10. PERFORATED C.M.P. DRAIN	52/5
11. FENCE	52/6
12. MARKER POINTS	40/10

NOTES:

1. ⊗ INDICATES A LOCATION OF A SINGLE OR A GROUP OF MARKER POINTS.
2. BACKFILL SHALL NOT BE PLACED UNTIL MARKER POINT DATA, ELEVATIONS, ETC. HAVE BEEN ESTABLISHED.

Big Stone Lake – Whetstone River Project
Highway 75 Dam
Water Control Manual

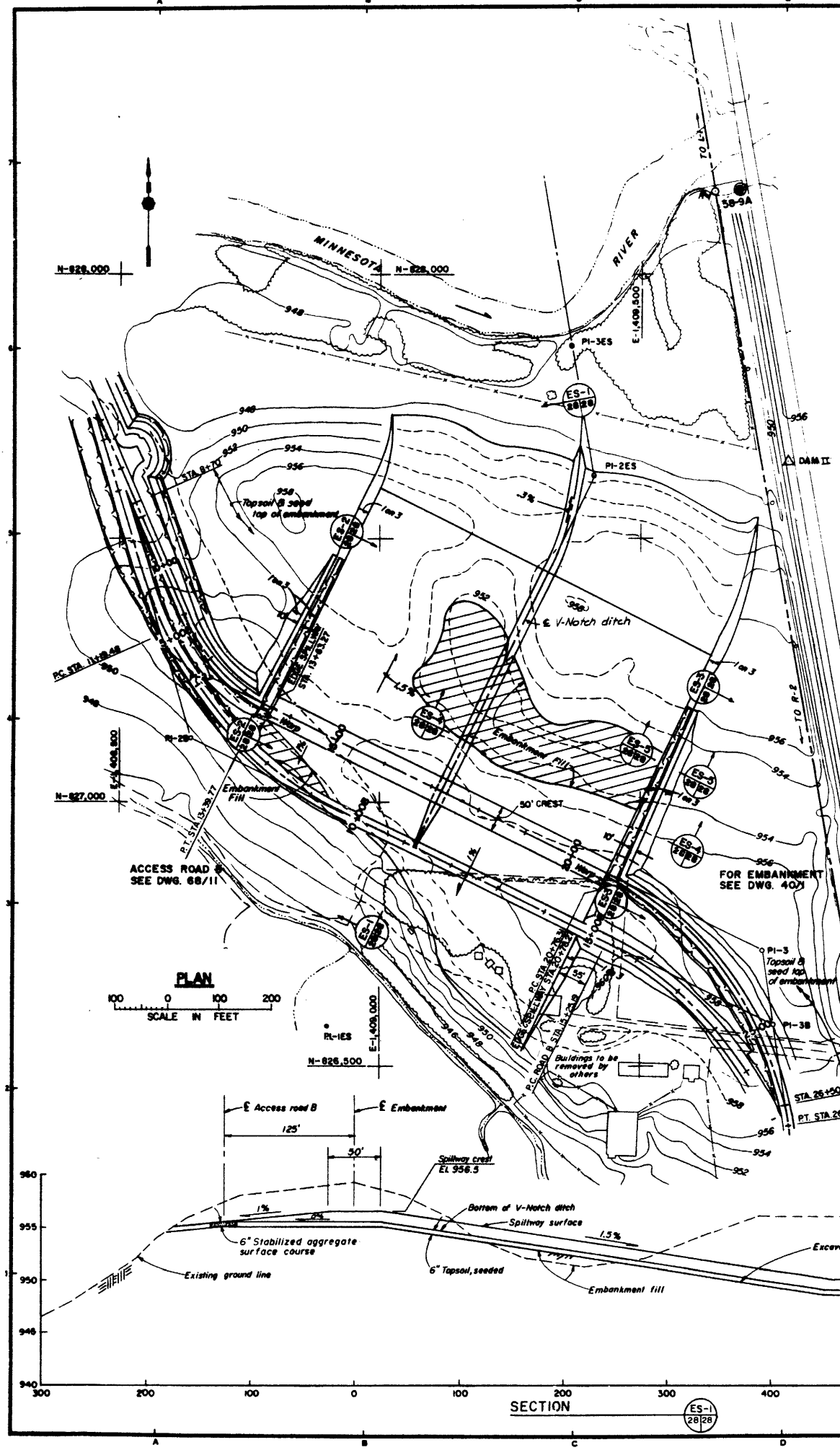
Service Spillway, Plan and Profile, Highway 75 Dam

