US Army Corps
of Engineers®
St. Paul District

WATER CONTROL MANUAL

MISSISSIPPI RIVER NINE FOOT CHANNEL
NAVIGATION PROJECT

LOCK AND DAM NO. 8

GENOA, WISCONSIN

APPENDIX 8 OF THE MASTER WATER CONTROL MANUAL

UPDATED FEBRUARY 2003

WATER CONTROL MANUAL

LOCK AND DAM No. 8
GENOA, WISCONSIN

UPPER MISSISSIPPI RIVER BASIN
MISSISSIPPI RIVER – NINE FOOT CHANNEL
NAVIGATION PROJECT

APPENDIX No. 8
of the
MASTER WATER CONTROL MANUAL

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

FEBRUARY 2003

Updated from
Reservoir Regulation Manual, December 1971
Operation of Navigation Pools, February 1943

LOCK AND DAM No. 8

GENOA, WISCONSIN

Aerial View Looking East – October 1995

5 Roller Gates and 10 Tainter Gates
Project Pool 631.0 feet (1912 Adjustment)

LOCK AND DAM No. 8

GENOA, WISCONSIN

New Lock and Dam No. 8 Control House - December 2002

Lock Chamber and Miter Gates in Foreground

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 St. Paul District prepared the *Preliminary Report on Operation of Navigation Pools* on 16 February 1943. This document provided the operational information for Lock and Dams 1 through 10. It was replaced by a Master Regulation Manual in September 1969. Appendices for each lock and dam were added during the years 1969 through 1972, with Appendix No. 8 being completed in December 1971. This manual is an update of Appendix No. 8. 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 (e.g. gate failure, excessive rainfall), the Lockmaster, Area Lockmaster, and Water Control should be notified as to the extent of the event. During normal water control duty hours (i.e. 0630 to 1730 hrs weekdays and 0630 to 1030 hrs weekends and holidays), contact with water control can be made at 651-290-5624 or 651-290-5474. On weekends and holidays, the Mississippi River Duty Regulator Pager number can be used. If communication with Water Control cannot be established, the following list can be used as a guide for establishing contact.

Water Control Regulation Assistance		
Scott R. Bratten	Primary Mississippi River Regulator scott.r.bratten@usace.army.mil	Duty: 651-290-5624 [redacted]
Duty Regulator	Mississippi River Duty Regulator; Pager and Fax	Pager: 612-660-8053 Fax: 651-290-5841
Dennis D. Holme	Physical Scientist dennis.d.holme@usace.army.mil	Duty: 651-290-5614 [redacted]
Theodore D. Petersen	Water Control Gage Crew theodore.d.Pedersen@usace.army.mil	Duty: 651-290-5253 [redacted]
Ferris W. Chamberlin	Hydraulic Engineer ferris.w.chamberlin@usace.army.mil	Duty: 651-290-5619 [redacted]
Kenton. E. Spading	Hydraulic Engineer kenton.e.spading@usace.army.mil	Duty: 651-290-5623 [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 Br michael.r.knoff@usace.army.mil	Duty: 651-290-5600 [redacted]
John J. Bailen	Chief, Engineering Division john.j.bailen@usace.army.mil	Duty: 651-290-5303

Lock and Dam No. 8
Genoa, Wisconsin

U.S. Army Corps of Engineers
St. Paul District – February 2003

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Location: Lock and Dam No. 8 is located on the Mississippi River, 679.2 river miles above the mouth of the Ohio River, 23.3 river miles below Lock and Dam No. 7, and 31.3 river miles above Lock and Dam No. 9. The lock is on the left bank of the river adjacent to the village of Genoa, WI at approximate latitude 43° 34' 12" N and longitude 91° 13' 54" W.

Drainage Area: 64,770 square miles

Datum: MSL - 1912 adjustment

Fixed Height Dam:

Type:	Earth Dike with Fixed Crest Spillways
Length of Earth Dam	13,445 feet
Crest of Earth Dam	Elevation 639.5 – 640.0 feet
Top Width of Earth Dam	20 feet
Max Height of Earth Dam	24 feet
Length of Submersible Dams	2,275 feet
Reno Dam Length	937.5 feet
Hastings Dam Length	1337.5 feet
Crest of Submersible Dams	Elevation 631.0 feet
Total Length	15,720 feet

Moveable Dam:

Roller Gates	5 Gates	80 feet by 20 feet
Tainter Gates	10 Gates	35 feet by 15 feet
Roller Gate Sill	Elevation 611.0 feet	
Tainter Gate Sill	Elevation 616.0 feet	

Lock:

Main Lock Chamber	110 feet by 600 feet
Top of Lock Walls	Elevation 639.0 feet
Top of Upper Gate Sill (Main)	Elevation 609.0 feet
Top of Upper Gate Sill (Auxiliary)	Elevation 609.0 feet
Top of Lower Gate Sill	Elevation 606.0 feet
Lock Floor	Elevation 605.0 feet
Height of Upper Miter Gates (Main)	27.0 feet
Height of Upper Miter Gates (Aux.)	27.0 feet
Height of Lower Miter Gates	30.0 feet

Pool:

Normal (Project) Upper Pool	Elevation 631.0 feet	
Normal (Project) Lower Pool	Elevation 620.0 feet	
Total Pool Area (at Project Pool)	20,800 acres	
Primary Control Point	La Crosse, WI	Elevation 631.0 ft
Secondary Control Point	Lock & Dam 8	Elevation 630.0 ft

Notes:
1. Roller gates are submergible to 3.0 feet below Normal Pool (631.0 feet).
2. Two tainter gates are submergible to 2.0 feet below Normal Pool (631.0 feet)

I – INTRODUCTION

1-01. Authorization for Preparation of this Manual. Pursuant to the instructions from the Chief of Engineers dated 15 May 1942 and 29 August 1942, subject "Operation of Flood Control and Multiple-Purpose Reservoirs", the methods and the technique used in operating the navigation pools on the Mississippi River in the St. Paul District was documented in February 1943. Authority to prepare regulation manuals for the locks and dams was granted by Engineering Regulation (ER) 1110-2-240, *Reservoir Regulation*, 1958. While ER 1110-2-240 has been updated and amended many times since the date of issuance, the document continues to give the Corps of Engineers authority to prepare what became known as "Water Control Manuals" by ER 1110-2-240, *Water Control Management*, 1982. This manual supercedes Lock and Dam 8 Regulation Manual dated December 1971 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 Systems*, 30 November 1987.
c. Division Regulation, DIVR 1110-2-240, *Water Control Management, Preparation of Water Control Plans and Manuals*, 1 January 1992.
d. Engineering Regulation, ER 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. The Upper Mississippi River Lock and Dam system was authorized when Congress approved the nine-foot channel on 3 July 1930. A general scheme of operation was developed on 28 March 1935. The following is a list of related Manuals and Reports in chronological order.

a. *Survey of Mississippi River Between Missouri River and Minneapolis*, Letter from The Secretary of War, 72 Congress, 1st Session, House Document No. 137, Part 1 – Report, 9 December 1931.
b. *Report on General Scheme of Operation for the Dams of the 9-Foot Channel Project*, by J. A. Grant, Senior Engineer, War Department, Office of the Chief of Engineers, 28 March 1935.
c. *Preliminary Report on Operation of Navigation Pools*, War Department, US Engineer Office, St. Paul District, St. Paul, Minnesota, 16 February 1943.
d. *Master Regulation Manual for Mississippi River Nine-Foot Channel Navigation Projects*, US Army Corps of Engineers, St. Paul District, September 1969.
e. *Mississippi River Nine-Foot Channel Navigation Project, Reservoir Regulation Manual, Appendix 8, Lock and Dam No. 8, Genoa, Wisconsin,* US Army Corps of Engineers, St. Paul District, December 1971.
f. *Creativity, Conflict & Controversy: A History of the St. Paul District, US Army Corps of Engineers,* by Raymond H Merritt, 1979.
g. *Upper Mississippi River, Land Use Allocation Plan*, Master Plan for Public Use Development and Resource Management, Part I and Part II, US Army Corps of Engineers, St. Paul District, September 1983.
h. *Emergency Plan for Lock and Dam 8, Genoa, Wisconsin,* US Army Corps of Engineers, St. Paul District, August 1986.
i. *Scour Protection for Locks and Dams 2-10, Upper Mississippi River*, Technical Report HL-87-4, US Army Corps of Engineers, Waterways Experiment Station, Vicksburg, Mississippi, April 1987.
j. *Commerce and Conservation on the Upper Mississippi River*, by John O. Anfinson, District Historian, US Army Corps of Engineers, St. Paul District, St. Paul Minnesota, 1990.
k. *Gateways to Commerce*, The US Army Corps of Engineers' 9-Foot Channel Project on the Upper Mississippi River, National Park Service, Rocky Mountain Region, 1992.
l. *Authorized and Operating Purposes of Corps of Engineers Reservoirs*, US Army Corps of Engineers, Washington D. C., July 1992.
m. *Channel Maintenance Management Plan,* Upper Mississippi River Navigation System, US Army Corps of Engineers, St. Paul District, 1996.
n. *Discharge Ratings for Control Gates at Mississippi River Lock and Dam 8, Genoa, Wisconsin*, Toltz, King, Duvall, Anderson and Associates, Inc., St. Paul, Minnesota, 27 February 1996.
o. *Channel Maintenance Management Plan, Final Environmental Impact Statement (FEIS),* Lead Agency US Army Corps of Engineers, St. Paul District, Volumes I and II, 6 June 1997.
p. *Record of Decision (ROD) for Final Environmental Impact Statement, Channel Maintenance Management Plan,* Major General Robert B. Flowers, Commander and Division Engineer, Mississippi Valley Division, US Army Corps of Engineers, June 1997.
q. *Zebra Mussel Response Plan*, Environmental Section, St. Paul District, US Army Corps of Engineers, November 1997.

r. *Locks and Dams Sounding Reports, Volume 2,* US Army Corps of Engineers, St. Paul District, 1999.

s. *Pilot Pool Drawdown, Definite Project Report/Environmental Assessment, Pool 8, Upper Mississippi River, Wisconsin and Minnesota,* Water Level Management Task Force River Resources Forum in cooperation with St. Paul District, US Army Corps of Engineers, June 1999.

t. *Finding of No Significant Impact, Pilot Pool Drawdown Pool 8, Upper Mississippi River,* Environmental and Economic Analysis Branch, Planning Programs and Project Management Division, St. Paul District, US Army Corps of Engineers, June 1999.

u. *2001 Annual Report – Water Quality Management Program,* US Army Corps of Engineers, St. Paul District, January 2002.

1-04. Project Owner. The United States Government is the owner of Lock and Dam No. 8. The US Army Corps of Engineers, St. Paul District, St. Paul, Minnesota, is responsible for operation and regulation of Lock and Dam No. 8.

1-05. Operating Agency. Lock and Dam No. 8 is regulated, operated, and maintained by the US Army Corps of Engineers, St. Paul District. Regulation is the responsibility of Engineering Division, while operation and maintenance is the responsibility of Construction and Operations (Con-Ops) Division. The following chart shows the command structure for Lock and Dam No. 8.

St. Paul District Office
← ← ← **District Engineer** → → →

↓	↓
Chief Engineering Division	**Chief Con-Ops Division**
↓	↓
Chief H&H Branch	**Chief Lock & Dam Project Office**
↓	↓
Chief Water Control Section	**Area Lockmaster**
↓	↓
Water Control Manager	**Lockmaster**
651-290-5624 → → → → → →	608-689-2625
fax 651-290-5841	fax 608-689-2196

The project is attended 24 hours a day, every day of the year. The Chief, Con-Ops Division and the Chief, Engineering Division are located in the St. Paul

District Office, whereas the Lock and Dam Project Office is located in Fountain City, Wisconsin and the Area Lockmaster is stationed at Lock and Dam No. 9.

1-06. Regulating Agency. Regulation of Lock and Dam No. 8 is under the supervision of the Water Control Section as by the above command structure.

II – DESCRIPTION OF PROJECT

2-01. Location. Lock and Dam No. 8 is located on the Mississippi River, 679.2 river miles above the mouth of the Ohio River, 23.3 river miles below Lock and Dam No. 7, and 31.3 river miles above Lock and Dam No. 9. The lock is on the left bank of the river about 18 river miles below the city of La Crosse, Wisconsin at approximate latitude 43° 34' 12" N and longitude 91° 13' 54" W. The project is bordered by Vernon County on the Wisconsin side and Houston County on the Minnesota side. The project location is shown on **Plate 2-1**.

2-02. Purpose. Lock and Dam No. 8 is a unit of the Inland Waterway Navigation System of the Upper Mississippi River Basin. The system includes 29 locks and dams, which provide a "stairway of water" from Minneapolis, Minnesota to St. Louis, Missouri. The primary purpose of the dams is to maintain a depth of nine feet for navigation. The authorized purposes for Lock and Dam No. 8 are navigation under the River and Harbors Act of 1930 (PL 71-250) and recreation under the Flood Control Act of 1944 (PL 78-534). Access and facilities are provided for recreation but water is not controlled for that purpose.

2-03. Physical Components. Lock and Dam No. 8 consists of a main and uncompleted auxiliary lock, a movable dam section, an earthen dike, and two submersible dams. The locks and moveable dam are supported on timber piling driven into sand and gravel. All but the earthen dike have sheet pile cutoff walls. The following gives a detailed description of each component.

Figure 2-1. Lock and Dam No. 8 (Looking Downstream)

a. Lock. Lock and Dam No. 8 has a main and an uncompleted auxiliary lock (**Plate 2-1**). The upper and lower miter gates of the main lock have a height of 27.0 feet and 30.0 feet respectively. The respective sill elevations are 609.0 feet and 606.0 feet (1912 adjustment). A walkway is located atop the miter gates. It extends three feet above the top of miter gates (elevation 636.0 feet) to meet the top of lock walls (elevation 639.0 feet). While the main lock is fully functional, the auxiliary lock consists of only an upper gate bay. The miter gates on the auxiliary lock are 27 feet high with a sill elevation of 609.0 feet. The gates of the auxiliary lock have no machinery and therefore are inoperable. However, should an upper miter gate in the main lock become damaged, a miter gate from the auxiliary lock can be pulled to serve as a replacement. This operation requires assistance from Rock Island District because they have the equipment and expertise.

The main lock is 110 feet wide with a clear length of 600 feet. Filling and emptying of the lock chamber is controlled by tainter valves; two at the upstream (upper) end of the lock and two at the downstream (lower) end. During the filling or emptying process, the miter gates are closed thus sealing the lock chamber. For a filling operation, the upper tainter valves are opened allowing flow to enter the culverts (**Plate 2-2**, Section C-C). Flow then enters the lock chamber through ports along the lock wall (Section X-X) and the water level in the lock chamber rises until it equals the pool elevation. The upper tainter valves are then closed and the lower tainter valves are opened thus emptying the lock chamber. Under normal conditions, filling and emptying times are about seven minutes.

Periodically, the lock chamber is flushed of sediment and debris. This is accomplished at the end of an emptying cycle. The upper miter gates and lower tainter valves are in the closed position, the lower miter gates are opened in the recessed position, and the upper tainter valves are operated to provide the flushing action.

Guidewalls are located upstream and downstream of the lock to provide a landing for down bound and up bound tows (**Plate 2-1**). The upper guide wall extends 519 feet upstream and the lower guide wall extends 504 feet downstream.

b. Moveable Dam. The moveable dam section extends from the auxiliary lock to the right bank of the main channel (see **Plate 2-1**). The moveable dam consists of five roller gates, 80-feet wide by 20-feet high, and 10 tainter gates, 35-feet wide by 15-feet high (**Figure 2-1**). The gate sill elevations are 611.0 feet (1912 adjustment) for the roller gates and 616.0 feet for the tainter gates. The end sill elevations for the roller and tainter gates are 608.0 feet and 613.0 feet respectively. The roller gates can be submerged up to three feet below normal pool (elevation 631.0 feet). Two of the 10 tainter gates can be submerged up to two feet below normal pool elevation.

Each roller gate is equipped with an individual electrically operated hoist enclosed in an operating house located on the pier. The roller gates are driven from one end only. The travel rate of the gate is approximately 0.75 feet per minute. A position indicator (**Figure 2-2**), marked in increments of 0.1 feet, is attached to the hoist mechanism.

Figure 2-2. Roller Gate Position Indicator

An alternate position indicator (**Figure 2-3**), showing the gate opening and top of roller gate drum elevation in increments of 0.5 ft, is attached to a shaft with a gear driven by the hoist mechanism.

Figure 2-3. Alternate Roller Gate Position Indicator

Should the need arise to block flow through a roller gate bay, there are six bulkheads stored on site. They measure 4 feet-2 inches by 85 feet-½ inches. The sill elevation is 611.0 feet; therefore, with five bulkheads in place, the top of the bulkheads would be at elevation 631.83 feet (i.e. 631 feet-10 inches).

Each tainter gate is individually operated by machinery consisting of an electrically operated central driving unit and two chain hoisting units. The electric controls consist of push buttons located on the deck rail. A position indicator (**Figure 2-4**) is mounted on the pier about midway between the trunion and the gate surface. The indicator is marked in 0.1-foot increments. The tainter gates move at a rate similar to the roller gates. There are four bulkheads stored on site measuring 4 feet-2 inches by 37 feet-6 inches. The sill is at elevation 616.0 feet; therefore, the top of the bulkheads would be at elevation 632.67 feet (i.e. 632 feet-8 inches).

Figure 2-4. Tainter Gate Position Indicator

A service bridge, at elevation 660.5 feet, spans the entire length of the moveable dam and storage yard and provides for the operation of the crane. The 45-foot boom crane, with 25-ton capacity, was replaced in 1983. The new crane has a boom length of 60 feet and a capacity of 30 tons.

c. Channel Protection. Immediately upstream and downstream of the moveable dam, the channel is protected by concrete followed by stone protection. Sections A-A and B-B of **Plate 2-2** show the original derrick stone protection. Over the years, scour upstream and downstream of the dam caused some unraveling of the derrick stone. In 1983, riprap protection was extended upstream and downstream in the form of capstone and rockfill. **Plate 2-3** shows two transects of the added protection. The following gives a description of the riprap protection near the roller gates, tainter gates, lock, auxiliary lock, and storage yard.

(1) Roller Gates. Downstream protection originally consisted of derrick stone 4-feet thick with a top of rock elevation of 606.0 feet (1912 adjustment). The derrick stone extended 25 feet downstream of the end sill. Upstream protection consisted of a 12-foot wide, 3-foot thick section of derrick stone with a top elevation of 610.0 feet.

The scour holes that formed within the deteriorating original derrick stone were filled in 1983. Downstream of the three roller gates closest to the lock, riprap was placed in a wedge 10 feet thick with a top of rock elevation of 606.0 feet, corresponding to the top of the original derrick stone. It was placed at this elevation to a point 25 feet downstream of the end sill where the original derrick stone ended. Beneath and downstream of the riprap wedge, a minimum 30-inch thick rockfill section was placed to a maximum distance of 125 feet downstream of the roller gate end sill. Downstream of the remaining two roller gates, a horizontal 54-inch riprap section was placed from the end of the original derrick stone to a point 60 feet downstream of the end sill where it then sloped down on a 1V:3H slope until it met the existing ground. A minimum 30-inch rockfill section was placed beneath the riprap and extended downstream to a maximum distance of 125 feet from the end sill. Upstream of the roller gates, a horizontal 42-inch thick riprap section, underlain by a rockfill section a minimum of 30-inches thick, was placed with a top of rock elevation of 610.0 feet. The riprap extended 25 feet upstream and the rockfill extended a minimum of 65 feet upstream of the roller gates.

(2) Tainter Gates. Downstream protection originally consisted of derrick stone 4-feet thick with a top of rock elevation of 611.0 feet (1912 adjustment). It extended 25 feet downstream of the end sill for the two tainter gates closest to the roller gates, 53.5 feet downstream for the third tainter gate, and 40 feet downstream for the remaining seven tainter gates. Upstream, the derrick stone section was 12-feet wide and 3-feet thick with a top of rock elevation of 615.0 feet.

The scour hole upstream and downstream of the derrick stone was filled in 1983 by a horizontal 42-inch thick riprap section, underlain by a rockfill section a minimum of 30-inches thick. The riprap extended 60 to 88 feet downstream of the end sill at the four tainter gates closest to the roller gates with a top of rock elevation of 611.0 feet. Downstream of the remaining tainter gates, a 10-foot thick riprap wedge with a top of rock elevation of 611.0 feet was placed from the downstream edge of the existing derrick stone to a point 40 feet downstream of the end sill. It was underlain by a minimum 30-inch thick rockfill section that extended downstream on a 1V:3H slope until it intersected with the channel bottom. Upstream, a horizontal 42-inch thick riprap section, underlain by a rockfill section a minimum of 30-inches thick, extended 25 feet from the dam with a top of rock elevation of 615.0 feet.

(3) Lock and Guidewalls. The original scour protection downstream of the lock and along the guidewall was a combination of rock filled cribs and derrick stone. A 20-foot wide by 437-foot long section of rock filled cribs was placed on the riverward side of the intermediate lock wall. A 12-foot wide section of derrick stone protection was provided from the downstream end of the concrete paving on the partially completed auxiliary lock, downstream along the riverward side of the intermediate lock wall riverward of the timber cribs, along the concrete apron on the downstream side of the landward lock, and 100 feet downstream along the lower guide wall. The derrick stone section was 3-feet thick and had a top of rock elevation of 604.0 feet (1912 adjustment). Upstream scour protection consisted of a 15-foot wide derrick stone section placed at the upstream end of the riverward and intermediate lock walls.

Additional scour protection was placed along the downstream apron of the main lock chamber and the upper and lower guide walls in 1981. A 2-foot thick, 20-foot wide horizontal section of 2 to 3 ton stone underlain by rockfill was placed downstream of the apron. Along a 173-foot long reach at the upstream end of the upper guide wall, the channel was shaped to allow the placement of a 20-foot wide horizontal rockfill section, a minimum of 30-inches thick, with a top of rock elevation of 607.0 feet. Twenty feet from the wall, the rock surface sloped riverward at 1V:2H to meet the existing channel bed. Along the entire length of the lower guide wall, a 30-inch thick riprap section underlain by 12-inch bedding was placed with a top of rock elevation of 606.5 feet at the wall. The rock surface sloped downward to an elevation of 604.5 feet at a distance of 20 feet from the wall. At this point, the rock section sloped downward at 1V:2H to meet the existing channel bed.