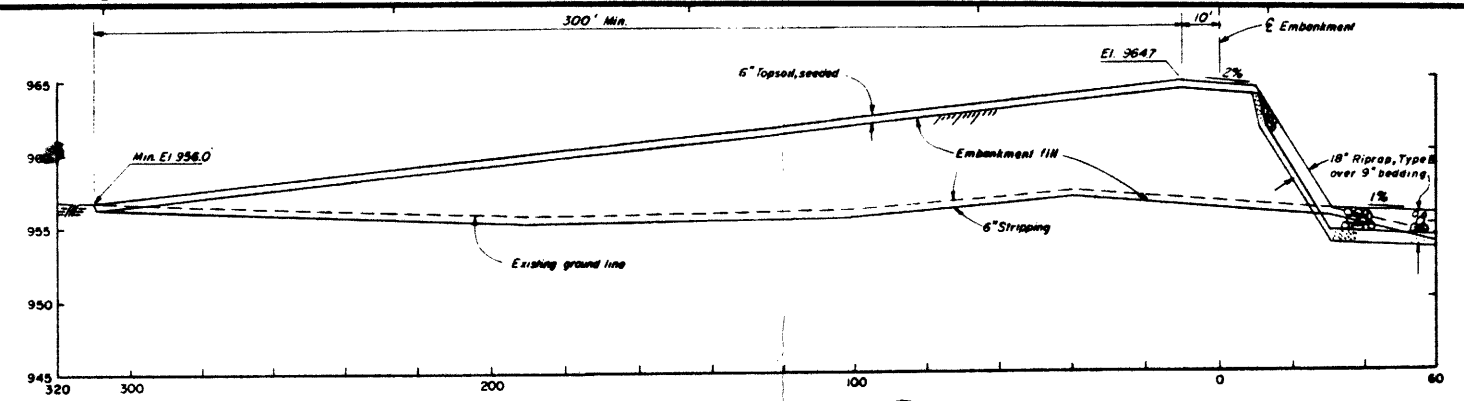
U.S. Army Corps of Engineers
St. Paul District – St. Paul, MN

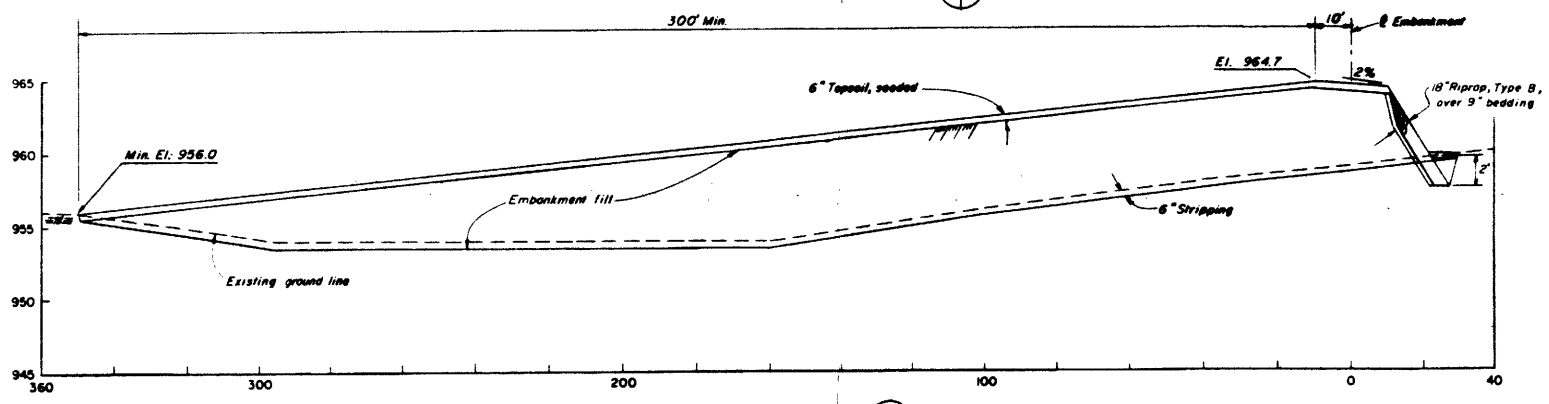
Plate 2-5

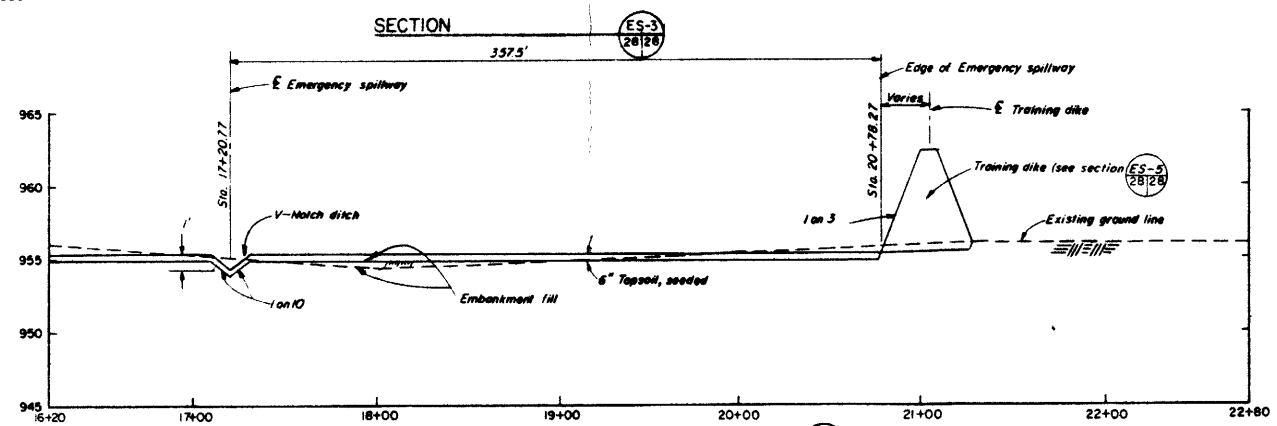
CORPS OF ENGINEERS

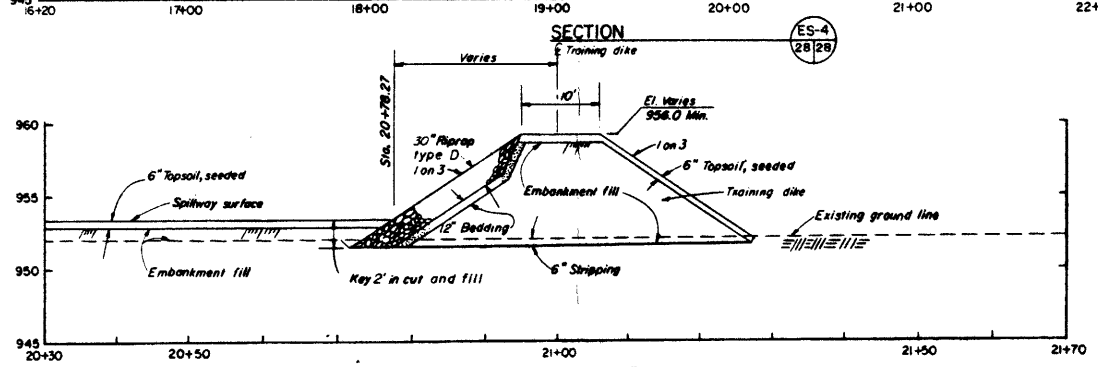
U. S. ARMY











Notes:
1. For additional borings see dwg. 40/1.