In 1983, a minimum 30-inch thick rockfill section was placed upstream of the dam at the end of the riverward lock wall with a top of rock elevation of 608.5 feet. Downstream of the auxiliary lock, a minimum 30-inch thick rockfill was placed with a top elevation of 604.0 feet. The rockfill section extended 50 feet downstream of the intermediate lock wall. At a point 110 feet riverward of the intermediate lock wall, the rockfill surface sloped at 1V:3H to the base of the scour hole located downstream of the second roller gate.

(4) Storage Yard. Original scour protection downstream of the storage yard consisted of riprap placed on a 1V:5.5 H slope for a maximum distance of about 100 feet. Upstream protection consisted of riprap placed on a 1V:3H slope for a maximum distance of about 60 feet.

In 1983, rockfill was placed downstream of the storage yard to a top of rock elevation of 607.5 feet. Where the existing ground was above 605.0 feet, a minimum 30-inch thick rockfill section was placed. Upstream of the storage yard, a minimum 30-inch thick rockfill section was placed on the existing ground for a maximum distance of 113 feet.

d. **Earthen Dam and Submersible Dams.** An earthen dam, 15,720 feet in length, extends from the end of the moveable dam section to the high ground on the Minnesota side of the river (**Plate 2-1**). The dam has a crest elevation ranging from 639.5 feet (1912 adjustment) at the movable dam end to elevation 640.0 feet at the Minnesota end. It has a top width of 20 feet and a maximum height of 24 feet (**Plate 2-2**). The pool side slope is 1V:3H, while the tailwater slope is 1V:5.5H. The side slopes are protected by 12-inch riprap underlain by 6-inches of crushed rock. Protection on the pool side extends to the dam crest; whereas protection on the tailwater slope extends to three feet above the lower project pool elevation (i.e. 620.0 + 3.0 = 623.0 ft).

Within the earthen dike are two earth-and-stone, fixed-crest, submersible dams (**Plates 2-1 and 2-2**). The submersible dam located near the Minnesota side (Reno) is 937.5 feet in length while the other located on Hastings Slough near the center of the earthen dike (Hastings) is 1,337.5 feet in length. The crest elevation for both submersible dams is 631.0 feet (i.e. project pool elevation).

A corrugated metal culvert passes through the Reno submersible dam to provide aeration to backwater areas upstream and downstream of the dam. The culvert is arched with a flat bottom and is approximately 65-inches wide by 45-inches high. The pipe is 28 feet long and has an invert elevation of 626.0 feet. A headwall provides for the installation and removal of stop logs.

A corrugated metal culvert with similar dimensions also passes through the Hastings submersible dam to provide flow to Hastings Slough. Stop logs also control flow through this culvert.

2-04. Related Control Facilities. There are no related control facilities in Pool No. 8; however, several habitat restoration projects have been constructed in Pool No. 8. The restoration project consists of five phases of island construction. Phases I and II are complete, Phase III is designed, and Phases IV and V are proposed. Phases I and II consist of eight barrier islands and eight seed islands. Phases III through V consist of 16 barrier islands and seven seed islands. The islands are to reduce wave action in backwater areas, prevent further erosion of existing habitat, and provide conditions necessary for the re-establishment of aquatic vegetation. **Figures 2-5** and **2-6** show portions of the first two Phases of construction.

Figure 2-5. Grassy, Boomerang, and Horseshoe Islands (Phase I)

Figure 2-6. Island and Rock Sills (Phase II), Stoddard, Wisconsin

2-05. Real Estate Acquisition. In Pool No. 8, 24,084 acres are held in fee by the US Government. Of this total, 9,496 acres are under the jurisdiction of the Corps of Engineers, and the balance of 14,588 acres is under the jurisdiction of the US Fish and Wildlife Service (USFWS). Of the Corps of Engineers land, all but 2 acres at the dam site are managed by the USFWS as part of the Upper Mississippi River National Wildlife and Fish Refuge.

2-06. Public Facilities. The new Central Control Station and public facilities at Lock and Dam No. 8 was completed in July 2002. In addition to the facilities at the Lock and Dam, there are numerous other facilities located throughout the pool including one of the largest campgrounds on the Upper Mississippi River (Goose Island Campground), which is located about 2 miles south of La Crosse, Wisconsin. **Tables 2-1 and 2-2** show a list of the recreational facilities located in Pool No. 8 on the Mississippi River and the Black River respectively.

Table 2-1 Recreation Facilities on the Mississippi River								
River Mile	Name	Manager	Fee	Slips	Parking	Camp Sites	Toilets	Picnic Tables
702.3R	Upper I-90 Landing	MN DNR/DOT			40	No	Yes	Yes
702.0L	LowerSpillway-FrenchSlough	Campbell			30	No	Yes	No
701.8R	Lower I-90 Landing	FWS/MNDOT			30	No	Yes	No
700.4L	Al's Marina-French Slough	Private		26	10	No	Yes	No
698.3R	Sportsmens Landing	MNDOT			15	No	No	No
697.7R	Bikini Yacht Club	Private		153	50	No	Yes	Yes
698.5R	Pettibone Park	La Crosse			60	No	Yes	Yes
698.0L	Riverside Park	La Crosse			40	No	Yes	Yes
697.4R	Pettibone Boat Club	Concession		260	70	No	Yes	Yes
696.8L	La Crosse Harbor Marina	Concession		185	70	No	Yes	No
695.6L	7th Street Ramp	La Crosse			50	No	Yes	Yes
695.0L	Chuts Landing	Private		110	10	No	Yes	No
692.8L	Upper Goose Island	La Crosse Co.			20	Yes	Yes	Yes
692.1L	Goose Island Main Ramp	La Crosse			30	Yes	Yes	Yes
690.4L	Hunters Point	FWS/La Crosse			10	Yes	Yes	Yes
690.5R	Lawrence Lake Marina	Concession	Yes	40	5	No	Yes	No
688.5R	Wildcat Park	Houston Co.			40	Yes	Yes	Yes
686.5L	Waters Edge Motel	Private	Yes	40	10	Yes	Yes	Yes
685.7L	Stoddard Landing	Stoddard			20	No	Yes	Yes
679.3L	Genoa Harbor	Genoa			5	No	No	No

Table 2-2 Recreation Facilities on the Black River								
River Mile	Name	Manager	Fee	Slips	Parking	Camp Sites	Toilets	Picnic Tables
5.0L	Sias Isles Boat Livery	Private	Yes	25	10	Yes	Yes	No
4.2R	Black River Boat Ramp	La Crosse			5	No	No	No
2.8L	Blacks Cove	Private		48	10	No	No	No
2.7L	Midway Motel	Private		46	100	No	Yes	No
2.4R	Richmond Bay Landing	Campbell			None	No	No	No
2.0L	Logan Street	La Crosse			50	No	No	No
1.9L	Clinton Street	La Crosse			50	No	No	No
1.8R	Clinton Street West	La Crosse			100	No	Yes	No
1.7L	Copeland Park Boat Stop	Concession		10	40	No	Yes	Yes
1.6R	North Bay Marina	Private	Yes	170	40	No	Yes	No

III – HISTORY OF PROJECT

3-01. Authorization. The Lock and Dam No. 8 project was authorized on 3 July 1930 when the 71st Congress, second session, passed an act that modified the existing six-foot channel project in accordance with the plan for a comprehensive project to procure a channel of nine-foot depth, submitted in House Document No. 290. The nine-foot channel was to be achieved by construction of a system of locks and dams, supplemented by dredging.

3-02. Planning and Design. The lock and dam system is necessary to provide a nine-foot channel during low to moderate flows. The site for Lock and Dam No. 8 was not dictated by unusual river features so much as simply the need for a suitable lock location in that stretch of river. A good six-foot channel was available if dredging continued, so the site was given a relatively low priority in the nine-foot channel project. The dam is operated to accommodate river flow conditions. In normal operation, all gates are partially open to allow water through. As the river flow increases or decreases, the gate openings are increased or decreased accordingly. If there were no flow in the pool, the pool would be level throughout its entire length. This is the "project pool" level that ensures a nine-foot channel depth. When there is flow, there is a slope to the water surface. Typically the water surface is maintained at project pool elevation at a predetermined point upstream of the dam, known as the "primary control point". Its location is near the point of intersection of the "project pool" (flat pool level) and the "ordinary high water" profile. The ordinary high water mark can be considered "the point up to which the presence and action of the water is so continuous as to destroy the value of the land for agricultural purposes by preventing the growth of vegetation, constituting what may be termed any ordinary agricultural crop". The government of the United States holds an easement to use the riparian lands up to the ordinary high water in the public interest. Therefore, land inundated by the lock and dam above the ordinary high water profile was purchased in fee. This land lies between the primary control point and the dam.

The primary control point for Lock and Dam No. 8 was located at La Crosse, Wisconsin with an elevation of 631.0 feet (1912 adjustment). The project pool elevation is maintained at the primary control point until discharge at the dam is sufficient to allow for a drawdown at the dam. As originally designed, maximum drawdown was established at 3.5 feet below project pool, or elevation 627.5 feet. Because the drawdown interfered with navigable depths, it was reduced to 2.0 feet in 1941. In an effort to maintain more stable water surface elevations in the lower pool, it was again reduced to 1.5 feet in 1963. In 1970, over-dredging procedures ended and drawdown was reduced to 1.0 foot, or elevation 630.0 feet in 1971. As discharges increase, the gates are raised to maintain the maximum drawdown. As discharge continues to increase, eventually all the gates are raised above the water surface and open river conditions exist. When this condition occurs, the dam is said to be “out of control”.

The total number of gates required at each site is based on the allowable swellhead at extreme high water. For Lock and Dam No. 8 the swellhead is limited to less than one foot. The project design flood for Lock and Dam No. 8 was the flood of 1880. The design high water was elevation 635.80 feet with a flow rate of 193,000 cfs. The swellhead limitation required that the available floodway area be utilized to the greatest possible degree. As a consequence gate sills were set to the lowest possible elevation. The valley and the main channel at the lock and dam are both narrow. The double locks occupy so much of the main channel that the five roller gates utilize much of the remaining space, leaving room for only 10 tainter gates. The gates did not allow sufficient flow to meet the swellhead limitation. Therefore, a spillway was required. Two submersible dam sections with a combined length of 2,275 feet were constructed within the earthen embankment with a crest height set at the project pool elevation of 631.0 feet.

In 1970, a 30-inch corrugated metal culvert was installed through the Reno submersible dam to provide aeration to backwater areas upstream and downstream of the dam. Around the mid-1970’s, a corrugated metal culvert with similar dimensions was installed through the Hastings submersible dam to provide flow to Hastings Slough. At project pool elevation (631.0 feet), a continuous flow of about 100 cfs is maintained through each of the culverts. Although both culverts provide for the installation of stop logs to regulate flow, they are typically not used unless needed for making repairs.

3-03. Construction. Before construction of the lock could commence, a dredging project was necessary. The navigable channel at the site had been maintained adjacent and parallel to the Wisconsin shore. A temporary channel had to be dredged before the construction of the coffer dam was started so navigation could continue. The temporary channel was completed on 21 June 1934. Construction of the lock began on 19 December 1933 and was completed on 4 March 1935. Construction of the dam began on 17 September 1935 and was completed on 30 April 1937. The earthen dike was completed on 22 December 1936. The total cost of Lock and Dam No. 8 was approximately $6,076,000.

3-04. Related Projects. Lock and Dam No. 8 is one part of the 29 locks and dams on the Mississippi River necessary to maintain the nine-foot navigation channel between Minneapolis, Minnesota and St. Louis, Missouri. Thirteen of the 29 locks and dams are located in the St. Paul District. These include Upper and Lower St. Anthony Falls, as well as Lock and Dam Numbers 1 through 10.

3-05. Modifications to Regulation.

a. 1941 Modification. The original maximum allowable drawdown for Lock and Dam No. 8 was established at 3.5 feet below the project pool elevation in 1936. Maximum drawdown was based on the concept that further drawdown may result in jeopardizing navigation depths upstream of the dam, but would have no effect on the water surface elevation at the primary control point. It was soon realized that this drawdown had negative impact on navigation and was reduced to 2.0 feet below project pool or elevation 629.0 feet (1912 adjustment).

b. 1948 Modification. The nine-foot channel depth was only important during the navigation season. Therefore, the pool could be drawn down far below project pool over the winter months whenever it was considered necessary. On 19 June 1948, an amendment was made to the act of Congress dated 10 March 1934, entitled “An act to promote the conservation of wildlife, fish and game, and for other purposes”. The amendment was Public Law 697 and it prevented drawdown of the pools on the Mississippi River between Rock Island, Illinois and Minneapolis, Minnesota during the non-navigation season. The law is known as the “Anti-Drawdown Law”. The law states that the “…dam structures shall generally operate and maintain pool levels as though navigation was carried on throughout the year.”

c. 1963 Modification. To reduce the adverse effects drawdown at the dam had on navigation, riverfront property, and conservation interests, the maximum allowable drawdown was reduced from 2.0 feet to 1.5 feet or elevation 629.5 feet (1912 adjustment).

d. 1970 Modification. A 30-inch corrugated metal culvert was installed through the Reno submersible dam to provide aeration to backwater areas upstream and downstream of the dam. The headwall of the culvert is an arched, flat-bottomed opening 65-inches wide by 45-inches high that provides for the installation and removal of stop logs. At a later date, a corrugated metal culvert with similar dimensions was installed through the Hastings submersible dam to provide flow to Hastings Slough. At project pool elevation of 631.0 feet (1912 adjustment), a continuous flow of about 100 cfs is maintained through each culvert. Although both culverts provide for the installation of stop logs to regulate flow, they are typically not used unless needed for making repairs.

e. 1971 Modification. In an attempt to reduce the frequency of dredging, the navigation channel was often over dredged. This practice stopped in 1970.

Therefore, drawdown at the dam was reduced from 1.5 feet to 1.0 foot, or elevation 630.0 feet (1912 adjustment). This remains today as the secondary control elevation.

f. 1973 Modification. Discharge through the dam was reevaluated in 1973. This resulted in a slight change in the discharge per foot of opening on the roller and tainter gates. Therefore, there was a need to revise the Gate Regulation Schedule. Included in this revision was a redistribution of flow across the dam. The previous Gate Regulation Schedule had a more even flow distribution across the dam; however, to achieve that, the recommended tainter gate settings hugged the maximum allowable outflow velocity (4.5 feet per second). The new Gate Regulation Schedule, distributed flow across the dam based on a more equal distribution of outflow velocities.

g. 1983 Modification. In 1981, the Waterways Experiment Station began a study of the scour protection upstream and downstream of the Mississippi River dams and published their results in *Scour Protection for Locks and Dams 2-10, Upper Mississippi River,* Technical Report HL-87-4, April 1987. Since 1952, hydrographic surveys indicated that scour had occurred upstream and downstream of the dam. The purpose of the study was to develop a riprap design that would stabilize the existing conditions. Based on the preliminary results of the study, additional riprap protection was placed upstream and downstream of the dam in 1983. Because there may occasionally be a need to raise a gate for clearing debris, the riprap was designed to remain stable for extreme conditions under a very short duration. The design conditions were full open or half open single gate with normal pool and minimum tailwater. Before placement of the riprap, the maximum allowable gate openings were based on a flow velocity of 4.5 feet per second; however, for emergency purposes, it was permissible for flow velocities to go as high as 6.0 feet per second. Because of the additional channel stability, the maximum outflow velocity for routine gate movements was raised to 6.0 feet per second, and under emergency situations, this velocity may be exceeded for brief periods (i.e. 15 to 20 minutes). Therefore, a new Gate Regulation Schedule was developed showing the new maximum allowable gate openings.

h. 1995 Modification. The motors that operate the lock miter gates were raised in 1995. Before this, the motors were pulled when the pool reached elevation 634.0 feet (1912 adjustment). Since the motors were raised, the lock does not technically go out of operation until the pool is at the top of the upstream miter gates at elevation 636.0 feet; however, because of wave action, the Corps closes the lock at elevation 635.5 feet.

Historically, winter regulation allowed for a tolerance of plus or minus 0.3-foot above or below the project pool elevation at the primary control point. This was for the purpose of providing for delays in gate operations due to ice. The Water Level Management Task Force, which is a subcommittee of the River Resource Forum, is a multi-agency group that shares information and provides suggestions on river management (see **Section 9-02.e. River Resources Forum**). In 1995 the Task Force requested that Water Control hold the Mississippi River pools on the high side of the band during winter regulation on a trial basis. Therefore, starting in the winter of 1995, the primary control point at La Crosse was maintained between elevations 631.0 feet and 631.3 feet. The purpose was to keep as much volume of water as possible in the backwater areas to avoid or delay dissolved oxygen depletion during the winter. The plan was implemented every year since and became official in the year 2000 when it was incorporated as a routine part of the operating plan.

i. 1998 Modification. The original site for the primary control point was located at the La Crosse Sewage Treatment Plant (river mile 696.9). In the mid-1980's, the control point was relocated to an abandoned US Geological Survey gage house in Riverside Park (river mile 697.8) where power and telephone were readily available. The official primary control point site was reestablished in July of 1998 when power and telephone were made available at the original site.

j. 2002 Modification. Outflow measurements for the roller and tainter gates were taken between March 1995 and November 1995. The results published by Toltz, King, Duvall, and Anderson and Associates in February 1996 showed an increase in the discharge per foot for the roller gates at high head differentials and for the tainter gates at all head differentials. A new Gate Regulation Schedule (**Table 7-2**) was developed based on these findings.

3-06. Principal Regulation Problems.

a. Outdraft. An outdraft problem exists at Lock and Dam 8 for down-bound as well as up-bound tows. Signs are located at the end of the upper and lower guidewalls to warn of outdraft when flows are above 40,000 cfs. The signs are circular, about three feet in diameter, and are orange in color. They are permanently mounted on a hinge, thereby allowing them to be swung out into view when necessary.

b. Submersible Dam Culverts. Debris tends to accumulate at the entrance to the two 30-inch corrugated metal culverts located at each of the submersible dams during flood events. The debris must be removed after these events to maintain operability.

c. Zebra Mussels. An infestation of zebra mussels is having impacts on operations at Lock and Dam No. 8. During the 2001 navigation season, Zebra mussel populations were 6 to 8-inches thick in locations on the lock walls and were clogging the intake screens. Zebra Mussels are present at all St. Paul District locks and dams on the Upper Mississippi River. It is possible that they may foul the gage wells, concrete surfaces, and untreated metal surfaces such as the lock miter gates. Masses of dead zebra mussels could accumulate in the gate recesses, hindering operation. The St. Paul District developed a "Zebra Mussel Response Plan" in November 1997. There were five methods for short-term control identified for locks and dams. The following tables show the possible problems and the recommended control techniques identified in the study.

Table 3-1
Zebra Mussel Control Techniques

Code	Method	Description
A	Physical Removal	Removed by scraping, brushing, or high-pressure water or steam spraying.
B	Mollusicides	Primarily oxidizing biocides (chlorine) with possibility of periodic use of nonoxidizing biocides.
C	Thermal Treatments	Hot water, steam, or air injection periodically to kill adult and larval zebra mussels.
D	Dewatering Dislocation	Isolation of susceptible components from the river. Components removed from river if possible.
E	Replacement Components	Replacement components which can be easily removed should infestation occur.

Table 3-2
Proposed Zebra Mussel Control Techniques for Locks and Dams

Component	Potential Problem	Method
Lock Walls	Heavy encrustations can be expected. Structural damage limited to abrasion during cleaning.	A,D
Gages	Occlusion of the pipe leading from the well to the River. Encrustation of level markings.	A,B,C,D
Thermometers	Encrustations could reduce reliability of readings.	A
Miter Gates	Increased corrosion of metal surface, paint deterioration, and unbalanced loading.	A,D
Bulkhead Slots	Accumulation along the sealing surfaces.	A,D
Lock Culverts	Reduced flow area and increased roughness could cause increased emptying and filling times.	A,D
Roller Gates	Increased gate weight and corrosion.	A,D
Side Seals	Accelerated deterioration of seals.	A,D,C,E
Tracks, Chains, Cables	Accumulation could prevent movement of roller gates. Metal and paint deterioration.	A,D

IV – WATERSHED CHARACTERISTICS

4-01. General Characteristics. At project pool elevation of 631.0 feet (1912 adjustment), the pool has a total surface area of 20,800 acres. The drainage area of Pool No. 8 totals 64,770 square miles in Minnesota and Wisconsin. Except for several small creeks, there are two major tributaries that flow into Pool No. 8; the La Crosse River with a total drainage area of 480 square miles and the Root River with a total drainage area of 1,660 square miles. The La Crosse River enters the pool from the Wisconsin side of the Mississippi River and the Root River enters the from the Minnesota side. Although the Black River now empties into Pool No. 7, a minimum discharge of 1,000 cfs in the summer and 500 cfs in the winter is maintained through the Onalaska Dam. This flow continues down the last four miles of the old Black River channel to the point of original junction with the Mississippi River.

4-02. Topography. The Master Water Control Manual for the Locks and Dams contains a description of the topography for the Upper Mississippi River basin. Presented here is description of the topography for the two major tributaries to Pool No. 8; the La Crosse River in Wisconsin and the Root River in Minnesota.

The La Crosse River basin is located in the southwestern portion of Wisconsin. The basin has a drainage area of about 480 square miles and is elliptical in shape with a length of about 40 miles in the east-west direction and a width of about 15 miles in the north-south direction. The basin encompasses portions of La Crosse and Monroe counties. The basin contains a mix of mostly forested land with minor areas of agricultural land.

The Root River Basin is located in the southeastern portion of Minnesota. The basin has a drainage area of 1,660 square miles and is elliptical in shape with a length of approximately 77 miles and a width of approximately 34 miles. The basin encompasses all or portions of Houston, Olmsted, Fillmore, and Mower counties. The Root River has steep slopes in the upper reaches of the basin and mild slopes near its confluence with the Mississippi River. The river passes through incorporated areas as well as large expanses of agricultural areas. A number of the communities in the upper reaches of the basin are flash flood prone.

4-03. Sediment. Part of the nine-foot navigation plan authorized by Congress included periodic dredging of sediment. There are eleven sites within the Pool No. 8 navigation channel that require periodic dredging. Also requiring periodic dredging is the lower approach to Lock No. 8 (Pool No. 9). Quantities and frequency of dredging these areas are presented in **Paragraph 5-03**.

4-04. Climate. The National Weather Service maintains temperature and precipitation records for Lock and Dam No. 8. Pan evaporation data was collected at Lock and Dam No. 6, but stopped after 1997. Temperature and precipitation data shown in the following tables were taken from National Oceanic and Atmospheric Administration's *Climatological Data Annual Summaries*, for Genoa Dam 8, Wisconsin. Pool evaporation was estimated by assuming a pan coefficient of 0.7.