Big Stone Lake – Whetstone River Project
Highway 75 Dam
Water Control Manual

Emergency Spillway, Plan and Profile, Highway 75 Dam

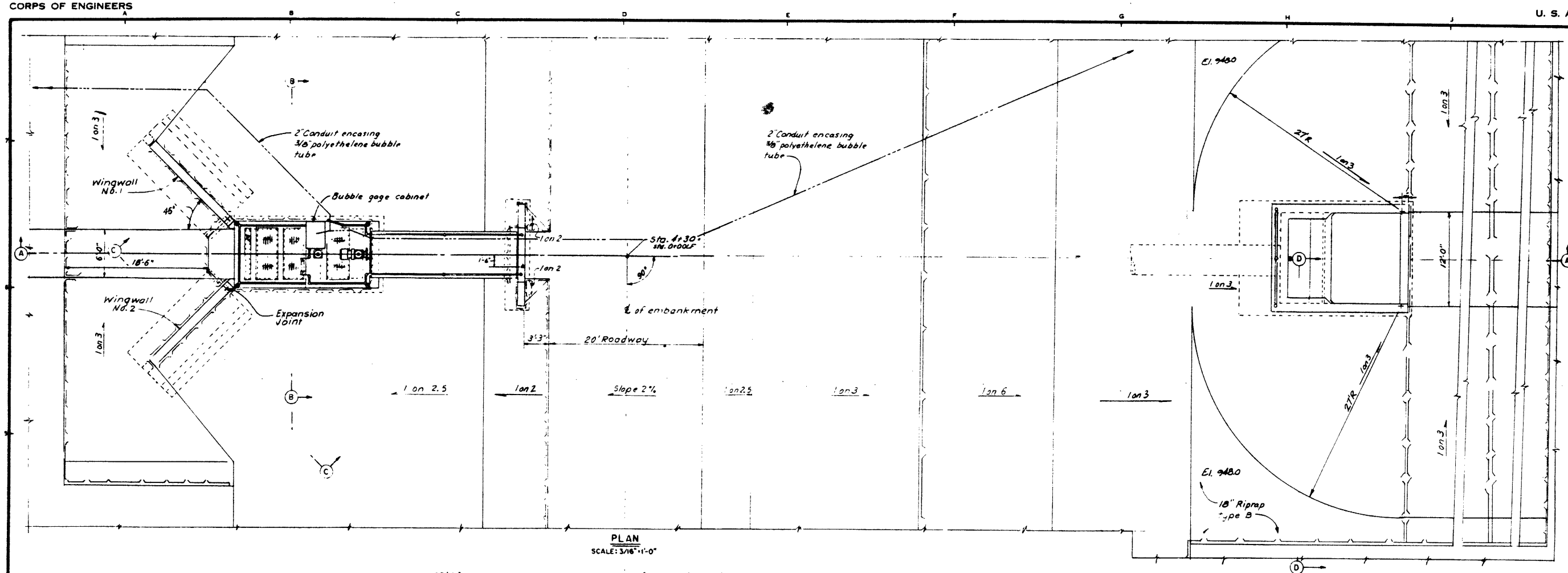
U.S. Army Corps of Engineers
St. Paul District – St. Paul, MN

SAFETY DAYS

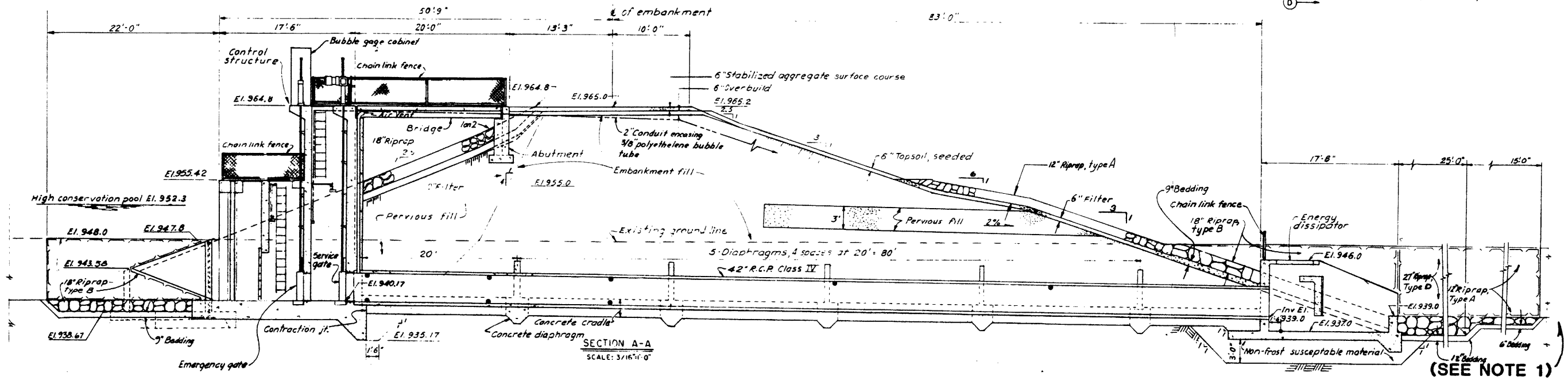
Plate 2-6

CORPS OF ENGINEERS

U. S. ARMY



PLAN
SCALE: 3/16"=1'-0"



SECTION A-A
SCALE: 3/16"=1'-0"

NOTE 1 – LOW FLOW CONTROL WEIR LOCATED AS SHOWN IN THE PLAN VIEW ON PLATE 9

SAFETY PAYS

Big Stone Lake – Whetstone River Project
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Water Control Manual

Low Flow Outlet, Plan and Profile, Highway 75 Dam

U.S. Army Corps of Engineers
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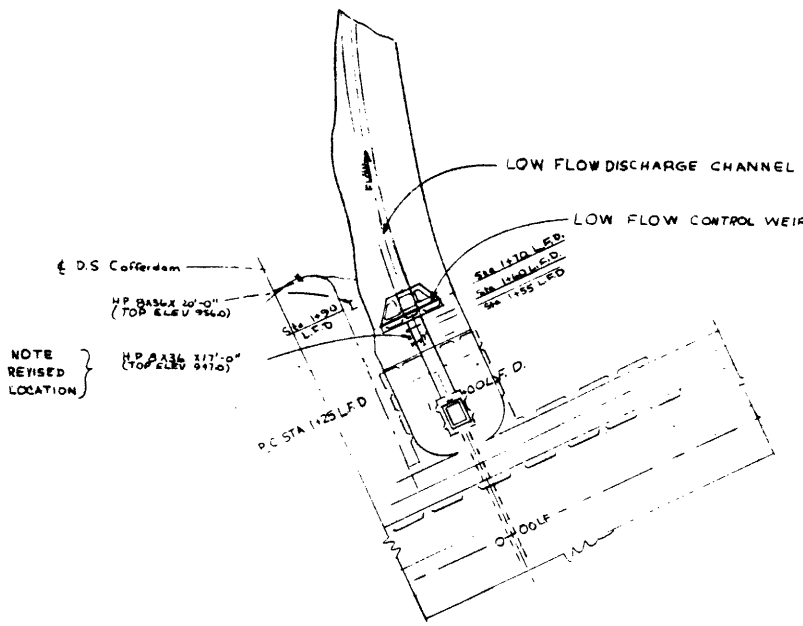
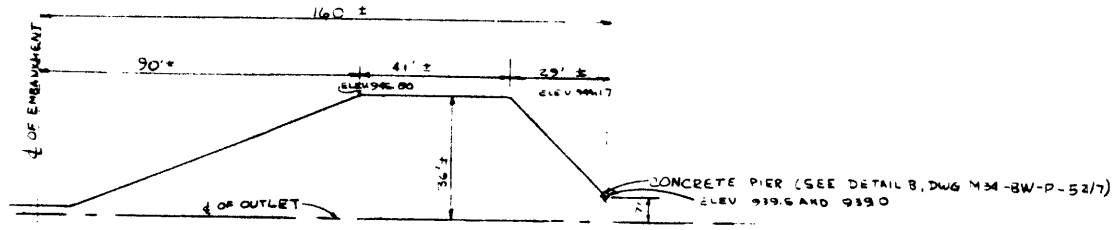
Plate 2-7



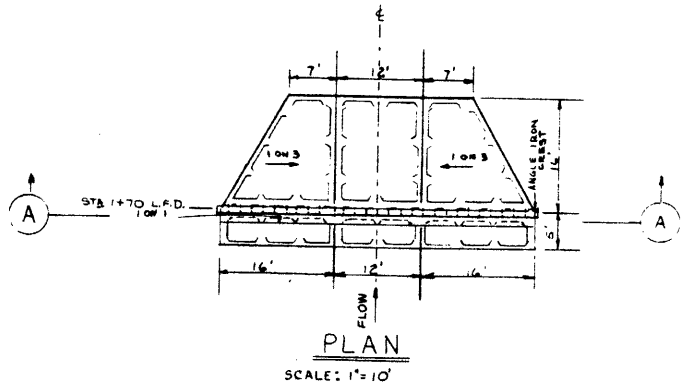
PLAN

SCALE: 1"=50'



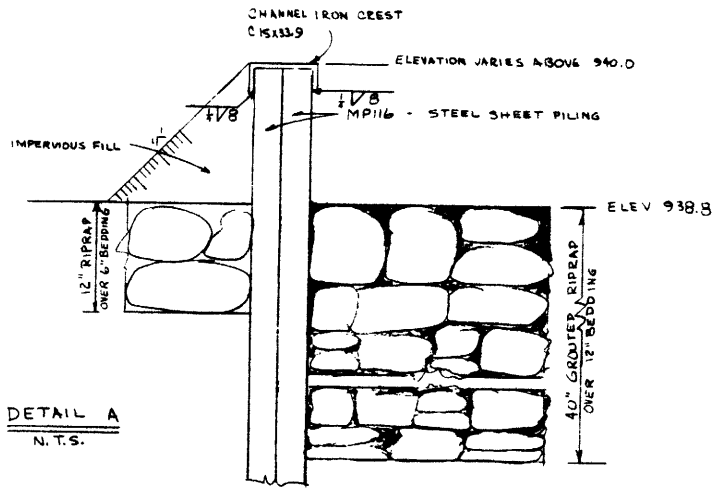
PLAN - ALTERED LOCATION OF ORIFICE PIER

SCALE: 1"=20'