Table 4-1
30-Year Normal Monthly Temperature in Degrees Fahrenheit

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
15.9	20.9	33.6	47.9	59.8	68.7	73.2	70.8	62.2	51.3	36.5	21.7	46.9

Table 4-2
30-Year Normal Monthly Precipitation in Inches

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
0.88	0.79	1.78	3.17	3.28	3.84	4.26	3.89	3.86	2.35	1.86	1.19	35.70

Table 4-3 Pan and Pool Monthly Evaporation in Inches (Lock and Dam No. 6)								
	Apr	May	Jun	Jul	Aug	Sep	Oct	Period of Record
Pan Evaporation	0.26	3.35	3.92	5.15	4.66	2.88	0.65	(1983 – 1997)
Pool Evaporation	0.18	2.35	2.74	3.61	3.26	2.02	0.46	(1983 – 1997)

Wind speed and direction are recorded each morning at Lock and Dam No. 8. While this information is valuable for the regulation of the dam, it is of little value for presenting monthly highest wind speeds and directions. The *Climatic Atlas of the United States* (June 1968) contains monthly Fastest Mile information for La Crosse, Wisconsin. 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 typically obtained from a short period of time, usually less than two minutes duration. The Fastest Mile wind speeds presented in the Atlas were modified to time-dependant (1-hour) average wind speeds using procedures presented in the US Army Corps of Engineers' *Shore Protection Manual* (1984).

Table 4-4 Highest Monthly Wind Speed and Direction in MPH for La Crosse, WI												
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Direction	NNW	WNW	NNW	SSW	E	NNW	N	N	SSW	WNW	S	NNW
Fastest Mile	35	36	40	50	58	60	36	46	36	38	46	43
1-Hour	29.5	30.3	33.3	41.0	46.8	47.2	30.3	37.9	30.3	31.8	37.9	38.1

Because of the bluffs along the river, winds tend to be channeled either up river or down river. The wind blowing across the pool 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 change in water level is due to “wind setup”. The rise in water can be estimated by (EM 1110-2-1414):

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

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

The above equation neglects the time required for the full wind setup to occur. The stronger the wind, the more time required. While it is recognized that the relationship is not linear, a rule of thumb has been developed that seems to work quite well for the lock and dam pools. For each ten miles per hour of wind speed, figure the change in the pool level to be 0.1 feet. Therefore, a northern wind at 20 mph would cause a 0.2 feet rise in the water surface at the dam, and conversely, a southern wind of 10 mph would result in a lowering of the water surface at the dam by 0.1 feet.

4-05. Storms and Floods. While an isolated storm over the Root River basin can have a significant impact on water levels in Pool No. 8 during low flows, it is high inflows from upstream that produce flooding of the pool. After construction of the Lock and Dam in 1937, the first significant flood events didn’t occur until spring of 1951. On the 19th of April, the Mississippi River at La Crosse crested at 1.9 feet above flood stage with a gage height of 13.9 feet. This stage was exceeded the following year. On the 20th of April 1952, the La Crosse gage peaked at 15.3 feet with a peak pool gage elevation of 641.62 feet (1912 adjustment). Estimated discharge was 196,500 cfs. This remained the flood of record until 1965. **Table 4-5** gives a summary of peak elevations and discharges followed by a brief description of some of the larger events.

Table 4-5 Summary of Peak Stages/Elevations and Discharges						
La Crosse, WI – Control Point			**Lock and Dam No. 8**			
Date	Stage Ft	Elev. ft (1912)	Date	Pool ft (1912)	Tailwater ft (1912)	Discharge cfs
19-Apr-51	13.93	640.25	20-Apr-51	634.81	633.90	-
20-Apr-52	15.30	641.62	22-Apr-52	635.30	634.52	196,500
21-Apr-65	**17.96**	**644.28**	**23-Apr-65**	**639.18**	**638.40**	**274,000**
7-Apr-67	13.86	640.18	9-Apr-67	634.09	633.35	168,000
20-Apr-69	15.66	641.98	21-Apr-69	636.30	635.24	207,500
27-Jun-93	14.67	640.99	28-Jun-93	634.75	633.94	179,100
13-Apr-97	14.99	641.31	14-Apr-97	635.11	634.42	187,700
18-Apr-01	16.41	642.73	20-Apr-01	636.87	636.21	229,300

a. April - May 1965. Because of the magnitude of the snow-water content on the ground, forecasts and warnings of floods were issued by the Weather Bureau (now the National Weather Service). An advisory on the flood potential in the Upper Mississippi River basin was published as early as the 19th of March 1965. The forecast predicted a stage of 13.5 feet at La Crosse, Wisconsin (flood stage is 12.0 feet) with normal precipitation and a snowmelt of more than three days. The forecast cautioned that if rainfall of one inch should occur before or during the crest, the resulting peak stage at La Crosse would be near the 1952 level. Almost four inches of rain fell in the first two weeks of April. The Weather Bureau revised the forecast for La Crosse, predicting a stage of 18.0 feet. The forecasted discharge of almost 270,000 cfs translated into a predicted elevation of 638.8 feet (1912 adjustment) at the dam. Based on this, the earthen dike with a crest elevation of 639.5 feet was strengthened and raised to provide sufficient freeboard and the spillway abutments were protected by sandbags. Because the top of the lock walls are at elevation 639.0 feet, the central control station had to be ringed with sandbags. The rapid increase of inflow began on the 1st of April when the discharge rose from 13,600 cfs on this date to 70,000 cfs on the 6th of April. By this time the head at the dam had been reduced to 0.75 feet and the gates were removed from the water. The motors that operate the lock miter gates were pulled on the 18th of April and the lock was out of operation for 17 days until the 5th of May. The Mississippi River crested at elevation 644.28 feet (stage 17.9 ft) at La Crosse on the 21st of April. This was 5.9 feet above flood stage and was 2.6 feet higher than the peak stage of 1952. The pool at Lock and Dam No. 8 crested on the 22nd – 23rd of April at elevation 639.18 feet with a peak flow of 274,000 cfs. The pool returned to secondary control (elevation 629.5 feet) on the 27th of May and the dam was put back into operation. The Root River peaked on the 2nd of March with a discharge of 31,000 cfs. At the time of peak flow at Lock and Dam No. 8, it only contributed 900 cfs.

b. April 1997. The magnitude of the snow-water content on the ground indicated a high potential for flooding along the Upper Mississippi River. On the 13th of March, the National Weather Service outlook predicted a stage of 15.5 feet at La Crosse, Wisconsin. On the 13th of April, La Crosse crested at 15.0 feet (elevation 641.31 feet – 1912 adjustment). The pool at the dam crested on the 15th of April at elevation 635.16 feet. Peak discharge was 189,500 cfs. Because the lock miter gate motors were raised in 1995, the lock was able to remain in operation.

c. April 2001. The National Weather Service's 2001 Spring Snowmelt Flood Outlook predicted minor to moderate flooding for Pool No. 8. This forecast was primarily due to the significant autumn precipitation the year before and the heavy winter snowfall. A less than ideal snowmelt followed by record breaking April precipitation resulted in producing the second highest flood stages in Pool No. 8. In the early morning of the 18th of April, the stage at La Crosse, Wisconsin peaked at 16.41 feet (elevation 642.73 – 1912 adjustment). On the 20th of April, the pool at Lock and Dam No. 8 peaked at elevation 636.87 feet with a discharge of 229,300 cfs. The pool reached the closure elevation of 636.0 feet on 16th of April and did not fall below elevation 636.0

feet until the morning of the 23rd of April. However, additional rainfall resulted in a second crest of elevation 636.08 feet on the 1st of May. The pool did not fall below elevation 636.0 feet until the 3rd of May. While the lock may have been operable before the 16th of April and after the 3rd of May, the Coast Guard closed the river to navigation from the 9th of April to the 9th of May. By this time the pool had fallen to elevation 634.1 feet.

4-06. Runoff Characteristics. The mean annual discharge at Lock and Dam No. 8 is 38,000 cfs based on a period of record from 1960 through 2002. The following table shows the monthly average discharges.

Table 4-6
Monthly Average Flow in cfs – (Years 1960 - 2002)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
19,100	20,100	40,000	77,300	62,600	48,500	40,300	28,500	29,500	31,600	32,300	23,400

A maximum discharge of 274,000 cfs occurred at the dam on 23 April 1965 (**Table 4-5**). The lowest winter discharge recorded was 4,500 cfs on 14 December 1980. The minimum discharge during navigation season occurred with the drought of 1988 where the discharge got as low as 6,600 cfs and remained there from 3 July through the 8 July. A discharge-frequency curve for the Mississippi River at La Crosse, Wisconsin is shown on **Figure 8-1**. The following table shows the discharge-duration at the dam.

Table 4-7
Discharge-Duration at Lock and Dam No. 8
Percent Time At or Above Indicated Discharge (Years 1972-2000)

Discharge	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
185,000				0.5									
180,000				0.6									
175,000				0.8	0.3	0.5	0.1						0.1
170,000				1.0	0.6	0.6	0.2						0.2
165,000				1.2	0.6	0.6	0.4						0.2
160,000				1.5	0.8	0.7	0.7		0.1	0.2			0.3
155,000				2.0	0.9	0.8	0.8		0.2	0.4			0.4
150,000				2.3	1.0	0.9	0.9		0.3	0.6			0.5
145,000				2.5	1.0	0.9	1.0		0.5	0.7			0.6
140,000			0.4	2.9	1.1	0.9	1.1		0.5	0.7			0.6
135,000			0.8	3.7	1.2	0.9	1.3		0.5	0.8			0.8
130,000			1.1	4.4	1.3	0.9	2.0		0.6	0.9			0.9
125,000			1.6	5.1	1.3	1.0	2.2		0.6	0.9			1.1
120,000			1.9	6.6	2.2	1.0	2.3		0.6	1.0			1.3
115,000			2.0	8.4	3.9	1.0	2.3		0.6	1.1			1.6
110,000			2.6	11.0	4.9	1.7	2.5		0.7	1.2			2.1
105,000			2.8	13.7	6.5	2.2	2.8		0.7	1.6			2.5
100,000			3.2	17.8	8.6	2.3	3.2		0.7	1.9			3.2
95,000			4.0	22.2	10.3	2.5	4.0	0.4	0.7	2.6			3.9
90,000			5.1	26.8	13.9	3.6	4.6	0.6	0.7	2.8			4.8
85,000			6.9	29.7	17.2	4.4	5.0	0.7	0.7	2.9			5.6
80,000			10.1	37.1	23.5	7.1	6.0	0.8	1.2	3.0	0.7		7.5
75,000		0.2	13.7	49.2	34.4	10.7	8.7	3.1	2.2	4.5	1.2		10.7
70,000		0.6	17.1	60.3	42.2	14.7	12.9	5.2	3.7	6.6	3.5		13.9
65,000		0.7	20.8	66.4	49.1	20.5	16.9	6.3	5.2	8.5	6.0	0.2	16.8
60,000		1.1	24.6	70.9	53.4	27.7	23.8	7.2	8.2	11.1	8.2	1.0	19.8
55,000		1.3	29.3	75.4	57.7	34.0	31.5	10.1	12.1	13.6	10.9	1.2	23.2
50,000		1.5	33.2	78.5	63.3	44.3	36.6	14.6	18.1	17.6	14.5	2.2	27.1
45,000		2.9	39.9	81.5	69.1	55.2	44.4	20.4	23.0	22.6	19.0	3.6	31.9
40,000	0.6	4.5	46.8	84.0	73.4	65.9	51.8	27.7	29.7	29.3	31.6	8.6	37.9
35,000	2.2	6.0	53.3	87.8	78.3	73.7	60.2	36.5	35.9	36.8	44.3	15.9	44.4
30,000	11.0	9.8	62.9	93.0	83.4	79.9	68.0	46.5	46.1	47.6	57.5	30.0	53.1
25,000	28.0	23.4	71.6	97.0	88.3	82.8	74.8	58.6	57.1	56.8	70.1	47.5	63.2
20,000	50.8	47.8	82.9	98.6	93.0	87.6	79.8	73.5	71.6	70.2	84.7	61.7	75.3
15,000	73.6	79.4	94.4	99.5	96.6	94.1	87.3	84.2	86.7	85.2	93.6	80.9	88.0
10,000	94.7	95.2	99.7	100.0	100.0	98.6	96.6	94.0	95.6	96.7	96.2	91.7	96.6
5,000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.9	100.0

Construction of the lock and dam greatly influenced stage-duration curves throughout the pool. Based on a period of record from 1972 to 2000, the following four elevation-duration tables were developed: (1) Lock and Dam No. 8 tailwater (2) Lock and Dam No. 8 pool, (3) Brownsville, Minnesota gage, (4) La Crosse, Wisconsin control point. The tables indicate the percent of time the water surface is at or above the indicated elevation (1912 adjustment). Gage zero for the pool and tailwater is elevation 616.80 feet. The La Crosse gage zero is elevation 626.32 feet and the Brownsville gage zero is elevation of 600.00 feet.

Table 4-8
Elevation-Duration, Lock and Dam No. 8 Tailwater
Percent of Time at or Above Indicated Elevation (Years 1972 to 2000)

Elev.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
633.5				1.0	0.4	0.5	0.2						0.2
633.0				1.5	0.7	0.7	0.6		0.1	0.1			0.3
632.5				2.2	0.9	0.9	0.8		0.4	0.4			0.5
632.0			0.1	2.6	1.0	0.9	1.0		0.5	0.7			0.6
631.5			1.1	4.0	1.2	0.9	1.6		0.6	0.8			0.9
631.0			1.7	6.0	1.6	1.0	2.2		0.6	0.9			1.2
630.5			2.3	9.2	3.8	1.1	2.4		0.7	1.1			1.7
630.0			2.9	13.9	6.5	2.1	2.8		0.7	1.5			2.5
629.5			3.6	20.9	9.9	2.4	3.7	0.3	0.7	2.3			3.7
629.0			5.7	27.9	18.8	4.1	4.7	0.7	0.8	2.9			5.2
628.5			8.1	34.4	21.3	5.8	5.8	0.8	1.0	3.4			6.7
628.0			10.6	41.6	29.3	8.5	7.2	1.0	1.3	4.2	0.1		8.7
627.5		0.5	13.1	48.8	35.2	11.2	10.7	2.1	2.1	5.4	1.2		10.9
627.0		0.7	16.8	57.7	42.8	15.3	14.0	5.0	3.8	6.7	2.6		13.8
626.5		0.9	19.5	65.0	49.2	20.6	17.8	6.4	5.0	8.5	5.2	0.5	16.6
626.0		1.6	23.9	68.5	53.8	27.1	23.0	9.1	7.8	10.9	7.4	1.0	19.6
625.5		2.1	28.1	72.7	57.7	33.4	29.6	11.3	12.2	12.5	10.2	2.2	22.7
625.0		2.7	32.9	76.8	61.1	42.9	34.8	14.6	17.0	16.7	13.3	4.0	26.5
624.5	0.6	3.7	38.6	79.2	64.8	51.7	39.3	18.2	20.8	20.6	17.7	7.8	30.3
624.0	5.2	5.1	44.5	81.8	70.2	59.7	46.6	21.9	26.2	24.5	24.1	14.6	35.5
623.5	14.4	9.5	51.7	84.2	73.8	67.7	53.2	28.6	31.3	30.5	33.3	21.4	41.7
623.0	26.4	18.9	58.2	87.7	78.2	74.1	60.7	38.3	36.8	36.9	44.6	31.1	49.4
622.5	37.2	30.5	66.6	92.4	82.5	78.7	67.1	46.4	45.2	46.2	55.8	41.4	57.6
622.0	50.7	46.2	75.2	96.1	87.1	82.3	74.2	56.3	55.1	54.7	67.0	54.2	66.7
621.5	71.5	72.3	87.3	98.3	91.3	86.4	78.7	69.8	66.5	66.3	80.3	70.2	78.2
621.0	87.8	88.7	95.8	99.4	94.8	91.8	84.1	81.2	79.1	77.3	90.0	84.1	87.8
620.5	95.7	94.3	98.1	99.8	98.7	97.6	94.0	91.4	93.0	93.3	96.1	94.0	95.5
620.0	98.0	98.3	100.0	100.0	100.0	100.0	99.7	99.7	99.0	99.7	99.2	98.9	99.4
619.5	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 4-9
Elevation-Duration for Brownsville, Minnesota
Percent of Time at or Above Indicated Elevation (Years 1972 to 2000)

Elev.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
636.0				1.1	0.4	0.7	0.1						0.2
635.5				2.5	1.2	1.0	0.7						0.5
635.0				4.6	2.2	1.1	1.0		0.5	0.4			0.8
634.5			0.4	6.3	3.8	1.2	1.3		0.6	0.6			1.2
634.0			1.6	8.6	4.4	1.2	2.2		0.8	0.8			1.6
633.5			3.7	10.6	6.1	1.4	2.5		0.8	0.9			2.1
633.0			6.1	14.7	9.4	2.1	2.8		0.8	1.3			3.1
632.5	0.2		8.7	21.7	15.4	4.3	4.3	0.9	1.1	2.2	0.4	0.3	4.9
632.0	2.3	1.1	16.8	32.9	26.1	9.3	10.0	1.8	1.8	3.9	1.7	2.4	9.1
631.5	5.5	8.0	32.4	61.3	45.6	25.9	24.3	10.8	11.8	12.7	8.3	8.5	21.2
631.0	48.1	43.6	69.9	86.5	77.8	75.2	69.9	55.8	61.7	65.8	49.6	46.7	62.9
630.5	95.8	94.9	97.9	99.3	98.7	97.8	96.5	97.7	97.1	98.7	98.1	93.6	97.2
630.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 4-10
Elevation-Duration, Lock and Dam No. 8 Pool
Percent of Time at or Above Indicated Elevation (Years 1972 to 2000)

Elev.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
634.2				1.0	0.4	0.6	0.2						0.2
634.0				1.0	0.6	0.6	0.4						0.2
633.8				1.4	0.7	0.7	0.6						0.3
633.6				1.8	0.8	0.8	0.7		0.1				0.4
633.4				2.0	0.8	0.8	0.8		0.2	0.2			0.4
633.2				2.4	0.9	0.9	0.9		0.3	0.3			0.5
633.0				2.5	0.9	0.9	0.9		0.5	0.4			0.5
632.8			0.2	2.9	1.0	0.9	1.0		0.5	0.56			0.6
632.6			0.7	3.1	1.1	0.9	1.1		0.5	0.6			0.7
632.4			0.9	3.8	1.1	0.9	1.3		0.6	0.7			0.8
632.2			1.1	4.3	1.2	1.0	1.8		0.6	0.7			0.9
632.0			1.6	4.8	1.3	1.0	2.0		0.6	0.8			1.0
631.8			1.6	5.5	1.3	1.0	2.2		0.6	0.8			1.1
631.6			2.0	7.0	2.0	1.0	2.2		0.6	0.9			1.3
631.4			3.1	8.2	2.9	1.2	2.3	0.3	1.5	1.0	0.9		1.8
631.2			3.9	10.7	4.2	2.0	4.6	3.9	3.8	3.2	3.6	0.5	3.4
631.0	2.2	1.2	6.1	12.3	6.1	6.2	11.7	14.0	13.1	13.5	8.4	3.9	8.3
630.8	8.1	5.7	10.1	15.6	10.0	15.1	21.6	23.6	27.4	28.9	16.3	14.9	16.5
630.6	17.8	15.9	18.9	20.0	15.7	21.2	26.6	32.4	42.6	41.9	27.0	28.6	25.8
630.4	34.4	27.2	30.1	26.6	26.1	30.1	31.9	42.2	53.8	56.6	41.8	47.1	37.4
630.2	58.1	48.5	52.3	44.8	44.9	49.1	49.6	62.6	70.8	71.4	62.1	63.8	56.6
630.0	86.8	84.2	80.5	81.2	79.0	83.6	81.9	86.4	90.1	91.2	85.4	85.2	84.6
629.8	95.6	95.4	96.3	98.6	98.4	98.3	98.1	98.0	98.9	99.2	97.5	95.4	97.5
629.6	97.4	96.6	99.4	99.9	100.0	100.0	100.0	100.0	99.77	99.8	99.7	98.3	99.3
629.4	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 4-11
Elevation-Duration for La Crosse, Wisconsin
Percent of Time at or Above Indicated Elevation (Years 1972 to 2000)

Elev.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
640.5				1.0		0.7							0.2
640.0				1.3	0.3	1.0	0.6						0.3
639.5				2.1	0.6	1.0	0.8		0.3				0.4
639.0				3.1	0.8	1.0	1.0		0.6	0.3			0.6
638.5			0.9	4.1	1.1	1.1	1.9		0.6	0.4			0.9
638.0			1.6	5.9	1.3	1.2	2.1		0.7	0.7			1.1
637.5			2.2	9.6	3.2	1.2	2.4		0.7	0.8			1.7
637.0			2.7	13.8	6.1	2.0	2.7		0.7	1.0			2.4
636.5			3.5	20.1	9.0	2.8	3.1	0.3	0.8	1.5			3.4
636.0			5.9	28.1	13.6	4.0	4.3	0.6	0.9	2.5	0.1		5.0
635.5			8.5	35.3	21.3	6.5	5.7	0.7	1.0	2.9	0.4		6.9
635.0		0.6	11.4	43.0	29.0	9.4	7.6	1.1	1.5	4.0	0.7		9.1
634.5		1.1	15.2	53.0	38.6	12.6	11.4	4.1	2.8	5.3	1.9	0.6	12.3
634.0		1.2	19.8	62.3	46.8	19.3	16.4	6.2	4.9	7.7	5.2	1.9	16.1
633.5	0.1	2.6	26.8	68.2	54.0	28.8	24.3	9.1	9.5	11.3	8.1	5.6	20.8
633.0	2.7	4.6	35.3	74.7	60.7	40.7	33.7	13.5	15.9	16.5	13.1	13.3	27.2
632.5	13.9	11.0	44.7	79.6	66.6	55.6	42.6	19.4	23.3	22.7	20.5	21.3	35.3
632.0	29.6	25.3	59.1	84.5	74.4	68.3	52.6	28.1	33.3	33.2	38.4	33.1	46.8
631.5	55.1	54.0	79.0	93.0	83.4	81.2	68.3	49.9	53.3	53.2	65.3	55.4	66.0
631.0	93.6	96.4	96.8	99.8	96.0	97.5	94.6	91.0	91.7	93.9	92.9	88.0	94.3
630.5	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

At a flat pool elevation of 631.0 feet (project pool), the storage volume in Pool No. 8 is 108,500 acre-feet. However, at moderate flows, there is a slope to the flowline that allows for a one-foot drawdown at the dam. A study of flood profiles shows two distinct slopes in the flow lines (see **Figure 8-3**). Therefore, storage volume for the pool was broken into two reaches. The two slopes intersect at about river mile 692. This is near the Brownsville gage (river mile 688.2). The first river reach extends from the Brownsville gage, upstream to the tailwater of Lock and Dam No. 7. The second reach extends from Lock and Dam No. 8 to the Brownsville gage. **Tables 4-12** and **4-13** can be used to determine the storage volumes in each reach for various elevations. Assuming an elevation of 630.0 ft at Lock and Dam No. 8, elevation 631.0 at the Brownsville gage, and elevation 634.0 at the tailwater of Lock and Dam No. 7, the approximate volume of Pool No. 8 would be 123,100 acre-feet (44,000 + 79,100 acre-ft). A flow rate of approximately 62,000 cfs would result in a daily exchange in storage. A relationship of storage to discharge is shown on **Plate 4-1**.

Table 4-12
Storage Volume of Pool No. 8 in 1,000 Ac-Ft
Between Brownsville, MN and Tailwater of Dam 7

TW Elev at Dam 7	Elevation at Brownsville, Minnesota																		
	638	637	636	635	634	633	632	631	630	629	628	627	626	625	624	623	622	621	620
645	234	225	214	204															
644	220	209	199	188	178														
643		195	185	174	164	153													
642		183	172	161	150	139	129												
641			162	150	140	130	119	111	103										
640				140	130	120	111	102	93	85									
639				127	118	108	99	90	82	74									
638				115	106	97	88	80	72	65	58								
637					95	87	78	70	62	55	48								
636					85	76	68	60	52	46	40								
635						69	60	51	44	38	33	29							
634							51	44	38	33	29	26	24						
633							43	37	32	28	25	23	21	19	18				
632								30	26	23	21	19	17	16	15				
631								26	22	20	18	16	14	13	12	11	10		
630											15	14	13	11	10	9	8		
629													11	10	9	8	7	6	
628													9	8	7	6	5	5	4

Table 4-13
Storage Volume of Pool No. 8 in 1,000 Ac-Ft
Between Brownsville, MN and Pool of Dam 8

Pool Elev at Dam 8	**Elevation at Brownsville, Minnesota**																				
	640	639	638	637	636	635	634	633	632	631	630	629	628	627	626	625	624	623	622	621	620
637	190	180	171																		
636	186	177	167	157																	
635	182	172	163	153	143																
634		167	158	149	139	130															
633			151	143	135	127															
632				138	131	123	115	106	97												
631					126	120	111	102	92	83											
630						115	106	97	88	79	70										
629							102	93	84	75	65	56									
628								89	80	70	61	52	43								
627									76	66	57	48	40								
626										63	53	44	36	29							
625											49	40	32	25	20						
624												36	29	23	18	14					
623													26	20	15	12	11				
622														18	14	11	10	9			
621															12	10	8	7	6		
620																9	8	7	6	5	
619																	7	6	5	4	3
618																		5	4	3	3

4-07. Water Quality. The St. Paul District does not collect water quality information for Pool No. 8. However, as an element of the Environmental Management Program (EMP), the Corps of Engineers oversees the Long Term Resource Monitoring Program (LTRMP) of the Upper Mississippi River System. The LTRMP was implemented to provide decision makers with the information needed to maintain the Upper Mississippi River System as a viable multiple-use large river ecosystem. The LTRMP is being implemented by the US Geological Survey (USGS) in cooperation with the states of Illinois, Iowa, Minnesota, Missouri and Wisconsin with guidance and overall program responsibility by the Corps of Engineers.

4-08. Channel and Floodway Characteristics. The top of the lower lock sill elevation at Lock and Dam No. 7 is elevation 619.0 feet and the top of the upper lock sill elevation at Lock and Dam No. 8 is elevation 609.0 feet. Therefore, there is a 10.0-foot drop in sill elevation along the pool, which has a length of 23.3 miles as measured along the navigation channel. The navigation channel is 300 feet in width in the straight stretches, and varies from 300 feet to 550 feet in the bends. The line of navigation is shown on **Plates 2-4** through **2-7**.

4-09. Upstream Structures. Lock and Dam No. 7 is located 23.3 miles upstream of Lock and Dam No. 8. The drainage area above Lock 7 is 62,340 square miles. The lock and dam system continues upstream to the Upper St. Anthony Falls Lock and Dam located in Minneapolis, Minnesota.

4-10. Downstream Structures. Lock and Dam No. 9 is located 31.3 miles downstream of Lock and Dam No. 8. The drainage area above Lock 9 is 66,610 square miles. The lock and Dam system continues downstream to Lock and Dam No. 27 in St. Louis, Missouri; however, St. Paul District terminates with Lock No. 10.

4-11. Economic Data. Pool No. 8 lies on the Minnesota-Wisconsin border. Houston County lies on the western side and Vernon and a portion of La Crosse Counties lie on the eastern side. Based on the US Census Bureau, county populations have increased slightly.

Table 4-14
County and City Populations Near Pool No. 8

	1990	2000	Difference	Change
County				
Houston, MN	18,497	19,718	1,221	6.6 %
Vernon, WI	25,617	28,056	2,439	9.5 %
La Crosse, WI	97,904	107,120	9,216	9.4 %
City				
Brownsville, MN	415	517	102	24.6 %
La Crosse, WI	51,003	51,818	805	1.6 %
Stoddard, WI	775	815	40	5.2 %

The following table gives a break down of the employment by industry. The data were taken from the US Census Bureau's 1997 Industry Report.

Table 4-15
Employment by Industry – Counties on Pool No. 8 (1997)

Industry	Houston	Vernon	La Crosse
Manufacturing	0	970	10,171
Wholesale Trade	536	217	3,217
Retail Trade	500	1,139	9,005
Real Estate, Rental, Leasing	11	32	774
Professional, Scientific, Tech Services	53	103	1,531
Admin & Support, Waste Management	84	49	2,384
Education Services	0	0	46
Health Care & Social Services	174	259	1,013
Arts, Entertainment & Recreation	60	33	750
Accommodations & Food Services	260	750	5,533
Other Services	77	72	1,271
Totals	1,755	3,624	35,695

V - DATA COLLECTION AND COMMUNICATION NETWORKS

5-01. Hydrometeorological Stations.

a. Facilities. The regulation and proper operation of the dam site requires the collection and evaluation of several hydraulic and hydrologic parameters. The Corps of Engineers (COE), US Geological Survey (USGS), and the National Weather Service (NWS) are involved in the data collection network. About 5.5 miles downstream of Lock No. 7 is the Pool No. 8 primary control point gage. It is located downstream of the Highway 16 bridge crossing the Mississippi River on La Plume Island at La Crosse, Wisconsin (see **Plate 5-1**). It is situated next to the La Crosse sewage treatment plant at river mile 696.9. The water surface elevation is determined by a float, attached to a tape, that sits in a stilling well. The site is a Data Collection Platform (DCP). It has a Sutron 8210 data recorder with GOES Telemetry and voice modem. The GOES Telemetry allows communication with the satellite system that provides hourly water surface elevations to Water Control. The voice modem allows telephone communication with the gage to obtain an instantaneous water surface elevation. In addition, there is a tipping bucket located atop the gage house for determining hourly precipitation. The gage system is battery operated. While there is a solar panel at the site, a power line has been run into the gage house. This provides power to a battery charger. There is no staff gage at the site; however, the lip of the gage well has been surveyed in so that a tape can be used to verify the gage elevation. The equipment is owned by the Corps of Engineers and is maintained by the Water Control Gage Crew. The gage is shown in **Figure 5-1**.

There is an additional gage in the pool located at Brownsville, Minnesota at river mile 688.2 (**Plate 5-1**). Like the La Crosse gage, this site is also a stilling well. The Brownsville gage was installed for the purpose of determining storage volume within the pool at any given time. At moderate flows, there are basically two slopes to the flow line in Pool No. 8. The break point is near Brownsville, Minnesota. The Brownsville gage is a DCP with the same equipment as the La Crosse gage. There is no power at this site; therefore a solar panel is used to keep the battery charged. The equipment is owned by the Corps of Engineers; however, it is maintained by the USGS through a cooperative agreement. The gage is shown in **Figure 5-2**.

Figure 5-1. La Crosse Gage.

Figure 5-2. Brownsville Gage.

The main tributaries to the pool are the La Crosse River, which drains a 480 square mile basin in Wisconsin, and the Root River, which drains a 1,660 square mile basin in Minnesota. The La Crosse River and Root River enter the Mississippi River about nineteen miles and fifteen miles upstream of the lock and dam, respectively. A stream gage is located on the La Crosse River approximately 13.5 miles upstream of the confluence at West Salem, Wisconsin. It is a wire weight gage located on an abandon bridge. Two gages are required for the Root River. Originally there was only one gage located on the main stem downstream of the South Fork; however, backwater influence made it impossible to determine discharge. Therefore, one gage was located on the main stem 18.5 miles upstream of the confluence near Houston, Minnesota and the other one was located on the South Fork Root River, 20 miles upstream of the confluence (also near Huston). Both of these sites are DCP's. Water surface elevations are obtained via a pressure transducer. The main stem gage has a voice modem. **Exhibits B** and **C** contain the USGS rating tables for the Root River and South Fork Root River gages. Inflow to Pool No. 8 from the Root River is obtained by adding the two discharges. **Exhibit D** shows the St. Paul District rating table for the La Crosse River gage. Root River and South Fork Root River gages are maintained by the USGS through a cooperative agreement. The location of the gage sites are shown on **Plate 5-1**.

The COE operates and maintains the pool and tailwater gages at the lock. The gage houses are located on the upper and lower guidewalls about 500 feet from the lock chamber. Each gage house has a well with a float and tape system that reports elevation to the Stevens PAV-C Recorder located in the lock house (**Figure 5-5**). Staff gages are mounted inside the gage houses and serve as backup or are used for verification of the tape in the well.

Figure 5-3. Pool Gage.

Figure 5-4. Tailwater Gage.

Figure 5-4. Stevens PAV-C Strip Chart Recorders.

Additional gage types at the lock and dam include a water temperature sensor, reading in degrees Fahrenheit, located in the upper ladder recess. An anemometer is located on the roof of the lock house. The water temperature and the wind speed and direction are all electronically transmitted to the control house. Site personnel are responsible for the maintenance of this equipment. A standard eight-inch precipitation gage is located near the lock house thereby providing the means of obtaining the 24-hour precipitation. The site is equipped with a measuring rod for snow depth and a snow tube and scale for determining snow-water content. The precipitation gage and snow measuring equipment are maintained by site personnel; however, Water Control is responsible for providing any replacement equipment. The NWS has a Fisher-Porter automatic weighing, punched tape, binary decimal recording gage installed at the site. Data types and equipment are listed in **Table 5-1**.

Table 5-1 Hydrometeorological Stations			
Location	**Data Type**	**Equipment**	**Notes**
Mississippi River at La Crosse, WI	Water Surface Elevation and Stage, Precipitation	Sutron 8210 Data Recorder Stilling Well GOES Telemetry Voice Modem Tipping Bucket	Gage Zero: 626.32 (1912) Flood Stage: 12.0 ft NWS ID: LACW3 Maintained by COE
Mississippi River at Brownsville, MN	Water Surface Elevation and Precipitation	Sutron 8210 Data Recorder Stilling Well GOES Telemetry Voice Modem Tipping Bucket	Gage Zero: 600.00 (1912) NWS ID: BRWM5 Co-Op Gage
La Crosse River at West Salem, WI	Stage	Wire Weight Gage Attached to Bridge	Gage Zero: 668.0 (1912) Read by Local Gage Reader Each Morning.
Root River near Houston, MN	Stage	Sutron 8210 Data Recorder Stilling Well GOES Telemetry Voice Modem	Gage Zero: 667.0 (1929) Flood Stage: 15.0 ft NWS ID: HOUM5 Co-Op Gage
S.F. Root River near Houston, MN	Stage	Sutron 8200 Data Recorder Stilling Well GOES Telemetry	Gage Zero: 680.41 (1929) NWS ID: HUSM5 Co-Op Gage
Lock & Dam No. 8 Upper Guide wall	Pool Elevation	Stevens PAV-C Recorder Stilling Well Staff Gage	Continuous Strip Chart record of pool elevations.
Lock & Dam No. 8 Lower Guide wall	Tailwater Elevation	Stevens PAV-C Recorder Stilling Well Staff Gage	Continuous Strip Chart record of TW elevations.
Lock & Dam No. 8	Snow Depth & Water Content	Snow Rod , Snow Tube, Scale	Water Control provides replacement as needed.
Lock & Dam No. 8 Lock House Roof	Wind Speed & Direction	Anemometer	Maintained by site personnel.
Lock & Dam No. 8 Upper Ladder Recess	Water Temperature	Water Temperature Sensor	Electronically transmitted to lock house.
Lock & Dam No. 8	Precipitation	Standard 8-inch Rain Gage	Recorded daily.
Lock & Dam No. 8	Precipitation	Fischer-Porter - Weighted Punch Tape	NWS Gage

b. Reporting. Daily log sheets of data are kept at the lock and dam site. The log sheet begins at 0400-hours. The data entry interval varies from once a day to every four hours. Four-hour interval data include pool elevation, tailwater elevation, and gate openings. Air temperature and wind speed and direction are entered every eight-hours beginning at 0800-hours. Daily records include water surface elevations at La Crosse and Brownsville (0800-hours), maximum and minimum air temperature (2400-hours), water temperature (0800-hours), and precipitation (0800-hours). The information needed to regulate the lock and dam is provided to Water Control, via computer by dam personnel, daily at 0630-hours. All 0800-hour data is collected between 0600 and 0630-hours and is archived as 0800-hours, thereby maintaining the record intervals. Each morning, Water Control is provided data for the last 24-hours beginning at 0800-hours the previous day. These data include the four-hour pool and tailwater elevations and gate openings, the morning elevations at La Crosse and Brownsville, wind speed and direction, 24-hour precipitation, and the stages and discharges for the La Crosse River at West Salem, Root River near Houston, and the South Fork Root River near Houston. The call to the West Salem gage reader is made by Lock and Dam No. 7 staff since it is a local call. The stage on the Root River near Houston is obtained by calling the voice modem. The stage on the South Fork Root River is obtained from the satellite telemetry presented on the Water Control web site at www.mvp-wc.usace.army.mil. All stages are converted to discharge using the latest rating tables (**Exhibits B, C** and **D**). An example of all the data given to Water Control is presented on page 7-13. The Stevens PAV-C strip charts containing the continuous record of pool and tailwater elevations are mailed to Water Control at least once a year where they are then periodically micro filmed.

During the winter months, percent of ice coverage over the lower pool and upper tailwater, ice thickness, snow depth, and snow-water content (all in inches) are recorded once a week on Mondays. The snow-water content is determined by instructions contained in the National Weather Service Observing Handbook No. 2.

c. Maintenance. All the gage equipment associated with the operation of Lock and Dam No. 8 is owned by the Corps of Engineers. The gages at the dam, La Crosse and West Salem are maintained the Water Control Gage Crew. The US Geological Survey maintains the gages at Brownsville and Houston under a cooperative agreement with the St. Paul District. The Water Control Gage Crew provides emergency backup. Dam personnel maintain the Stevens PAV-C strip chart recorders with the Gage Crew used as a backup if necessary. The anemometer, water temperature sensor, and standard precipitation gage are maintained by site personnel; however should the precipitation gage become damaged, a new one would be mailed to the site from Water Control. The Fischer-Porter precipitation gage is maintained by the National Weather Service. Repair of the snow survey equipment is the responsibility of the Water Control Gage Crew.

5-02. Water Quality Stations. There are no water quality stations in Pool No. 8; however, site personnel may be asked, on occasion, to assist district office personnel or contractors to collect water samples and/or water quality measurements in the project area.

5-03. Sediment Stations. Suspended sediment data was collected at several locations in Pool No. 8 and its tributaries. Gage locations where discrete samples were taken are listed in Table 5-2.

Table 5-2
Sediment Data Collection Sites

Location	River	USGS Gage #	Sampling Time Period
La Crescent, MN	Mississippi River (West Channel)	05380600	1998
La Crosse, WI	Mississippi River	05380500	1965 to 1979
La Crosse, WI	La Crosse River	05383075	1998
West Salem, WI	La Crosse River	05383000	1978
Houston, MN	Root River	05385000	1961 to 1981

Since 1998, there has been no sampling in Pool No. 8; however, routine dredging of sediment is part of the nine-foot navigation plan. There are several sites in Pool No. 8 that require periodic dredging due to sedimentation. Dredging is the responsibility of the St. Paul District's Fountain City Boat Yard located at Fountain City, Wisconsin. As soon as the ice leaves the river, hydrographic surveys are made to get an early indication of channel conditions. After spring high water, surveys of the historic problem spots are performed. Equipment is lined up and a priority list is made. **Table 5-3** gives a summary of dredging in Pool No. 8 and in the lower lock approach since 1970.

Table 5-3
Summary of Dredging Activity – 1970 through 2000

Cut Name	River Mile	Avg. Vol. Per Year	Avg. Vol. Per Job	Freq. of Dredging	Last Year Dredged
Lower Approach LD 7	702	390	12,089	3	1973
La Crosse R.R. Bridge	699.8-700.4	7,106	36,717	19	1992
Below La Crosse R.R. Bridge	698.7-699.4	723	11,203	6	1998
La Crosse	698.6-698.7	262	8,113	3	1989
Sand Slough	694.3-695.0	2,542	78,790	3	1970
Root River	693.5-693.7	500	15,493	3	2000
Picyune Island	691.4-692.4	2,476	38,383	6	1973
Above Brownsville	689.9-690.8	22,434	38,636	58	2000
Brownsville	688.7-689.4	21,875	30,824	71	1999
Head of Raft Channel	687.5-688.7	15,633	34,615	45	1999
Deadman's Slough	686.5-687.5	1,573	24,386	6	1989
Lower Approach LD 8	678.7-679.2	488	5,042	10	1988

5-04. Recording Hydrologic Data. Daily log sheets containing pool and tailwater elevations, roller and tainter gate settings, air temperature, precipitation, water surface elevations at La Crosse, Wisconsin and Brownsville, Minnesota, maximum and minimum air temperature, water temperature and wind speed and direction are kept at the lock and dam. All daily data received by Water Control from the dam site is now complied and archived using Hydraulic Engineering Center's Data Storage System (HEC-DSS) and is accessible from the Water Control web site. In 2001, log sheets were made available on the Water Control web site at *www.mvp-wc.usace.army.mil*. By using the lock and dam data stored in DSS files, log sheets were generated dating back to January 1993. Water Control also maintains DSS files of hourly stage/elevation data for the gages located at La Crosse, Brownsville, Root River, and South Fork Root River beginning 1 December 1997. The US Geological Survey (USGS) maintains a discharge for the Root River near Houston. The data are archived in the USGS WATSTORE data base in Reston, Virginia and are available from the annual publication of the USGS Water-Data Report, Water Resources Data, Minnesota. The daily record of max-min temperature, precipitation, weather characteristics, river stages, and general remarks are recorded on National Weather Service (NWS) Form B-91. This form is mailed at the end of each month, along with the punched tape from the Fischer-Porter gage, to the NWS in La Crosse, Wisconsin.

5-05. Communication Network. The communication network consists of computer terminal, T1 line, telephone, pager, facsimile, FM radio, voice modem, satellite, and the US Postal Service. Computer communication is done via e-mail, and "sig-na-term" which allows remote access to the Water Control network. When the computer is down, the transfer of data is by facsimile, telephone, or FM radio. During non-duty hours on weekends and holidays, dam personnel can contact the river regulator by calling the pager number (612-660-8053). The gage sites on the Mississippi River at La Crosse and Brownsville, as well the gages on the Root River and the South Fork Root River near Houston, send hourly stage/elevation data via satellite to Water Control. This information is made available to the dam site from the Water Control web site; *www.mvp-wc.usace.army.mil*. All but the La Crosse River at West Salem and the South Fork Root River near Houston gages have voice modem and can be contacted by telephone for immediate stage information. A T1 line ensures communication between Water Control and the Mississippi River Valley Division Office (MVD) in Vicksburg, Mississippi. Bulk items like Stevens PAV-C strip charts are delivered to Water Control through the postal service.

5-06. Communication with Project.

a. **Regulating Office with Project Office.** Dam site personnel input and transmit their data, via computer, to Water Control every day by 0630-hours. Water Control issues orders to Lock and Dam No. 8 every morning at approximately 0800-hours during the navigation season and around 0730-hours during the non-navigation season. Orders are typically delivered via e-mail; however, FM radio is available as backup, with the telephone serving as backup to the radio. Should the dam site have computer problems, such that the transfer of data is not possible, a facsimile is then sent to Water Control (651-290-5841). The Water Control river manager then enters the information into the Regulation Program and Information Management (IM) is notified of the computer problem. Communication with the project after orders are delivered is typically by telephone.

b. **Between Project Office and Others.** The general public has access to river level and discharge data by calling Water Control's "Corps of Engineers River Information Service" at 651-290-5861. This service provides a recording of daily stages/elevations and discharges along the Mississippi River. In addition, the Water Control web site at www.mvp-wc.usace.army.mil also provides river information to the general public. From here the public can access current water surface elevations for the Mississippi River as well as the daily log sheets for the locks and dams. Notifications of severe weather or impending unusual conditions are handled through local law enforcement, civil defense authorities, and the National Weather Service.

5-07. Project Reporting Instructions. The project staff reports hydrologic and climatic conditions to Water Control every morning. The lock operator may make gate changes required to remain within the pool band issued by Water Control provided it is less than ten percent of the total river flow. If the pool goes out of the band after 0400-hours, no gate changes are to be made by project staff until Water Control issues its morning orders. Gate changes to aid work efforts (e.g. painting) are to be coordinated with Water Control. Problems with machinery that operate the gates are to be reported to Water Control Section and Construction-Operations Division.

5-08. Warnings. In the event the lock operator makes a gate change to remain within the pool band issued by Water Control, Lock No. 8 personnel should notify Lock No. 9 of the cut or opening that was made. In the event of a gate failure, communications must be established as quickly as possible with the Water Control Section and the Construction-Operations Division. The installation of any bulkheads must be coordinated with Water Control.