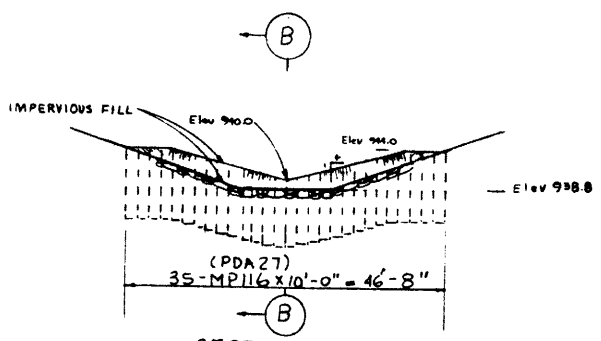
PLAN

SCALE: 1"=10'



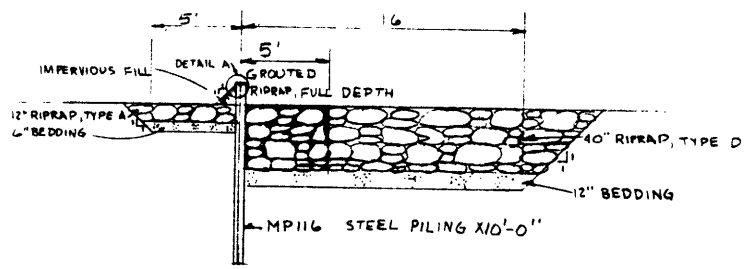
DETAIL A

N.T.S.



SECTION A-A

SCALE: 1"=10'



SECTION B-B

SCALE: ¼": 1'-0"

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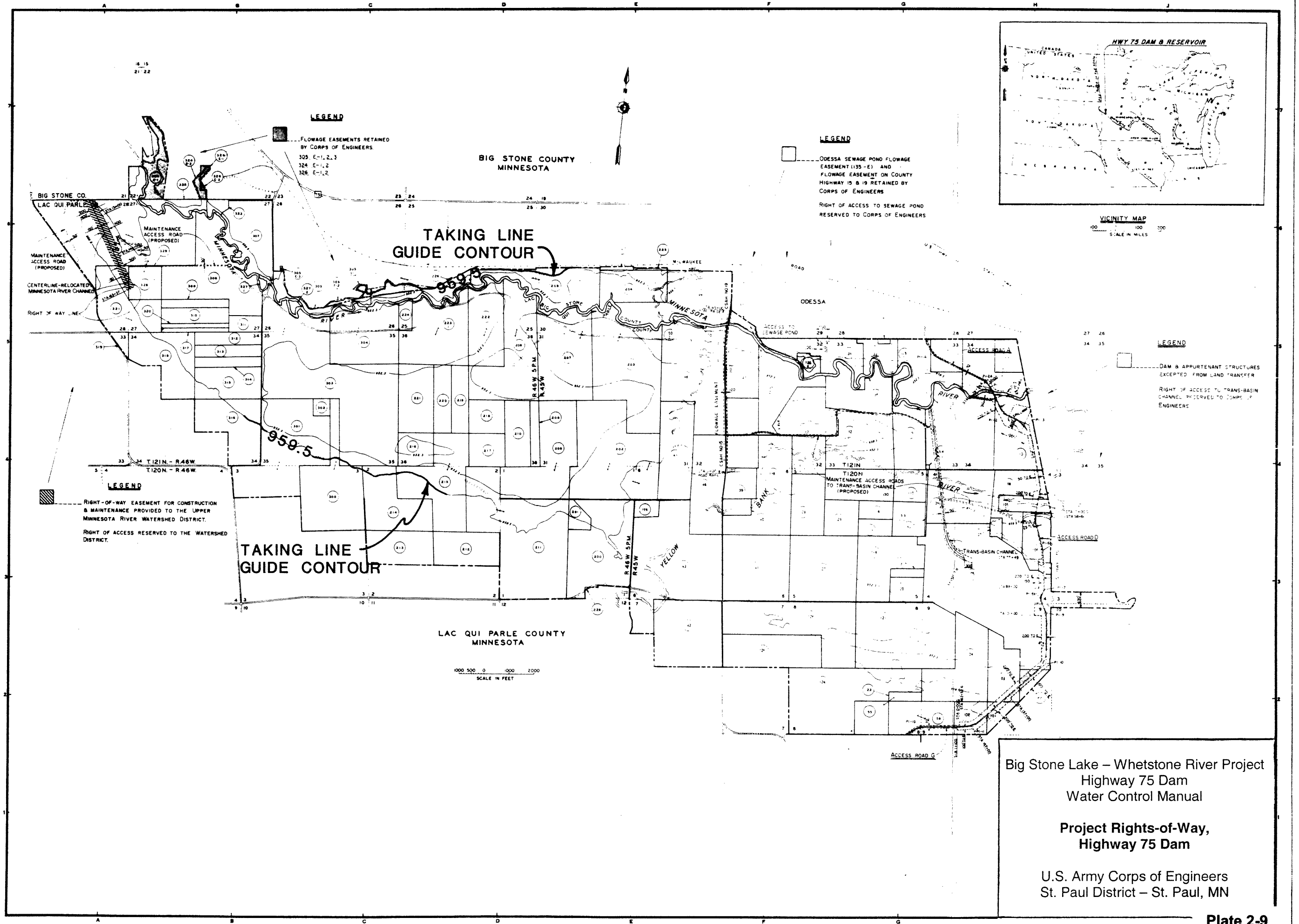
Highway 75 Dam
Water Control Manual