VI – HYDROLOGIC FORECASTS

6-01. General. During periods of low flow, the gates at the dam are regulated to pass inflow under pooled conditions, while during high flow they are raised free of the water surface and except for a slight swellhead due to the effect of the piers, the dam offers little obstruction to the flow. The storage capacity created by the dam is relatively small as compared with the volume of flow and inasmuch as the dam is out of operation at high discharges, the use of the dam to control floods is not possible. The lock goes out of operation at elevation 635.5 feet (1912 adjustment) at which time water is within half a foot of the top of the upstream miter gates. The timing and elevation of the crest is important for planning sand bagging operations and forecasting when the lock would go out of operation. In addition the timing on the receding limb of the hydrograph aids in determining when the lock would go back into service. In 1997, the St. Paul District developed an unsteady-flow model of the Mississippi River. The Mississippi Basin Model System utilizes the computer program UNET for forecasting purposes.

a. **Role of the Corps.** The St. Paul District previously relied solely on the National Weather Service (NWS) for Mississippi River forecasts. However, the NWS only forecasts for designated sites along the Mississippi River. The nearest forecast site to Lock and Dam No. 8 is La Crosse, Wisconsin. Also, the NWS forecast typically is only a five-day forecast with a projected crest height and date. The District saw a need for a model to forecast not only the time and elevation of the crest at the dam for planning sand bag operations, but also the receding limb for forecasting when the lock may go back into operation. In 1997, the District developed such a model. It is called the Mississippi Basin Model System (MBMS) and utilizes the unsteady flow program UNET. The river regulator in the Water Control Section runs the MBMS model every morning. For the flood events of 1997 and 2001, the model provided excellent predictions of when the crest would occur and when the lock would be placed back into operation. This was of great use to planning sand bagging efforts, work scheduling, and keeping the towing industry abreast of the situation.

b. Roles of Other Agencies. The National Weather Service (NWS) electronically provides the District forecasted flow hydrographs of the major tributaries to the Mississippi River by 0830-hours daily. Water Control Section inputs these hydrographs into the Mississippi Basin River System model and makes a run. The results are then electronically transferred to the NWS River Forecast Center in Chanhassen, Minnesota by 0930-hours. The NWS uses the UNET results and the results from their Mississippi River forecast model to provide stage forecasts at various points along the Mississippi River. The forecast site for Pool No. 8 is the control point at La Crosse, Wisconsin.

6-02. Flood Condition Forecasts. Since 1997, St. Paul District has been using the Mississippi Basin Modeling System (MBMS) to forecast flood conditions at Lock and Dam No. 8. The system utilizes UNET, which is an unsteady flow computer program. UNET was modified to simulate navigation dams according to operating rules. While the program allows the operating rules to vary according to the season, it does not account for gate operation. Therefore, model results are limited while the dam is in a regulated condition. Flow and stage data are required to provide the boundary conditions that drive the model. Observed stages are updated daily. The model is dependent upon forecasted tributary inflow. The National Weather Service (NWS) electronically mails the five-day forecasted discharge hydrographs for the major tributaries to Water Control by 0830-hours daily. The hydrographs typically include the 24-hour quantitative precipitation forecast (QPF). Water Control extrapolates the tributary discharge hydrographs to 30-days. Forecasts beyond 5-7 days are very approximate due to unknowns such as additional rainfall. Therefore, only the five-day forecast for the locks and dams is made available to the public via the Water Control web site; *www.mvp-wc.usace.army.mil*. The 30-day forecast is available to Corps personnel through the Intranet.

Modeling efforts as part of the Corps of Engineers Water Management System (CWMS) began in 2001. CWMS will contain hydrologic and hydraulic models of the District's reservoirs and the locks and dams. When the Mississippi River portion of CWMS becomes deployed and operational, the functionality of the MBMS model will be replaced. Rather than using UNET, CWMS will use a HEC-RAS unsteady flow model. The sharing of data with the NWS will remain unchanged.

6-03. Long-Range Forecasts. The Mississippi Basin Modeling System (MBMS) is used for making long-range forecasts. It is run everyday at about 0930-hours. The model forecasts elevation and discharge for the locks and dams and control points 30-days out. However, as previously noted, the five-day tributary inflow provided by the National Weather Service only includes the 24-hour quantitative precipitation forecast (QPF). Therefore, judgment is required when looking at long-range forecasts.

6-04. Drought Forecast. The lock and dam system operates as "run of the river". That is what ever flow enters the pool is passed on. During low flow, the project pool elevation is maintained provided there is sufficient inflow to meet withdrawal needs and pool evaporation. There is no drought forecasting model other than the Mississippi Basin Modeling System previously discussed.

VII - WATER CONTROL PLAN

7-01. General Objectives. The general objective of the water control plan is to maintain a minimum depth of nine feet along the navigation channel of Pool No. 8, without inducing higher stages during flood events. Project pool elevation for Lock and Dam No. 8 is 631.0 ± 0.2 feet (1912 adjustment). The control point for this elevation was established near the intersection of the ordinary high water line and the project pool elevation. For Pool No. 8, the "primary control point" is located just downstream of the Highway 16 bridge crossing the Mississippi River at La Crosse, Wisconsin (see **Figure 5-1**). Maintaining project pool elevation at this location during periods of low flows ensures a minimum channel depth of nine feet; however, periodic dredging is required.

The dam has minor localized impacts during flood events. The required spillway area at the dam was designed such that when all the gates are out of the water, the swellhead produced by the piers is less than one foot. Long before flood stage is reached, all the gates are raised above the water surface so that natural open river conditions exist during the flood period.

7-02. Constraints.

a. Pool Levels. For low discharges, the pool is maintained at elevation 631.0 ± 0.2 feet (1912 adjustment) at the primary control point at La Crosse, Wisconsin. This is "project pool" or "normal pool" for Lock and Dam No. 8 and was mandated by the 79th Congress (1st Session, House Document No. 137, 9 December 1931). As discharges increase, there is a "drawdown" in the water surface elevation at the dam. The drawdown elevation is based on necessary navigation depths upstream of the dam. Drawdown at the dam was first established at 3.5 feet below project pool level. Because this drawdown impacted navigation, it was reduced to 2.0 feet in 1941. It was further reduced in 1963 to 1.5 feet because it was felt at he time that wide fluctuations in pool level would have an adverse effect on navigation, riverfront property, and conservation interests. The final reduction came in 1971 when the process of over-dredging stopped. Maximum drawdown at the dam was established at one foot. Therefore, drawdown at the dam is constrained to elevation 630.0 ± 0.2 feet.

b. Maximum Outflow Velocity. Downstream scour protection limits outflow velocities from the roller and tainter gates. The design plan set maximum outflow velocities at 4.5 feet per second for standard operating procedures with an allowance to go to 6.0 feet per second for an emergency situation. In 1983, additional riprap was placed upstream and downstream of the dam. Since this time, routine maximum gate openings have been computed based on a maximum outflow velocity of 6.0 feet per second. The design velocity of 6.0 feet per second may be exceeded for short periods of time (15 to 20 minutes) during emergency operations (e.g. barge incident, passing of debris).

c. Open River Conditions. The dam is "out of control" when the gates are raised clear of the water surface and "open river conditions" exist. This typically happens when the differential head is less than one foot and the discharge is around 95,000 cfs. When gates are put back in the water, the total gate openings are 75 feet on roller gates and 100 feet on tainter gates.

d. Closure of the Lock to Navigation. Prior to 1995, the lock would close to navigation when high water dictated the removal of the miter gate motors. This occurred when the upper pool reached elevation 633.5 feet (1912 adjustment). As part of the major rehabilitation work in 1995, the motors were raised; therefore, the lock can now technically remain open to navigation provided water is not spilling over the upper miter gates of the main lock. This occurs at elevation 636.0 feet. While this is the physical constraint, closure has been established at elevation 635.5 feet due to wave action over the miter gates. Closure to navigation by the Coast Guard often occurs before this elevation is reached.

The lock is also closed when ice is too thick to permit tow traffic. As winter approaches, the lock remains open as long as towboats and barges can travel. Water temperatures are monitored to predict lock closure. When temperatures approach the low 30's, ice can form overnight and can impact the entire pool. In early March the ice becomes thin enough for some tow traffic and the lock is opened. The following table shows some of the recent history of opening and closing dates for Lock and Dam No. 8.

Table 7-1
Spring Opening and Fall Closing Dates

Year	Opening Date	Closing Date	Year	Opening Date	Closing Date
1972	16 Mar	13 Dec	1987	09 Mar	01 Dec
1973	7 Mar	06 Dec	1988	19 Mar	01 Dec
1974	13 Mar	14 Dec	1989	26 Mar	25 Nov
1975	19 Mar	15 Dec	1990	12 Mar	30 Nov
1976	02 Mar	19 Dec	1991	21 Mar	25 Nov
1977	23 Mar	18 Dec	1992	07 Mar	02 Dec
1978	03 Apr	30 Nov	1993	19 Mar	27 Nov
1979	29 Mar	05 Dec	1994	18 Mar	30 Nov
1980	25 Mar	05 Dec	1995	12 Mar	29 Nov
1981	06 Mar	04 Dec	1996	22 Mar	29 Nov
1982	23 Mar	08 Dec	1997	17 Mar	26 Nov
1983	02 Mar	18 Dec	1998	03 Mar	17 Dec
1984	03 Mar	01 Dec	1999	07 Mar	14 Dec
1985	16 Mar	01 Dec	2000	02 Mar	02 Dec
1986	20 Mar	05 Dec	2001	02 Mar	07 Dec

e. Maximum Number of Gates Closed. At times it is necessary to close one or more gates for maintenance purposes. All gate closures shall be coordinated with the river regulation desk at the Water Control Section. The maximum number of gates allowed to be closed will be at the discretion of Water Control based on conditions as they exist. **Table 7-2** was prepared based on outlet velocities of 4.5 feet per second. The table assumes **either** roller gates **or** tainter gates are being closed. Any mixing of roller gate and tainter gate closures would require additional evaluation by Water Control.

Table 7-2
Maximum Number of Gates Allowed to be Closed

Flow (cfs)	No. of Roller Gates Closed
Below 15,000	5
15,000 – 22,000	4
22,000 – 30,000	3
30,000 – 39,000	2
39,000 – 51,000	1
Above 51,000	0

Flow (cfs)	No. of Tainter Gates Closed
Below 30,000	10
30,000 – 33,000	9
33,000 – 35,000	8
35,000 – 38,000	7
38,000 – 41,000	6
41,000 – 44,000	5
44,000 – 48,000	4
48,000 – 51,000	3
51,000 – 55,000	2
55,000 – 60,000	1
Above 60,000	0

7-03. Overall Plan for Water Control.

a. General Plan. The navigation channel of Pool No. 8 is 300 feet wide along the straight reaches of the river and varies from 300 feet to 550 feet in the bends. The primary purpose of Lock and Dam No. 8, combined with periodic dredging, is to maintain a minimum depth of nine feet throughout the navigation channel without inducing higher stages during flood events. During flows of less than 23,000 cfs, the pool is fairly flat. To meet depth requirements in the upper pool requires the pool elevation at La Crosse, Wisconsin to be at elevation 631.0 feet (1912 adjustment). Therefore, "project pool" elevation for Lock and Dam No. 8 is 631.0 ± 0.2 feet, and La Crosse acts as the "primary control point" for maintaining this elevation. As discharges increase, gates are opened at the dam to maintain project pool at La Crosse. This results in a draw down in the water surface elevation at the dam. Maximum allowable drawdown is one foot below project pool elevation or 630.0 ± 0.2 feet. The lock and dam is now in "secondary control". As discharges continue to rise, gates are raised to maintain secondary control. At around 95,000 cfs, the differential head is reduced to less than one foot and it is no longer possible to maintain secondary control. At this time the gates are raised above the water surface and the dam is said to be "out of control" or in "open river conditions". On the recession limb of the hydrograph, the gates are put back into the water, maintaining secondary control, and as flow continues to decrease, control passes from secondary to primary. The operating curves, shown on **Plate 7-1**, were updated for this manual based on historical data.

Table 7-3 Control Conditions at Lock and Dam No. 8			
Control Conditions	**Approximate Discharge**	**La Cross Gage Elevation**	**Lock and Dam 8 Pool Elevation**
Primary	< 23,000 cfs	631.0 ft	≤ 631.0 ft
Primary to Secondary	23,000 to 28,000 cfs	> 631.0 ft	< 631.0 ft > 630.0 ft
Secondary	28,000 to 95,000 cfs	> 631.0 ft	630.0 ft
Open-River	> 95,000 cfs	> 631.0 ft	> 630.0 ft

b. Computed Discharge. Discharges are computed as part of the "River Program". Outflows were determined on a per foot opening basis for various heads. Flows through the dam are then computed based on the differential head and the gate settings. At high discharges when the gates are out of the water, discharges are computed based on the tailwater-rating curve. To prevent a discontinuity from computed outflows to the tailwater rating curve, outflows are transitioned to the tailwater rating.

Discharge ratings for the gates were originally developed based on laboratory tests with a hydraulic model. A Gate Regulation Schedule was developed based on gate discharge, maximum outflow velocity of 4.5 feet per second, and an effort to equally distribute flow across the dam. In 1973, the US Geological Survey measured outflows in the prototype. This resulted in a new relationship in the per foot discharge for the roller and tainter gates. The analysis also showed a slight change in the tailwater rating. These changes were presented in a new Gate Regulation Schedule (revised July 1973).

Included with the change in per foot discharge, was a reevaluation of the flow distribution across the dam. Flow was now to be distributed based on balancing outflow velocities. This schedule remained unchanged until 1983 when riprap was placed upstream and downstream of the dam. Based on this, the maximum outflow velocity was raised to 6.0 feet per second and hence the maximum gate openings were changed on the Gate Regulation Schedule to reflect this.

In 1996, the St. Paul District contracted with Toltz, King, Duvall, Anderson and Associates, Inc. (TKDA) to verify the measurements taken in 1973. The discharge measurements were made using an Acoustic Doppler Current Profiler (ADCP). Flow equations were developed for different head conditions. Some adjustments were required to produce a smooth curve. A comparison of the 1973 and 1996 results are shown on **Plate 7-3**. The 1996 results indicate similar discharge measurements at low head for the roller gates; however, at high head differentials, the ADCP showed greater discharge in the roller gates. The ADCP showed higher discharges for the tainter gates at all head values. The Gate Regulation Schedule was updated to reflect the change in discharge per foot opening of the gates. The distribution of flow was based on equalizing the outflow velocities. For example, consider a flow of 54,000 cfs and a respective head across the dam of 5.0 feet with a tailwater elevation of 624.98 feet. The discharge per foot opening for roller and tainter gates are 1,243 cfs and 692 cfs, respectively. By setting the roller gates at a total opening of 26.5 feet (26.5 x 1,243 = 32,900 cfs) and the tainter gates at 30.5 feet (30.5 x 692 = 21,100 cfs) gives a total discharge of 54,000 cfs. Outflow velocities are calculated based on $Q=VA$, where Q is the discharge in cfs, V is the flow velocity in fps, and A is the flow area in sq ft. Q is the discharge through one gate. Area is the gate width, plus one pier width, times the depth of flow over the end sill. Roller gates are 80-feet long with a pier width of 15 feet. Tainter gates are 35-feet long with a pier width of 8 feet. The respective end sill elevations for roller and tainter gates are 608.0 feet and 613.0 feet. Therefore, the flow velocities are:

<u>Roller Gate</u>
$Q = VA$
(26.5 ft/5 roller gates) 1,243 cfs = V (80 ft + 15 ft) (624.98 ft – 608.0 ft)
V = 4.08 ft/sec

<u>Tainter Gate</u>
$Q = VA$
(30.5 ft/10 tainter gates) 692 cfs = V (35 ft + 8 ft) (624.98 ft – 613.0 ft)
V = 4.10 ft/sec

To complete the update of the Gate Regulation Schedule to reflect the change in per foot discharge, also requires a change in the maximum allowable gate openings. Maximum allowable gate openings are based on flow velocity at the end sill downstream of the gates. Again, let's consider a discharge of 54,000 cfs and a differential head of 5.0 feet with a tailwater elevation of 624.98 feet. Based on $Q = VA$, where Q is the discharge per foot, times the maximum allowable gate opening, V is the maximum allowable flow velocity of 6.0 feet per second, and A is the flow area over the end sill for one gate, the following maximum allowable gate openings were determined.

<u>Roller Gate</u>
$Q = VA$
1,243 cfs (max gate opening in ft) = 6.0 fps (80 ft + 15 ft) (624.98 ft – 608.0 ft)
Max Gate Opening = 7.8 ft

<u>Tainter Gate</u>
$Q = VA$
692 cfs (max gate opening in ft) = 6.0 fps (35 ft + 8 ft) (624.98 ft – 613.0 ft)
Max Gate Opening = 4.5 ft

Table 7-4 shows the new Gate Regulation Schedule.

Table 7-4
Gate Regulation Schedule
5 Roller Gates and 10 Tainter Gates

Total Discharge cfs	Total Gate Opening in Feet		Elevation in Feet 1912 Adjustment		Head In Feet	Discharge (cfs) per Foot of Opening		Discharge (cfs)		Max Allowable Opening of a Gate	
	Rollers	Tainters	Pool	TW		Rollers	Tainters	Rollers	Tainters	Rollers	Tainters
10,000	3.5	3.5	631.00	620.20	10.80	1737	1099	6,100	3,850	4.0	1.7
11,000	4.0	3.5	630.98	620.30	10.68	1734	1094	6,950	3,850	4.0	1.7
12,000	4.5	4.0	630.96	620.40	10.56	1729	1081	7,800	4,300	4.1	1.8
13,000	5.0	4.0	630.94	620.50	10.44	1724	1076	8,600	4,300	4.1	1.8
14,000	5.5	4.5	630.92	620.60	10.32	1719	1064	9,450	4,800	4.2	1.8
15,000	5.5	5.5	630.90	620.70	10.20	1708	1047	9,400	5,750	4.2	1.9
16,000	6.0	5.5	630.86	620.80	10.06	1701	1042	10,200	5,750	4.3	1.9
17,000	6.5	6.0	630.83	620.90	9.93	1693	1031	11,000	6,200	4.3	2.0
18,000	7.0	6.0	630.79	621.00	9.79	1684	1025	11,800	6,150	4.4	2.0
19,000	7.5	6.5	630.76	621.10	9.66	1676	1014	12,550	6,600	4.5	2.1
20,000	7.5	7.5	630.72	621.20	9.52	1663	1000	12,500	7,500	4.5	2.1
21,000	8.0	8.0	630.65	621.30	9.35	1651	989	13,200	7,900	4.6	2.2
22,000	8.5	8.0	630.59	621.40	9.19	1639	981	13,950	7,850	4.7	2.2
23,000	9.0	8.5	630.52	621.50	9.02	1627	970	14,650	8,250	4.7	2.3
24,000	9.5	9.0	630.44	621.60	8.83	1612	958	15,300	8,600	4.8	2.3
25,000	10.0	9.5	630.35	621.70	8.65	1597	946	15,950	9,000	4.9	2.4
26,000	10.5	10.0	630.23	621.80	8.43	1579	932	16,600	9,300	5.0	2.4
27,000	11.0	11.0	630.12	621.90	8.22	1560	916	17,150	10,050	5.1	2.5
28,000	11.5	11.5	630.00	622.00	8.00	1541	902	17,700	10,400	5.2	2.6
29,000	12.0	12.0	630.00	622.10	7.90	1533	895	18,400	10,750	5.2	2.6
30,000	12.5	12.5	630.00	622.20	7.80	1525	888	19,050	11,100	5.3	2.7
31,000	13.0	13.0	630.00	622.31	7.69	1515	881	19,700	11,450	5.4	2.7
32,000	13.5	13.5	630.00	622.42	7.58	1506	874	20,300	11,800	5.5	2.8

Table 7-4 – Continued
Gate Regulation Schedule
5 Roller Gates and 10 Tainter Gates

Total Discharge cfs	Total Gate Opening in Feet		Elevation in Feet 1912 Adjustment		Head In Feet	Discharge (cfs) per Foot of Opening		Discharge (cfs)		Max Allowable Opening of a Gate	
	Rollers	Tainters	Pool	TW		Rollers	Tainters	Rollers	Tainters	Rollers	Tainters
33,000	14.0	14.0	630.00	622.53	7.47	1496	866	20,950	12,150	5.5	2.8
34,000	14.5	14.5	630.00	622.64	7.36	1486	859	21,550	12,450	5.6	2.9
35,000	15.0	15.0	630.00	622.75	7.25	1476	852	22,150	12,800	5.7	3.0
36,000	15.5	16.0	630.00	622.86	7.14	1466	843	22,700	13,500	5.8	3.0
37,000	16.0	16.5	630.00	622.97	7.03	1455	836	23,300	13,800	5.9	3.1
38,000	16.5	17.0	630.00	623.08	6.92	1445	829	23,850	14,100	5.9	3.1
39,000	17.0	18.0	630.00	623.19	6.81	1434	820	24,400	14,750	6.0	3.2
40,000	17.5	18.5	630.00	623.30	6.70	1423	813	24,900	15,050	6.1	3.3
41,000	18.0	19.5	630.00	623.42	6.58	1411	804	25,400	15,650	6.2	3.3
42,000	18.5	20.0	630.00	623.54	6.46	1399	796	25,900	15,900	6.3	3.4
43,000	19.0	21.0	630.00	623.66	6.34	1387	787	26,350	16,550	6.4	3.5
44,000	19.5	22.0	630.00	623.78	6.22	1374	778	26,800	17,100	6.5	3.6
45,000	20.5	22.0	630.00	623.90	6.10	1363	771	27,950	17,000	6.7	3.6
46,000	21.0	23.0	630.00	624.02	5.98	1350	763	28,350	17,550	6.8	3.7
47,000	21.5	24.0	630.00	624.14	5.86	1337	754	28,750	18,100	6.9	3.8
48,000	22.0	25.5	630.00	624.26	5.74	1323	744	29,100	18,950	7.0	3.9
49,000	22.5	26.5	630.00	624.38	5.62	1310	735	29,500	19,500	7.1	4.0
50,000	23.5	27.0	630.00	624.50	5.50	1297	727	30,500	19,650	7.2	4.1
51,000	24.0	28.0	630.00	624.62	5.38	1284	718	30,800	20,100	7.4	4.2
52,000	24.5	29.5	630.00	624.74	5.26	1270	709	31,100	20,900	7.5	4.3
53,000	25.5	30.0	630.00	624.86	5.14	1256	700	32,050	21,000	7.6	4.4
54,000	26.5	30.5	630.00	624.98	5.02	1243	692	32,950	21,100	7.8	4.5
55,000	27.5	31.0	630.00	625.10	4.90	1229	684	33,800	21,200	7.9	4.6

Table 7-4 – Continued
Gate Regulation Schedule
5 Roller Gates and 10 Tainter Gates

Total Discharge cfs	Total Gate Opening in Feet		Elevation in Feet 1912 Adjustment		Head In Feet	Discharge (cfs) per Foot of Opening		Discharge (cfs)		Max Allowable Opening of a Gate	
	Rollers	Tainters	Pool	TW		Rollers	Tainters	Rollers	Tainters	Rollers	Tainters
56,000	28.0	32.5	630.00	625.22	4.78	1214	674	34,000	21,900	8.1	4.7
57,000	29.0	33.5	630.00	625.34	4.66	1200	665	34,800	22,250	8.2	4.8
58,000	30.0	34.5	630.00	625.46	4.54	1185	655	35,550	22,600	8.4	4.9
59,000	31.0	35.0	630.00	625.58	4.42	1170	647	36,250	22,650	8.6	5.0
60,000	32.0	36.0	630.00	625.70	4.30	1155	637	36,950	22,950	8.7	5.1
61,000	32.5	38.0	630.00	625.82	4.18	1139	627	37,000	23,800	8.9	5.3
62,000	33.5	39.5	630.00	625.94	4.06	1123	617	37,650	24,350	9.1	5.4
63,000	34.5	41.0	630.00	626.06	3.94	1107	607	38,200	24,900	9.3	5.6
64,000	35.5	42.5	630.00	626.18	3.82	1091	597	38,750	25,350	9.5	5.7
65,000	36.5	44.0	630.00	626.30	3.70	1074	586	39,200	25,800	9.7	5.9
66,000	37.5	46.0	630.00	626.42	3.58	1057	576	39,650	26,500	9.9	6.0
67,000	38.5	47.5	630.00	626.54	3.46	1040	565	40,050	26,850	10.2	6.2
68,000	40.0	49.0	630.00	626.66	3.34	1023	555	40,900	27,200	10.4	6.4
69,000	41.0	51.0	630.00	626.78	3.22	1005	544	41,200	27,750	10.7	6.5
70,000	42.5	53.0	630.00	626.90	3.10	987	533	41,950	28,250	10.9	6.7
71,000	43.5	55.0	630.00	627.01	2.99	969	523	42,150	28,750	11.2	6.9
72,000	45.0	57.0	630.00	627.12	2.88	952	512	42,850	29,200	11.4	7.1
73,000	46.5	59.0	630.00	627.23	2.77	935	502	43,450	29,600	11.7	7.3
74,000	48.0	61.0	630.00	627.34	2.66	917	491	44,000	29,950	12.0	7.5
75,000	50.0	62.5	630.00	627.45	2.55	898	480	44,900	30,000	12.3	7.8
76,000	52.0	64.5	630.00	627.56	2.44	880	469	45,750	30,250	12.7	8.0
77,000	54.0	67.0	630.00	627.67	2.33	860	458	46,450	30,650	13.0	8.3
78,000	55.5	70.5	630.00	627.78	2.22	840	446	46,650	31,400	13.4	8.6

Table 7-4 – Continued
Gate Regulation Schedule
5 Roller Gates and 10 Tainter Gates

Total Discharge cfs	Total Gate Opening in Feet		Elevation in Feet 1912 Adjustment		Head In Feet	Discharge (cfs) per Foot of Opening		Discharge (cfs)		Max Allowable Opening of a Gate	
	Rollers	Tainters	Pool	TW		Rollers	Tainters	Rollers	Tainters	Rollers	Tainters
79,000	57.5	73.5	630.00	627.89	2.11	820	434	47,150	31,900	13.8	8.9
80,000	59.5	77.0	630.00	628.00	2.00	799	421	47,550	32,450	14.3	9.2
81,000	62.0	80.0	630.00	628.11	1.89	777	409	48,200	32,700	14.7	9.5
82,000	64.5	84.0	630.00	628.22	1.78	755	396	48,700	33,250	15.3	9.9
83,000	68.0	87.0	630.00	628.33	1.67	733	383	49,800	33,300	15.8	10.3
84,000	71.0	91.0	630.00	628.44	1.56	709	369	50,300	33,600	16.4	10.8
85,000	74.0	97.0	630.00	628.55	1.45	684	355	50,600	34,450	17.1	11.3
86,000	78.0	102.0	630.00	628.66	1.34	659	341	51,350	34,750	17.9	11.9
87,000	82.0	108.0	630.00	628.77	1.23	632	325	51,800	35,150	18.7	12.5
88,000	86.5	115.5	630.00	628.88	1.12	604	309	52,200	35,750	19.7	13.2
89,000	90.0	124.0	630.00	628.97	1.03	581	296	52,300	36,750	20.6	13.9
90,000	95.0	130.5	630.00	629.05	0.95	557	283	52,950	36,950	21.5	14.6
91,000	99.5	136.0	630.00	629.11	0.89	540	274	53,750	37,200	22.3	15.2
92,000	104.0	143.0	630.00	629.17	0.83	522	264	54,300	37,700	23.1	15.8
93,000	109.0	150.5	630.00	629.23	0.77	504	253	54,900	38,100	24.0	16.5
94,000	114.0	160.0	630.00	629.29	0.71	484	242	55,200	38,750	25.1	17.3
95,000	120.0	170.0	630.00	629.35	0.65	464	231	55,700	39,300	26.2	18.3
96,000	Out of Control – Gates clear of water. Put gates back in at 75 ft Roller Gates and 100 ft Tainter Gates.										

c. **Regulation Procedure.** Each morning at 0640-hours, the Water Control manager prints the Regulation Sheets containing all the input from the lock and dam sites. Regulation for Lock and Dam No. 8 begins at Lock and Dam No. 4. Gate changes at Lock and Dam No. 4 directly influence action needed at Dam No. 5, which in turn directly influences Dam No. 5A, and so on down to Lock and Dam No. 8. After regulating Lock for Dam 7, inflow to Pool No. 8 is determined. Inflow consists of outflow from Lock and Dam No. 7 (including Onalaska Dam), inflow from the La Crosse and Root Rivers, and any miscellaneous inflow. Outflow from Lock and Dam 7 is computed as part of the daily regulation. Lock and Dam 7 personnel call the voice modems at the gages located at La Crosse and Brownsville on the Mississippi River and enter the elevations. They also call the gage reader for the La Crosse River at West Salem gage and input the stage and discharge at their site. River stages for the Root River and South Fork Root River are directly input to River Program from their respective DCP's. The River Program computes discharge from a rating table and both stage and discharge are automatically input to the Regulation Sheet. Miscellaneous inflow will vary seasonally but for simplicity it is assumed to be a constant 500 cfs. This may be modified if precipitation has occurred in the last 24-hours. As a general rule, for each inch of rainfall that has fallen in past 24-hours, an additional 1,000 cfs is added to the miscellaneous inflow. Inflow is totaled and the 24-hour change is noted. Also noted is the change in outflow and any gate changes made in the past 24-hours. Next the rate of fall or rise of the pool is calculated. This is done at the dam and at the control point. Note the changes. Allow for wind at the dam. That is, adjust the pool elevation up or down 0.1 foot per 10 mph of wind (see **Section 4-04**). Determine if the pool is in primary or secondary control. Estimate the needed change in discharge to maintain the proper pool band. To aid in this assessment, it has been determined that a change in outflow of 1,200 cfs over a 24-hr period of time will result in about a one tenth of a foot change in the overall pool elevation. This value was computed based on the effective project pool area of 20,800 acres.

Once the needed change in discharge is determined, the Gate Regulation Schedule is used to distribute flow and hence set gate changes. The gate change information is e-mailed to the lock site and the St. Paul District's intranet at approximately 0800-hours each day. The orders are typically one of four types; (1) no change, (2) no change at present, (3) open a given amount of flow, or (4) cut a given amount of flow. A "no change at present" order is followed by an "if statement". For example, "if the pool falls to elevation 629.60 feet, cut 1 foot on roller gates". All "open" and "cut" orders include the anticipated gate change impact on flow. All four types of orders are followed by a "pool band" to be maintained at the dam. For example, "hold 629.7 ± 0.2 feet". As a final note, the orders may also include "allow for wind on the high side" or "allow for wind on the low side", if appropriate. Sometimes it is necessary to check back with the lock site in the afternoon. If this were the case, the site would be informed, via the morning's orders, that Water Control will be contacting them at a given time (typically 1400-hours). At that time, site personnel would provide present and noon pool and tailwater elevations, and present wind conditions. Water Control would then provide any gate change verbally over the telephone or via e-mail.

The following is a sample of the regulation of Lock and Dam No. 8. The portion printed in black represents the daily regulation sheet while that printed in blue represents regulation notes.

Regulation of Lock and Dam No. 8 for 23 September 2001

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Orders to LD 7:  Open 2 ft RG. Increase 2,600 to 20,500 cfs.
Note:  There were no gate changes at LD 7 in the past 24-
        hours.

                                            5-RG   10-TG  [primary = 631.00
gates in/out:  75/100 @ 96,000              Total  Total   for flow<24,000]
                | sec: |                    Roller Tainter     CP-8
LOCK 8          |630.00|   Tail     Flow    Gate   Gate    LaCrosse Brownsville
          ------------------------------------------        OBS7       TM7
22SEP01 0800    629.92   620.95   18500     7.0    8.0      630.68    630.44
        1200    629.98   620.87   17000     6.0    8.0 <--  Cut 1 ft
        1600    629.99   620.86   17000     6.0    8.0
        2000    630.00   620.83   17100     6.0    8.0
        2400    630.02   620.90   17000     6.0    8.0
23SEP01 0400    630.25   620.87   17300     6.0    8.0
        0630    630.30   620.89   17300     6.0    8.0        630.92   630.73
             up 0.38          dn 1200                       up 0.24  up 0.29
                                               West Salem  Houston   Houston, SF
phone   HEAD      9.4                             TM7        DCP        DCP
##033   Q/foot    1702/866                  Stage: 2.75       3.72       2.02
        temp.     58
        precip.   0.0                       Flow:   80        408        146
        wind (dir&speed)   360 @ 13