Low Flow Control Weir, Highway 75 Dam

U.S. Army Corps of Engineers
St. Paul District – St. Paul, MN



Big Stone Lake – Whetstone River Project
Highway 75 Dam
Water Control Manual

Project Rights-of-Way, Highway 75 Dam

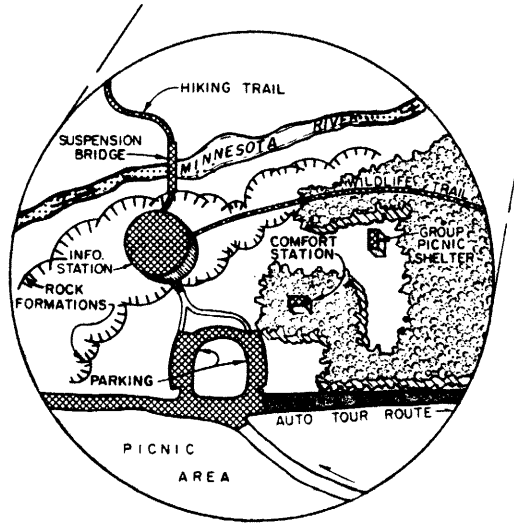
U.S. Army Corps of Engineers
St. Paul District – St. Paul, MN

Plate 2-9

CORPS OF ENGINEERS

U. S. ARMY

BIG STONE CO.
LAC QUI PARLE CO.
GRANT CO.
LAC QUI PARLE CO.
SOUTH DAKOTA
MINNESOTA
U.S. HIGHWAY NO. 75
CHICAGO, MILWAUKEE, ST. PAUL & PACIFIC R.R.
INITIAL CONTACT STATION
BOUNDARY, NATIONAL WILDLIFE REFUGE
CANOE ACCESS, PARKING & RAMP
CANOE TRAIL
PICNIC AREA
AUTO TOUR ROUTE
STA. 1
STA. 2
STA. 3
STA. 4
STA. 5
STA. 6
STA. 7
BIG STONE CO.
LAC QUI PARLE CO.
ODESSA
CANOE ACCESS PARKING & RAMP
QUARRY
LEVEE
CANOE TRAIL
CSAH 15
YELLOW BANK RIVER
MINNESOTA RIVER
INFO STATION & OVERLOOK
HIGHWAY 75 DAM
BANK FISHING
OUTLET CHANNEL
PARKING
HEADQUARTERS
C.S.A.H. 40
R. 46 W
R. 45 W
T. 121 N
T. 120 N
R-1 R-2 R-3 R-4 R-5 R-6 R-7 R-8 R-9 R-10 R-11 R-12 R-13 R-14 R-15 R-16 R-17 R-18 R-19 R-20 R-21 R-22 R-23 R-24 R-25 R-26 R-27 R-28 R-29 R-30
0 1/8 1/4 1/2 3/4 1
SCALE IN MILES