          INFLOW:
          L/D 7 -      20500                Orders:
          Lacrosse R.   100                 Open 2.0 ft on RG
          Root R.    -  600                 Inc. Flow 3,200 to 20,500 cfs
           1200 CFS -                       Hold 630.00 ± 0.2 ft
          Misc.     -   500                 AFW H.S.
                       21700
```

The following steps walk through the regulation procedure for this particular day. This is intended only as an example.

Step 1. Determine inflow to Pool 8.
- LD 7 Orders: Open 2,600 cfs and go to 20,500 cfs.
- La Crosse River is at 100 cfs and Root River is at 600 cfs.
- Miscellaneous inflow is 500 cfs.
- Rainfall was 0.0 inches.
- Total Inflow = 21,700 cfs (up 3,600 cfs from yesterday).

Step 2. Note change in outflow.
- Down 1,200 cfs due to gate change.

Step 3. Note change in pool elevation.
- Pool is up 0.24 feet at La Crosse.
- Pool is up 0.29 feet at Brownsville.
- Pool is up 0.38 feet at the dam.
- Wind is 13 mph out of the north
- Therefore, about 0.1 ft of increase at dam is due to wind.

Step 4. Primary or Secondary Control?
- Flow is less than 24,000 cfs; therefore, Primary Control.
- Primary Control is 631.00 ± 0.2 ft at La Crosse.

Step 5. Estimate needed change in discharge.

Inflow is up 3,600 cfs from yesterday.
The rise in pool is due to yesterdays 1-foot cut (1,500 cfs).
We need to increase pool elevation 0.08 feet at La Crosse.
Pool elevation will increase 0.1 foot per 1,200 cfs in 24 hrs.
Needed Change in Outflow: "opening made at LD 7" plus "stem rising pool" minus "needed rise in pool elevation at La Crosse".

"Increase Flow 2,600 + 1,500 - 900 = 3,200 cfs"

Step 6. Set gate change.

The Gate Reg Schedule shows ideal gate settings for 21,000 cfs to be 8.0 ft on RG and 8.0 ft on TG.
We are presently 6.0 on RG and 8.0 on TG.
Therefore, the entire gate opening will be on the Roller Gates.
The program indicates 1-foot change on RG's is 1702 cfs.
Yesterdays cut of 1-ft on RG's resulted in a change of 1,500 cfs.
A one-foot opening on RG's would increase outflow ~1,600 cfs.

"Open 2.0 ft on RG. Increases flow 3,200 to 20,500."

Step 7. Set the pool band.

After allowing for wind, present pool at dam is less than 630.2 ft.

"Hold elevation 630.00 ± 0.2 feet."
"Allow for Wind on the High Side"

d. Winter Regulation. Each year in early winter, the tainter gates are set at predetermined heights and are allowed to freeze in place. In late November, Water Control makes an estimate of the anticipated minimum base flow for the winter months. The estimate is based on the average flow from 1 October through 15 November and the minimum winter flow rate curve. The curve was developed using historic discharge information for the gage site at McGregor, Iowa. "Average October Flow" and "Average November Flow" were plotted against the "Minimum Winter Flow". Curves were drawn through the lowest data points. A composite curve was then developed. By entering the average flow for the period 1 October through 15 November, the anticipated minimum base flow can be selected from the curve. To determine what to set the tainter gates, we must first consider the roller gates. Because we are using the minimum base flow rate, we must consider minimum submerged roller gate settings. Roller gates can be submerged from 0.5 feet to 3.0 feet. Discharges for these and other gate settings are shown in **Table 7-5**.

Table 7-5 Discharge through Submerged Roller Gate – cfs							
Pool Elevation	**Head Feet**	**Depth of Submerged Gate**					
		0.5 ft	1.0 ft	1.5 ft	2.0 ft	2.5 ft	3.0 ft
631.0	10.0	280	620	1000	1440	1890	2220
	9.0	270	600	970	1400	1840	2170
630.9	10.0	260	590	960	1380	1820	2140
	9.0	250	560	930	1340	1780	2100
630.8	10.0	240	560	920	1340	1760	2070
	9.0	230	540	890	1300	1710	2030
630.7	10.0	220	530	880	1290	1700	2000
	9.0	210	510	850	1250	1650	1960
630.6	10.0	210	510	850	1240	1630	1920
	9.0	200	490	820	1200	1590	1880
630.5	10.0	190	490	820	1200	1580	1860
	9.0	180	470	780	1150	1530	1810
630.4	10.0	-	470	780	1160	1530	1800
	9.0	-	450	750	1120	1490	1750
630.3	10.0	-	450	750	1120	1490	1730
	9.0	-	430	730	1080	1430	1680
630.2	10.0	-	430	730	1080	1430	1670
	9.0	-	410	700	1040	1390	1620
630.1	10.0	-	410	700	1040	1380	1610
	9.0	-	400	680	1000	1340	1560
630.0	10.0	-	400	680	1010	1340	1560
	9.0	-	380	650	970	1290	1510
629.9	10.0	-	360	660	980	1300	1500
	9.0	-	340	630	940	1250	1460
629.8	10.0	-	-	650	950	1260	1460
	9.0	-	-	610	910	1220	1410
629.7	10.0	-	-	630	925	1220	1410
	9.0	-	-	600	885	1170	1360
629.6	10.0	-	-	620	900	1180	1360
	9.0	-	-	580	860	1140	1320
629.5	10.0	-	-	600	880	1160	1320
	9.0	-	-	570	840	1110	1270
629.5	8.0	-	-	530	800	1060	1220
	7.0	-	-	500	750	1010	1170

Roller gates are typically not submerged less than one foot due to ice interference. Therefore, the total discharge for all roller gates at one-foot submergence is deducted from the estimated minimum base flow. Tainter gate settings are then determined for the remainder of the flow. While two of the tainter gates can be submerged to 2.0 feet below project pool elevation, they are operated only in the raised position due to icing problems. The recommended tainter gate settings are sent to the Lockmaster for evaluation. The Lockmaster assesses the Water Control recommendations and makes the final decision on tainter gate settings before freeze up. Before ice begins to form on the pool, the roller gates are placed in a submerged position. Adjusting roller gates in the submerged position makes changes in discharge. When the roller gates are at an extreme setting and additional change in outflow is needed, a tainter gate, or tainter gates, must be freed up. Usually considerable time is spent steaming and chopping before an ice bound tainter gate becomes moveable.

Throughout the winter, the tainter valves in the lock walls are kept open one or two feet so that the lock chamber will remain ice free. In addition, the flow through the lock chamber reduces deposition of sediment.

During the winter, on the weekends and holidays, the shifts are limited to one person at the dam site. Two people are required to make a gate change. There is a one half hour over lap in the morning between the 0730 and 0800-hours. Therefore, Water Control makes an effort to get orders out by 0730-hours to prevent the third shift from hanging around on overtime to see if there is a gate change. Due to the limited staff at the site and the difficulty in moving the submerged roller gates, the tolerance for stage deviation is increased to plus or minus three tenths of a foot. That is, the La Crosse gage is typically maintained at elevation 631.0 ± 0.3 feet. A high pool level during the winter reduces oxygen depletion in the backwater areas, which benefits fish habitat. Therefore, Water Control operates on the high side of the band during winter months.

7-04. Standing Instructions to Lock and Dam No. 8 Staff. Lock and dam personnel are to maintain daily log sheets. Pool and tailwater elevations, and gate openings are recorded in 4-hour intervals beginning at 0400-hours. Wind speed and direction, and air temperature are recorded in 8-hour intervals begining at 0800-

hours. Elevations at La Crosse and Brownsville, maximum and minimum air temperature, water temperature, and precipitation are recorded daily. In addition, lock and dam personnel are to send via computer by 0630-hours, the last 24-hour data readings needed for regulation. This data includes pool and tailwater elevations (4-hr), discharges at the dam (computed internally every 4-hrs), gate settings (4-hr), precipitation (24-hr), air temperature (present), and wind speed and direction (present). All of the morning's readings are taken between 0600 and 0630-hours but are entered as being taken at 0800-hours to maintain the 4-hour interval. Max-min air temperature is taken at 1900-hours but is entered as a 24-hour reading. During the winter months, every Sunday the snow depth is measured and a snow-water equivalent is determined. Also pool and tailwater ice thickness is measured and an estimate is made of the percent of pool and tailwater ice coverage. Winter data are sent to Water Control via computer.

As noted, discharges at the dam are calculated internally on 4-hour intervals. They are based on pool and tailwater elevations and the gate settings. Total discharge includes flow through the roller and tainter gates (**Plate 7-3**), flow over the 937.5-foot Reno Submersible Dam and the 1,337.5-foot Hastings Submersible Dam (**Plate 7-2**), and flow through the two submerged culverts in the dams. When the gates are all raised clear of the water, a tailwater rating is used.

At 0645-hours everyday, the Water Control regulator analyzes the field data and at around 0800-hours, the daily orders for gate movements are sent to the site via e-mail. On weekends and holidays during winter operations, orders are sent by 0730-hours due to limited staffing at the dam site. Gate changes are then made as soon as possible. If Water Control has notified the site that they will contact them again at 1400-hours, site personnel will have the noon and present pool and tailwater elevations as well as any other pertinent information (e.g. wind speed and direction) available at that time.

Normal duty hours for Water Control are 0630 to 1500-hours during the week, and 0630 to 0930-hours on weekends and holidays. During the course of non-duty hours site personnel may make gate changes as necessary to stay within the pool band prescribed. The site is limited however to changes up to ten percent of the 1600-hour discharge. If a gate change greater than this is necessary, site personnel should contact the river regulator at home. If the need for a gate change becomes necessary at 0400-hours, no gate change will be made. Water Control will provide the necessary gate change and band limit with the morning's orders. The following is a list of Water Control personnel with river responsibilities. The first contact should be the person who issued the last orders. If that person is not available, contact should be made in the order listed below. The weekend pager number is 612-660-8053.

Table 7-6
Water Control Personnel Telephone Numbers

Name	Non-Duty	Office
Scott Bratten	651-436-6135	651-290-5624
Farley Haase	715-235-1928	651-290-5633
Ferris Chamberlin	651-653-7981	651-290-5619
Bob Engelstad	651-459-6343	651-290-5610

Lock personnel contacting Water Control personnel at home should have pool and tailwater readings, wind speed and direction, amount of precipitation since last report, latest discharge calculations, and all gate changes made since the morning gate change. If lock personnel have any questions regarding the Water Control order, they are to contact the regulator via telephone (651-290-5624) and the question will be resolved. During computer outages, log sheets will be faxed to Water Control Section (651-290-5841) and orders will be given via telephone.

In the event of a gate failure or any occurrence that will require the installation of the bulkheads, communications must be established as quickly as possible with Water Control Section and Construction and Operations (Con-Ops) Division. Under full head conditions at the dam, the force is too great to allow the installation of the bulkheads. Therefore, the operating head must be reduced. Water Control will coordinate gate movements with site personnel in preparation for installation and removal of the bulkheads.

7-05. Flood Control. Lock and Dam No. 8 has no flood control benefits. It is operated strictly for navigation. While it may seem possible that the pools be drawdown over the winter months to provide storage for spring runoff, this plan has no merit for two reasons. First the Anti-Drawdown Law (Public Law 697) of June 1948 prevents the drawdown of the pools during the winter months. Secondly, the storage volume that would be made available in the pool is insignificant in comparison to the flood flow volume. The pool would be filled in a matter of hours and would have no impact on the peak flood stage.

7-06. Recreation. The major recreation features for Lock and Dam No. 8 are fishing, hunting and boating. Construction of the lock and dam inundated the numerous wing dams that were constructed as part of the six-foot channel project. The inundated wing dams as well as the backwater areas provide excellent fish and waterfowl habitat. As for recreational boating, there were over 8,000 recreation boat lockages in the year 2000. **Table 7-7** shows a comparison of recreational to towboat lockages.

Table 7-7
Commercial & Recreational Lockages at Lock No. 8

Year	Towboats & Barges	Recreation Boaters	Other Lockages	Total Lockages	Percent Recreation
1991	1,502	7,015	131	8,646	81%
1992	1,607	8,437	81	10,125	83%
1993	1,007	4,159	58	5,224	80%
1994	1,160	9,281	120	10,561	88%
1995	1,408	8,680	140	10,228	85%
1996	1,517	7,724	111	9,352	83%
1997	1,376	9,281	101	10,758	86%
1998	1,499	9,578	109	11,186	86%
1999	1,568	9,625	93	11,286	85%
2000	1,497	8,468	78	10,043	84%

7-07. Water Quality. The Corps of Engineers does not perform any water quality analysis in Pool No. 8. However, as an element of the Environmental Management Program (EMP), the Corps of Engineers oversees the Long Term Resource Monitoring Program (LTRMP) of the Upper Mississippi River System. The LTRMP was implemented to provide decision makers with the information needed to maintain the Upper Mississippi River System as a viable multiple-use large river ecosystem. The LTRMP is being implemented by the US Geological Survey (USGS) in cooperation with the states of Illinois, Iowa, Minnesota, Missouri and Wisconsin with guidance and overall program responsibility by the Corps of Engineers.

7-08. Fish and Wildlife. Until 1970, during low to moderate flows, the only water flowing into Pool No. 9 was passed through the dam. In 1970, a 30-inch corrugated metal culvert was installed through the Reno submersible dam to provide aeration to backwater areas upstream and downstream of the dam. The headwall of the culvert is an arched, flat-bottomed opening, 65-inches wide by 45-inches high that provides for the installation and removal of stop logs. At project pool elevation of 631.0 feet, a continuous flow of 100 cfs is maintained through the culvert. At a later date, a corrugated metal culvert with similar dimensions was installed through the Hastings submersible dam to provide flow to Hastings Slough. At project pool elevation, a continuous flow of 100 cfs is maintained through the culvert. Although both culverts provide for the installation of stop logs to regulate flow, they are typically not used unless needed for making repairs.

Because the lock and dam was constructed for the purpose of navigation, the pool would sometimes be drawn down in non-navigation season. The 1948 Anti-Drawdown Law prevented any winter drawdown of the pool. The pool was to be regulated the same as during navigation season. A higher stage in the backwater areas during the winter months reduces the oxygen depletion. Because of this, Water Control typically operates on the high side of the winter band.

7-09. Water Supply. The cities of Brownsville, Minnesota and La Crosse, Wisconsin and the villages of Stoddard and Genoa, Wisconsin obtain their water from wells. Pool No. 8 does not provide water supply.

7-10. Hydroelectric Power. There is no hydroelectric power at Lock and Dam No. 8.

7-11. Navigation. The primary purpose of Lock and Dam No. 8 is to provide navigation. The lock is 110 feet wide and 600 feet long. In a single lockage, this will accommodate a towboat (about the same length as a barge) and two rows of three barges (typically 35 ft by 195 ft). On a double lockage, a maximum of 15 barges can be locked through. The first nine barges (three rows of three) enter the lock chamber and are broken free of the remainder. The haulage unit moves these through the lock and they are then tied to the guidewall. The towboat with the remaining six barges (two rows of three) passes through the lock and is rejoined with the nine other barges. Filling and emptying time for the lock under normal conditions is seven minutes. Lockage time for a double lockage depends on the experience of the deck hands breaking and making couplings, number of loaded and empty barges, wind speed and direction, flow conditions, and whether it is an up bound or down bound tow. A down bound tow will take longer due to outdraft conditions at the dam. On average, a double lockage takes about 1 hour and 30 minutes to 2 hours.

7-12. Emergency Action Plans. The Emergency Action Plan is a stand-alone document entitled *Emergency Plan for Lock and Dam 8, Genoa, Wisconsin*, August 1986. The plan addresses emergencies related to above normal reservoir water levels and/or rapid release of large volumes of water past the dam. It covers identification of impending or existing emergencies and notification of other parties concerning impending or existing emergencies. Potential causes of an emergency affecting the operation or safety of Lock and Dam No. 8 include excess seepage, sabotage, extreme storm, failure of earthen dike, and failure due to scouring.

There are several protective measures taken at Lock and Dam No. 8 when a flood occurs. When the pool level is forecasted to go above elevation 634.0 feet (1912 adjustment) material used to protect the earthen dike is to be stockpiled. This should take place prior to the pool reaching elevation 630.5 feet. As the pool continues to rises other actions are required. The following gives a brief summary of the steps to be taken as water levels go higher.

Pool Elevation	Action Taken
634.0 feet	Initial dike protection; protect limit switches.
636.0 feet	Lock closes to navigation.
637.0 feet	Control seepage in Central Control Station.
638.0 feet	Secure gratings; remove miter gate handrails.
638.5 feet	Protect fuel storage tanks.
638.8 feet	Sandbag around observation platform to keep water out of sewer.

7-13. Other. During a flood event, debris is passed beneath the gates as they are typically raised clear of the water. Debris that hangs up around the tainter gates may require assistance. This is handled after the peak has passed. During ice breakup, ice is passed over the submerged roller gates.

7-14. Deviation from Normal Regulation. Project pool elevation is mandated by Congress. While in primary control, the pool is to be maintained at elevation 631.0 ± 0.2 feet at the primary control point (La Crosse) as best as possible. During low flows, the pool is not to be intentionally raised above or lowered below this elevation; however, temporary deviations are permitted. Because these deviations are unplanned and are only temporary, while actions are being taken to correct the situation, these exceptions do not require notification of the division office. The Mississippi Valley Division office (MVD) must be notified when deviation outside the limits set by primary and secondary control is intentional and for a prolonged period of time. Planned deviations will be coordinated with MVD. A written request describing cause and effect will be sent to the Division Water Control Manager for approval. The District Commander or Chief of

Engineering Division may deviate from the approved plan in an emergency situation. The District will inform MVD as soon as possible. This will include a written confirmation of the deviation and description of the cause.

An example of a major deviation was the Pilot Pool Drawdown of Pool No. 8. River resource management agencies and the public had expressed interest in using the water-level management capabilities of the navigation dams to provide ecological benefits to the Upper Mississippi River. In response to this, the St. Paul District initiated a study to evaluate the potential for a greater drawdown of a navigation pool during the growing season to enhance conditions for growth of aquatic vegetation. Analysis and screening narrowed the potential pools to 5, 7, 8, and 9. Of these, Pool No. 8 was selected for a more detailed evaluation. The two-year plan was submitted to MVD and was approved. It was to be implemented from early July to mid-September 2000; however, because of the dry fall, it was postponed until 2001. The first year of the plan called for reducing the project pool from elevation 631.0 feet to 630.5 feet (1912 adjustment). Drawdown at the dam was set at 2.0 feet or elevation 628.5 feet.

The plan was implemented the first week of July 2001. The pool reached elevation 628.5 feet on the 6th of July 2001 and remained at or near this elevation until 12 August. Results of the drawdown showed an increase in vegetation growth in the lower pool.

In the second year of the plan (2002), the project pool elevation was reduced ¼ of a foot to elevation 630.75 feet, while drawdown remained at elevation 628.5 feet. Elevation 628.5 feet was achieved on the 2nd of July and lasted until the prescribed end on 16 September, at which time the pool was raised to the normal drawdown elevation of 630.0 feet at a rate of 0.2 feet per day. Again an increase in aquatic vegetation in the lower pool resulted as shown in **Figures 7-1 and 7-2**.

Figure 7-1. Raft Channel – River Mile 685 - 2 July 2002

Figure 7-2. Raft Channel – River Mile 685 - 22 July 2002

7-15. Rate of Release Change. The only guideline for rate of release change is the "ten percent rule" (**Section 7-04**). During Water Control's non-duty hours, lock and dam personnel may only make a gate change to remain within the prescribed band such that it does not exceed ten percent of the total flow. There are no other guidelines for rate of release change. Operation of the dam is basically run of the river. Therefore, rate of release change is nature driven.

VIII – EFFECT OF WATER CONTROL PLAN

8-01. General. The effect of the water control plan for Lock and Dam No. 8 is to maintain a nine-foot depth in the navigation channel of Pool No. 8. Lock and Dam No. 8 is just one piece of the lock and dam system that provides navigation from St. Louis, Missouri to Minneapolis, Minnesota. Navigation on the Upper Mississippi River progressed from a four-foot deep channel in 1866, to a four and one-half foot channel in 1878, to a six-foot channel in 1907, and finally, to a nine-foot channel in 1930's. A more complete description of this development is available in the Master Water Control Manual for the Locks and Dams.

8-02. Flood Control. The locks and dams provide no flood control benefits. They were constructed strictly for navigation purposes. The dam operates on a run-of-the-river principal. As discharge increases, the gates are opened. At around 95,000 cfs the gates are raised clear of the water surface. Therefore, for flood events, the only impact on the flow line is the swellhead at the dam, which is less than one foot.