LEGEND

- CONSERVATION POOL
- CORPS OF ENGINEERS TO PROVIDE
- B.S.F. & W. TO PROVIDE AT LATER DATE
- (R-1) SEDIMENT RANGES

Big Stone Lake – Whetstone River Project
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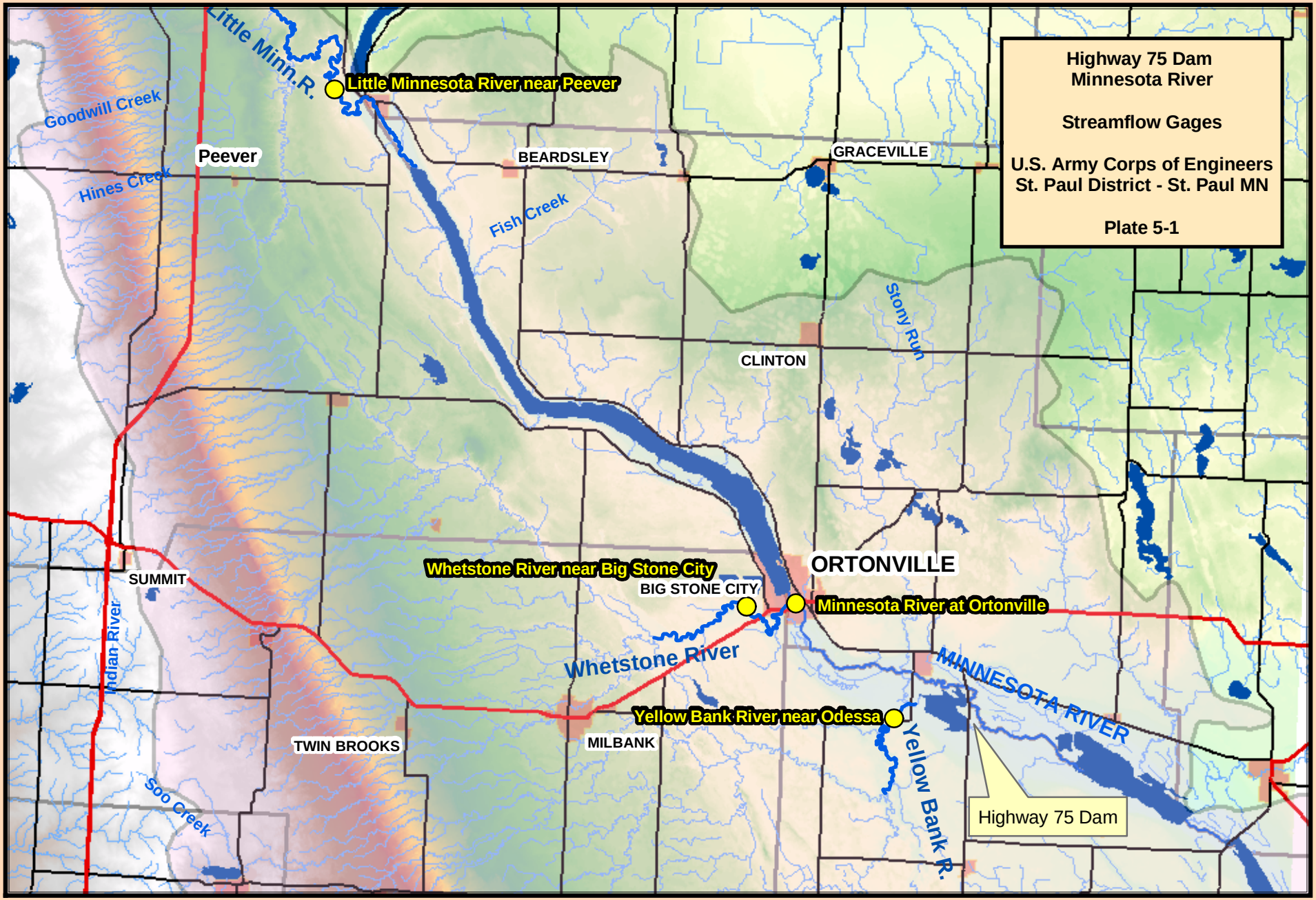
Sediment Ranges

U.S. Army Corps of Engineers
St. Paul District – St. Paul, MN

Plate 4-1


Highway 75 Dam
Minnesota River
Streamflow Gages
U.S. Army Corps of Engineers
St. Paul District - St. Paul MN
Plate 5-1
Little Minn.R.
Little Minnesota River near Peever
Goodwill Creek
Peever
Hines Creek
BEARDSLEY
Fish Creek
GRACEVILLE
Stony Run
CLINTON
ORTONVILLE
Whetstone River near Big Stone City
BIG STONE CITY
Minnesota River at Ortonville
SUMMIT
Indian River
Whetstone River
MINNESOTA RIVER
Yellow Bank River near Odessa
TWIN BROOKS
MILBANK
Soo Creek
Yellow Bank R.
Highway 75 Dam
St. Paul District
US Army Corps of Engineers
0 2.5 5 10 15 20 Miles
N