8-03. Recreation. The project is not regulated for recreation purposes; however, it does provide recreational benefits. The three recreation qualities associated with Pool No. 8 are fishing, hunting, and boating. Project pool inundated the wing dams, constructed as part of the six-foot navigation project, and created backwater areas, which provide good fish and waterfowl habitat. While Lock and Dam No. 8 provides the necessary depths for the towing industry, it also is a benefit to recreational boating. The more stable water surface provides a more suitable environment for docks and marinas. There were over 8,000 recreation boat lockages in the year 2000.

8-04. Fish and Wildlife. Part of the Upper Mississippi River National Wildlife and Fish Refuge is located in Pool No. 8 and includes all but the navigation channel. The Refuge was established in 1924 to preserve the Upper Mississippi River for fish, migratory birds, other wildlife, and people. The Refuge includes acreage acquired by the US Fish and Wildlife Service and land acquired during the 1930's by the Corps of Engineers for the construction of the nine-foot navigation channel. Today, the refuge consists of about 200,000 acres of wooded islands, forest, prairie, marsh, and water extending 261 miles southward from Wabasha, Minnesota to just above Rock Island, Illinois. The refuge still remains relatively untouched by modern civilization.

8-05. Navigation. The Upper Mississippi River Nine-Foot Channel Project originated in the 1920's when it was promoted as a way to alleviate the Nation's worsening farm crisis. It was also aimed at allaying the inequities in commercial rail and water freight rates. The project was authorized by the Rivers and Harbors Act of 1930, with most of the locks and dams, including Lock No. 8, being constructed in the 1930's. The project was not without its controversy. For example, railroads claiming damage to their right-of-ways and conservationists fearing its effects on the environment. Ultimately, the economic benefits overrode all other concerns. After completion of the project, river traffic increased from 2,400,000 tons in 1939 to 68,400,000 in 1976. **Table 8-1** shows the recent history of tonnage commodities at Lock and Dam No. 8. For more historical information concerning the Nine-Foot Channel Project, see the Master Water Control Manual for the Locks and Dams.

Table 8-1
Lock and Dam No. 8 Tonnage – Commodities

Year	Coal	Petrol Product	Chemical Products	Crude Material	Manu Goods	Farm Products	Equip Mach	Misc Product	Total Tonnage
1991	1,183,400	620,800	1,403,100	790,000	625,100	10,444,200	7,000	93,000	15,166,600
1992	1,092,000	446,900	1,945,900	1,044,200	643,400	11,376,500	29,500	36,300	16,614,700
1993	1,100,900	185,100	1,822,700	863,400	408,200	5,444,200	15,000	22,300	9,861,800
1994	1,275,800	231,000	2,233,600	935,800	575,900	6,869,500	2,800	45,800	12,190,000
1995	778,200	545,400	1,782,200	1,074,100	625,500	8,619,300	21,300	144,300	13,590,300
1996	992,700	409,400	1,785,200	1,059,600	441,800	10,036,100	26,400	95,900	14,847,100
1997	951,200	515,200	1,631,400	1,397,100	560,300	8,815,400	19,200	146,400	14,036,200
1998	1,098,600	836,100	1,855,500	1,219,200	812,000	9,136,200	30,100	53,500	15,041,200
1999	1,118,500	567,000	1,611,100	1,142,500	1,033,900	11,215,400	22,100	115,500	16,826,000
2000	983,912	642,630	1,921,007	1,240,063	635,694	9,935,300	21,200	295,742	15,875,548

8-06. Frequencies. St. Paul District developed a discharge-frequency relationships in 2002 for the control point at La Crosse, Wisconsin. The La Crosse gage is about 5.5 miles downstream of Lock and Dam No. 7. The frequency curve displayed in **Figure 8-1** represents peak flow relationships for the Mississippi River at river mile 696.9. The frequency curve is derived from regionalized statistics for the mean and standard deviation, based on drainage area relationships at this location.

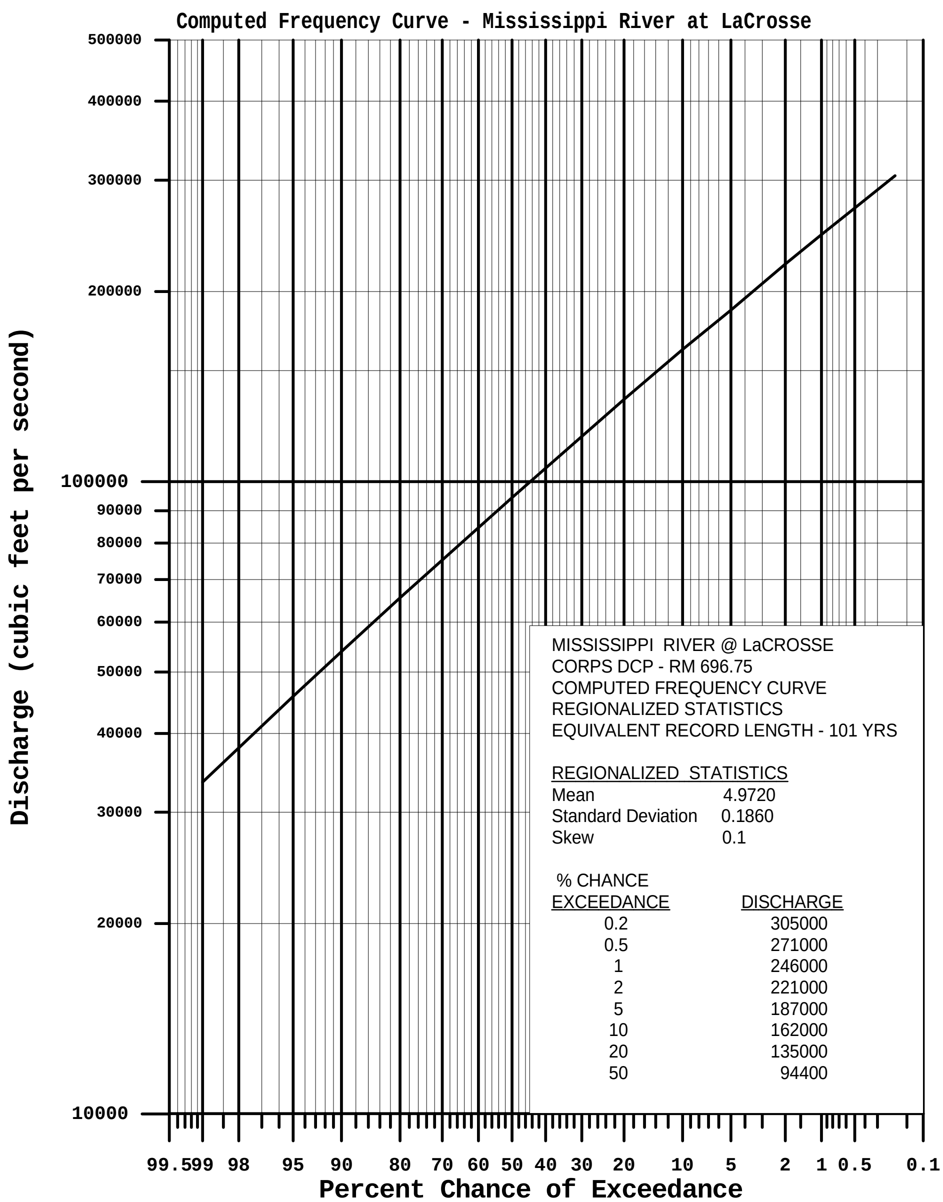


Figure 8.1 Mississippi River at LaCrosse – Discharge/Frequency

Construction of the dam was completed in April 1937. By July, project pool elevation was achieved. The following shows a history of the pool elevation. The high elevations represent flood events and the lows represent drawdown at the dam (typically secondary control). When in secondary control, the pool elevation at the dam was allowed to be drawn down 3.5-foot below project pool level to elevation 627.5 feet (1912 adjustment) until 1941 when it was reduced to elevation 629.0 feet. It was further reduced in 1963 to elevation 629.5 feet. The final reduction came in 1971 with maximum drawdown was established at elevation 630.0 feet. Prior to the Anti-Drawdown Law, passed by Congress in 1948, the pools were sometimes drawn down below primary and secondary elevations during the winter months. The greatest drawdown occurred in January 1944 when the pool was drawn down to elevation 620.88 feet.

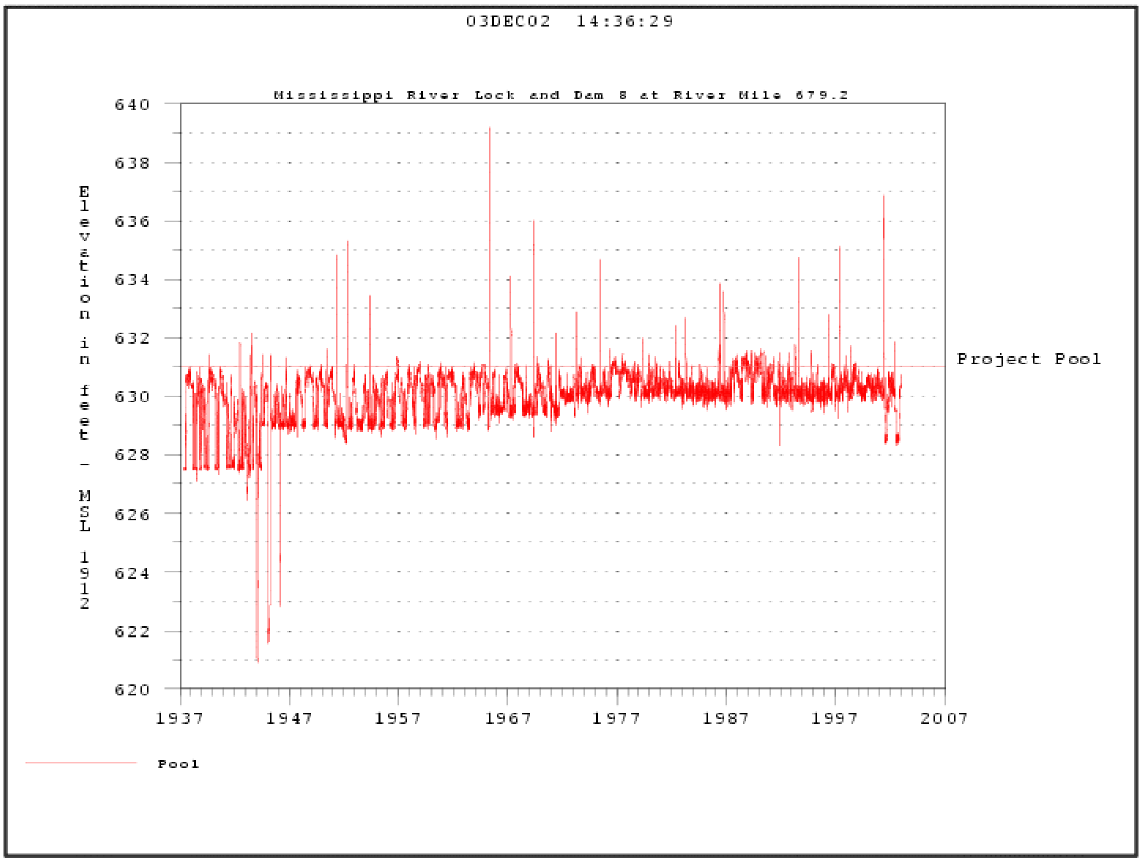


Figure 8-2. History of Pool Elevation

Water surface profile frequencies were developed in 1979 for Pool No. 8. The following figure shows how these profiles compare with historic floods. Note that the flood of 2001 was not documented at the time of this report.

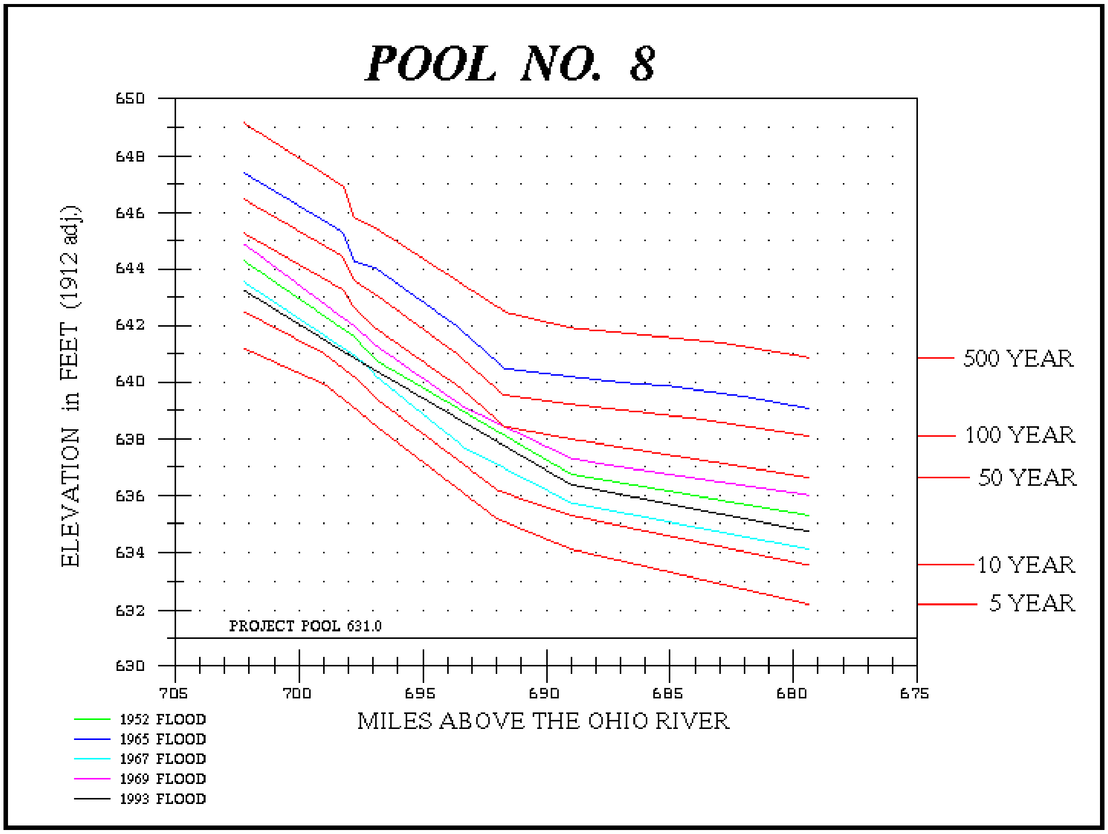


Figure 8-3. Water Surface Profiles - Flood Frequencies and Historic Floods

IX – WATER CONTROL MANAGEMENT

9-01. Responsibilities and Organization.

a. Corps of Engineers. The Corps of Engineers is the owner, operator, and regulator for Lock and Dam No. 8. The St. Paul District, Water Control Section has direct day-to-day responsibility for gate adjustments at the dam. Construction and Operations Division is responsible for operation and maintenance of the lock and the dam. The following shows the working relationship for the locks and dams within the St. Paul District.

St. Paul District Office

← ← ← District Engineer → → →

↓	↓
Chief Engineering Division	**Chief Con-Ops Division**
↓	↓
Chief H&H Branch	**Chief Lock & Dam Project Office**
↓	↓
Chief Water Control Section	**Area Lockmaster**
↓	↓

Water Control Manager → → → → → Lockmaster

b. Other Federal Agencies. During high water, the National Weather Service (NWS) forecasts stage heights for the control point at La Crosse, Wisconsin. Water Control Section provides the NWS with the daily output from the Mississippi Basin Modeling System to aid them in making their forecast. The US Geological Survey (USGS) maintains the gage sites at Brownsville, Minnesota (gage # 05386400), Root River near Houston, Minnesota (gage # 05385000) and South Fork Root River near Houston, Minnesota (gage # 05385500). Daily stage values for the Brownsville and Root River gages can also be obtained from the USGS link on the Water Control web site at www.mvp-wc.usace.army.mil. The US Fish and Wildlife Service (USFWS) operates and maintains the Upper Mississippi River National Wildlife and Fish Refuge, a portion of which is located in Pool No.8.

9-02. Interagency Coordination.

a. **Local Press and Corps Bulletins.** Information concerning regulation of Lock and Dam No. 8 is provided by the St. Paul District's Public Affairs Office (PAO) to the local news media in response to their requests. In addition, Construction and Operations Division coordinates with PAO to provide News Releases regarding the opening or closing of the lock to navigation.

b. **National Weather Service.** The National Weather Service (NWS) provides the St. Paul District a "Work 10" file daily by 0830-hours. The file contains the five-day forecast for tributaries to the Mississippi River lock and dam system. The five-day forecast includes the 24-hour quantitative precipitation forecast (QPF). These hydrographs are input to Mississippi Basin Modeling System which is an unsteady flow model utilizing the computer program UNET. After the model is run, the output is sent to the NWS by 0930-hours. The NWS uses this information to forecast stages along the Mississippi River, which includes La Crosse, Wisconsin in Pool No. 8.

c. **US Geological Survey.** To maintain the vast network of stream gages for operation of the locks and dams in the St. Paul District would be a costly undertaking. Because of the existing infrastructure of the US Geological Survey (USGS), the St. Paul District enters into a cooperative agreement each year with the USGS to maintain many of the gages on the Mississippi River and its tributaries. As for Pool No. 8, this includes the Mississippi River at Brownsville, Minnesota, the Root River near Houston, Minnesota and the South Fork Root River near Houston, Minnesota. St. Paul District owns all the gage equipment. The USGS publishes the daily discharges for Brownsville and Root River near Houston gages annually as part of their *Water Resources Data – Minnesota*. Daily data can be obtained from the USGS link on the Water Control web site at www.mvp-wc.usace.army.mil.

d. US Fish and Wildlife Service. The St. Paul District, in coordination with the US Fish and Wildlife Service, has constructed Habitat Rehabilitation and Enhancement Projects within the Upper Mississippi River National Wildlife and Fish Refuge located in Pool No. 8. The restoration projects consisted of the construction of eight islands totaling approximately 4.5 miles in length. The islands were created to reduce wave action in backwater areas, prevent further erosion of existing habitat and provide conditions necessary for the re-establishment of aquatic vegetation. The current islands are part of a five-phase project of island construction in lower Pool No. 8. See **Section 2-04** for photos.

e. River Resources Forum. The River Resources Forum and the subcommittee, Water Level Management Task Force, shares information and provides recommendations to the Corps of Engineers on river management. Participants include the US Fish and Wildlife Service, US Geological Survey, US Environmental Protection Agency, National Park Service, US Coast Guard, US Department of Transportation, Departments of Natural Resources of Minnesota and Wisconsin, Departments of Transportation of Minnesota and Wisconsin, and representatives of the commercial navigation industry.

9-03. Reports. "Water Log Sheet" is the name for the daily log of river and dam conditions. These are kept at the site. National Weather Service (NWS) Form B-91 contains pertinent weather information at the lock site. This is mailed to the NWS on the first of each month. The "Stevens Strip Charts" are sent to Water Control section at a minimum of once per year.

EXHIBIT A
SUPPLEMENTARY PERTINENT DATA

General Information

Location:	Mississippi River Mile 679.2 Genoa, Wisconsin Lat 43° 34' 12" N Long 91° 13' 54" W 23.3 miles below Lock and Dam No. 7 31.3 miles above Lock and Dam No. 9
Type of Project:	Lock and Dam for Navigation Purposes
Project Owner:	Corps of Engineers
Operating Agency:	St. Paul District; Construction-Operations Division
Regulating Agency:	St. Paul District; Water Control Section
Completion Date:	April 1937
Datum:	MSL – 1912 adjustment

Hydrology

Drainage Area:	64,770 square miles
Design Flood:	Flood of 1880 Design High Water: Elevation 635.8 ft Design Discharge: 193,000 cfs
Minimum Flow:	Of Record: 1933 Discharge 3,300 cfs Post Const, Nav-Season: Jul 1988 Discharge 6,600 cfs
Maximum Flow:	23 April 1965: Discharge 274,000 cfs
Average Annual Flow:	Years 1959-1993: Discharge 36,000 cfs
Maximum Monthly Flow:	April 1965: Discharge 165,000 cfs
Maximum Daily Flow:	23 April 1965: Discharge 265,900 cfs
Key Stream Flow Locations:	Mississippi River @ La Crosse, Wisconsin Mississippi River @ Brownsville, Minnesota La Crosse River @ West Salem, Wisconsin Root River near Houston, Minnesota S.F. Root River near Houston, Minnesota

Data Recorded at Dam Site:	Pool & Tailwater Elevations (4-hr) Roller Gate Discharge (4-hr) Tainter Gate Discharge (4-hr) Culvert Discharge (4-hr) Tainter Valve Discharge (4-hr, winter only) Total Discharge (4-hr) Gate Openings (4-hr) Wind Speed & Direction (8-hr) Air Temperature (8-hr) Precipitation (daily) Water Temperature (daily) Maximum-Minimum Air Temperature (daily) Snow Depth & Water Content (weekly) Percent Pool & Tailwater Ice Coverage (weekly) Pool & Tailwater Ice Thickness (weekly)
Precipitation Gages:	Lock & Dam No. 7, 8, and 9 Mississippi River @ Brownsville, MN Mississippi River @ La Crosse, WI
Snow Survey:	At LD No. 8 (weekly by site personnel) Root River Basin (late Feb by Gage Crew) Chatfield, Preston, and Rushford, Minnesota La Crosse River Basin (late Feb by Gage Crew) Sparta and Cashton, Wisconsin

Physical Features

Moveable Dam:	Roller Gates:	5 Gates	80 feet by 20 feet
	Tainter Gates:	10 Gates	35 feet by 15 feet
	Roller Gate Sill:		Elevation 611.0 ft
	Tainter Gate Sill:		Elevation 616.0 ft
	Roller Gate End Sill:		Elevation 608.0 ft
	Tainter Gate End Sill:		Elevation 613.0 ft
	Roller Gate Submergence:		3 feet below PP
	Bulkheads:	Roller Gates: 5 @	4'-2" by 85'-0.5"
		Tainter Gates: 4 @	4'-2" by 37'-6"
	Top of Bridge Deck:		Elevation 660.5 ft
Submersible Dams: (within earthen dam)	Length:		Reno - 937.5 feet Hastings – 1337.5 feet
	Crest Elevation:		Elevation 631.0 ft
	Culvert in Reno Spillway:		30-inch CMP
	Flow @ Project Pool:		100 cfs
	Culvert in Hastings Spillway:		30-inch CMP
	Flow @ Project Pool:		100 cfs

Earthen Dam:	Length:	15,720 feet
	Crest Elevation:	639.5 ft – 640.0 ft
	Top Width:	20 feet
	Maximum Height:	24 feet
	Pool Side Slope:	1V:3H
	Tailwater Slope:	1V:5.5 H
	Slope Protection:	12 inch riprap
	To crest on pool side.	
	To elevation 623.0 ft on TW side.	
Lock:	Main Lock Chamber:	110 ft by 600 ft
	Top of Lock Walls:	Elevation 639.0 ft
	Top of Upper Gate Sill (main):	Elevation 609.0 ft
	Top of Upper Gate Sill (aux):	Elevation 609.0 ft
	Top of Lower Gate Sill:	Elevation 606.0 ft
	Lock Chamber Floor:	Elevation 605.0 ft
	Height of Upper Miter Gates (main):	27.0 feet
	Height of Upper Miter Gates (aux):	27.0 feet
	Height of Lower Miter Gates:	30.0 feet
	Lift:	11.0 feet
	Upper Guidewall Length:	519 feet
	Lower Guidewall Length:	504 feet
	Freeboard @ Project Pool:	8 feet
	Average Filling/Emptying Time:	7 minutes
	Average Double Lockage Time:	1.5 to 2.0 hours
Pool:	Normal (Project) Upper Pool:	Elevation 631.0 ft
	Normal (Project) Lower Pool:	Elevation 620.0 ft
	Total Pool Area (at Project Pool):	20,800 acres
	Primary Control Point (La Crosse):	Elevation 631.0 ft
	Secondary Control Point (dam):	Elevation 630.0 ft
	Length in River Miles:	23.3 miles
	Navigation Channel Width;	
	Straight Reaches:	300 feet
	Curved Reaches:	300-550 feet
	Most Frequent Dredge Site:	Brownsville

EXPANDED RATING TABLE TYPE: LOG

05385000 DATE PROCESSED: 06-07-2000 @ 09:37 BY mitton

ROOT RIVER NEAR HOUSTON, MN DD: 7 TYPE: 001 RATING NO: 42.0

OFFSET: 2.00 START DATE/TIME: 06-01-2000 (0100)

Extended and shifted to right above 14.0 ft.

EXHIBIT B

Root River near Houston Rating Table

GAGE HEIGHT (FEET)	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	DIFF IN Q PER TENTH FT
	DISCHARGE IN CUBIC FEET PER SECOND (EXPANDED PRECISION)										
2.90	210.0*	213.5	216.9	220.4	224.0	227.5	231.0	234.6	238.2	241.8	35.40
3.00	245.4	249.1	252.7	256.4	260.1	263.8	267.5	271.3	275.0	278.8	37.20
3.10	282.6	286.4	290.2	294.1	297.9	301.8	305.7	309.6	313.5	317.4	38.80
3.20	321.4	325.4	329.4	333.4	337.4	341.4	345.5	349.5	353.6	357.7	40.40
3.30	361.8	365.9	370.1	374.2	378.4	382.6	386.8	391.0	395.2	399.5	41.90
3.40	403.7	408.0	412.3	416.6	420.9	425.2	429.6	433.9	438.3	442.7	43.40
3.50	447.1	451.5	455.9	460.4	464.8	469.3	473.8	478.3	482.8	487.3	44.80
3.60	491.9	496.4	501.0	505.6	510.2	514.8	519.4	524.1	528.7	533.4	46.10
3.70	538.0	542.7	547.4	552.1	556.9	561.6	566.4	571.1	575.9	580.7	47.50
3.80	585.5	590.3	595.2	600.0	604.9	609.7	614.6	619.5	624.4	629.3	48.80
3.90	634.3	639.2	644.2	649.1	654.1	659.1	664.1	669.1	674.2	679.2	50.00
4.00	684.3	689.3	694.4	699.5	704.6	709.7	714.9	720.0	725.1	730.3	51.20
4.10	735.5	740.7	745.9	751.1	756.3	761.5	766.8	772.0	777.3	782.6	52.40
4.20	787.9	793.2	798.5	803.8	809.2	814.5	819.9	825.3	830.6	836.0	53.50
4.30	841.4	846.9	852.3	857.7	863.2	868.6	874.1	879.6	885.1	890.6	54.70
4.40	896.1	901.6	907.2	912.7	918.3	923.9	929.5	935.0	940.7	946.3	55.80
4.50	951.9	957.5	963.2	968.8	974.5	980.2	985.9	991.6	997.3	1003	57.10
4.60	1009	1015	1020	1026	1032	1038	1043	1049	1055	1061	58.00
4.70	1067	1073	1078	1084	1090	1096	1102	1108	1114	1120	59.00
4.80	1126	1132	1138	1144	1150	1156	1162	1168	1174	1180	60.00
4.90	1186	1192	1198	1204	1210	1216	1222	1228	1234	1240	61.00
5.00	1247	1253	1259	1265	1271	1277	1284	1290	1296	1302	62.00
5.10	1309	1315	1321	1327	1334	1340	1346	1353	1359	1365	62.00
5.20	1371	1378	1384	1391	1397	1403	1410	1416	1423	1429	64.00
5.30	1435	1442	1448	1455	1461	1468	1474	1481	1487	1494	65.00
5.40	1500	1507	1513	1520	1526	1533	1539	1546	1553	1559	66.00
5.50	1566	1573	1579	1586	1592	1599	1606	1612	1619	1626	67.00
5.60	1633	1639	1646	1653	1659	1666	1673	1680	1686	1693	67.00
5.70	1700	1707	1714	1720	1727	1734	1741	1748	1755	1762	68.00
5.80	1768	1775	1782	1789	1796	1803	1810	1817	1824	1831	70.00
5.90	1838	1845	1852	1859	1866	1873	1880	1887	1894	1901	70.00
6.00	1908	1915	1922	1929	1936	1943	1950	1957	1965	1972	71.00
6.10	1979	1986	1993	2000	2007	2015	2022	2029	2036	2043	72.00
6.20	2051	2058	2065	2072	2080	2087	2094	2101	2109	2116	72.00
6.30	2123	2131	2138	2145	2153	2160	2167	2175	2182	2189	74.00
6.40	2197	2204	2212	2219	2226	2234	2241	2249	2256	2264	74.00

Extended and shifted to right above 14.0 ft.

GAGE HEIGHT (FEET)	DISCHARGE IN CUBIC FEET PER SECOND .00	.01	.02	.03	.04	.05	(EXPANDED PRECISION) .06	.07	.08	.09	DIFF IN Q PER TENTH FT
6.50	2271	2278	2286	2293	2301	2308	2316	2323	2331	2339	75.00
6.60	2346	2354	2361	2369	2376	2384	2391	2399	2407	2414	76.00
6.70	2422	2430	2437	2445	2452	2460	2468	2475	2483	2491	77.00
6.80	2499	2506	2514	2522	2529	2537	2545	2553	2560	2568	77.00
6.90	2576	2584	2591	2599	2607	2615	2623	2631	2638	2646	78.00
7.00	2654	2662	2670	2678	2686	2693	2701	2709	2717	2725	79.00
7.10	2733	2741	2749	2757	2765	2773	2781	2789	2797	2805	80.00
7.20	2813	2821	2829	2837	2845	2853	2861	2869	2877	2885	80.00
7.30	2893	2901	2909	2917	2925	2933	2942	2950	2958	2966	81.00
7.40	2974	2982	2990	2999	3007	3015	3023	3031	3040	3048	82.00
7.50	3056	3064	3072	3081	3089	3097	3105	3114	3122	3130	82.00
7.60	3138	3147	3155	3163	3172	3180	3188	3197	3205	3213	84.00
7.70	3222	3230	3238	3247	3255	3264	3272	3280	3289	3297	84.00
7.80	3306	3314	3323	3331	3339	3348	3356	3365	3373	3382	84.00
7.90	3390	3399	3407	3416	3424	3433	3442	3450	3459	3467	86.00
8.00	3476	3484	3493	3501	3510	3519	3527	3536	3545	3553	86.00
8.10	3562	3570	3579	3588	3596	3605	3614	3622	3631	3640	86.00
8.20	3648	3657	3666	3675	3683	3692	3701	3710	3718	3727	88.00
8.30	3736	3745	3753	3762	3771	3780	3789	3797	3806	3815	88.00
8.40	3824	3833	3842	3850	3859	3868	3877	3886	3895	3904	89.00
8.50	3913	3922	3930	3939	3948	3957	3966	3975	3984	3993	89.00
8.60	4002	4011	4020	4029	4038	4047	4056	4065	4074	4083	90.00
8.70	4092	4101	4110	4119	4128	4137	4146	4155	4165	4174	91.00
8.80	4183	4192	4201	4210	4219	4228	4237	4247	4256	4265	91.00
8.90	4274	4283	4292	4302	4311	4320	4329	4338	4348	4357	92.00
9.00	4366	4375	4384	4394	4403	4412	4421	4431	4440	4449	93.00
9.10	4459	4468	4477	4486	4496	4505	4514	4524	4533	4542	93.00
9.20	4552	4561	4570	4580	4589	4599	4608	4617	4627	4636	94.00
9.30	4646	4655	4664	4674	4683	4693	4702	4712	4721	4731	94.00
9.40	4740	4750	4759	4769	4778	4788	4797	4807	4816	4826	95.00
9.50	4835	4845	4854	4864	4873	4883	4892	4902	4912	4921	96.00
9.60	4931	4940	4950	4960	4969	4979	4988	4998	5008	5017	96.00
9.70	5027	5037	5046	5056	5066	5075	5085	5095	5105	5114	97.00
9.80	5124	5134	5143	5153	5163	5173	5182	5192	5202	5212	97.00
9.90	5221	5231	5241	5251	5261	5270	5280	5290	5300	5310	98.00
10.00	5319	5329	5339	5349	5359	5369	5379	5388	5398	5408	99.00
10.10	5418	5428	5438	5448	5458	5468	5478	5488	5498	5507	99.00
10.20	5517	5527	5537	5547	5557	5567	5577	5587	5597	5607	100.0
10.30	5617	5627	5637	5647	5657	5667	5677	5687	5698	5708	101.0
10.40	5718	5728	5738	5748	5758	5768	5778	5788	5798	5808	101.0

Extended and shifted to right above 14.0 ft.

GAGE HEIGHT (FEET)	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	DIFF IN Q PER TENTH FT
	DISCHARGE IN CUBIC FEET PER SECOND						(EXPANDED PRECISION)				
10.50	5819	5829	5839	5849	5859	5869	5879	5890	5900	5910	101.0
10.60	5920	5930	5941	5951	5961	5971	5981	5992	6002	6012	102.0
10.70	6022	6033	6043	6053	6063	6074	6084	6094	6104	6115	103.0
10.80	6125	6135	6146	6156	6166	6177	6187	6197	6208	6218	103.0
10.90	6228	6239	6249	6259	6270	6280	6290	6301	6311	6322	104.0
11.00	6332	6342	6353	6363	6374	6384	6395	6405	6415	6426	104.0
11.10	6436	6447	6457	6468	6478	6489	6499	6510	6520	6531	105.0
11.20	6541	6552	6562	6573	6583	6594	6604	6615	6626	6636	106.0
11.30	6647	6657	6668	6678	6689	6700	6710	6721	6731	6742	106.0
11.40	6753	6763	6774	6785	6795	6806	6817	6827	6838	6849	106.0
11.50	6859	6870	6881	6891	6902	6913	6923	6934	6945	6956	107.0
11.60	6966	6977	6988	6999	7009	7020	7031	7042	7052	7063	108.0
11.70	7074	7085	7096	7106	7117	7128	7139	7150	7160	7171	108.0
11.80	7182	7193	7204	7215	7226	7236	7247	7258	7269	7280	109.0
11.90	7291	7302	7313	7323	7334	7345	7356	7367	7378	7389	109.0
12.00	7400*	7414	7429	7443	7457	7472	7486	7501	7515	7530	144.0
12.10	7544	7558	7573	7587	7602	7616	7631	7646	7660	7675	145.0
12.20	7689	7704	7719	7733	7748	7762	7777	7792	7807	7821	147.0
12.30	7836	7851	7865	7880	7895	7910	7925	7939	7954	7969	148.0
12.40	7984	7999	8014	8029	8044	8058	8073	8088	8103	8118	149.0
12.50	8133	8148	8163	8178	8193	8208	8224	8239	8254	8269	151.0
12.60	8284	8299	8314	8329	8345	8360	8375	8390	8405	8421	152.0
12.70	8436	8451	8467	8482	8497	8512	8528	8543	8559	8574	153.0
12.80	8589	8605	8620	8636	8651	8666	8682	8697	8713	8728	155.0
12.90	8744	8760	8775	8791	8806	8822	8837	8853	8869	8884	156.0
13.00	8900*	8920	8939	8959	8979	8999	9019	9039	9058	9078	198.0
13.10	9098	9118	9138	9158	9178	9198	9218	9239	9259	9279	201.0
13.20	9299	9319	9340	9360	9380	9401	9421	9441	9462	9482	204.0
13.30	9503	9523	9544	9564	9585	9605	9626	9647	9667	9688	206.0
13.40	9709	9729	9750	9771	9792	9813	9833	9854	9875	9896	208.0
13.50	9917	9938	9959	9980	10000	10020	10040	10060	10090	10110	213.0
13.60	10130	10150	10170	10190	10210	10240	10260	10280	10300	10320	210.0
13.70	10340	10360	10390	10410	10430	10450	10470	10490	10520	10540	220.0
13.80	10560	10580	10600	10620	10650	10670	10690	10710	10730	10760	220.0
13.90	10780	10800	10820	10840	10870	10890	10910	10930	10960	10980	220.0
14.00	11000*	11030	11060	11090	11110	11140	11170	11200	11230	11260	290.0
14.10	11290	11320	11340	11370	11400	11430	11460	11490	11520	11550	290.0
14.20	11580	11610	11640	11670	11700	11730	11760	11790	11820	11850	300.0
14.30	11880	11910	11940	11970	12000	12030	12060	12090	12120	12150	300.0
14.40	12180	12210	12240	12270	12300	12330	12360	12390	12420	12450	300.0

Extended and shifted to right above 14.0 ft.

GAGE HEIGHT (FEET)	DISCHARGE IN CUBIC FEET PER SECOND .00	.01	.02	.03	.04	.05	(EXPANDED PRECISION) .06	.07	.08	.09	DIFF IN Q PER TENTH FT
14.50	12480	12520	12550	12580	12610	12640	12670	12700	12730	12770	320.0
14.60	12800	12830	12860	12890	12920	12960	12990	13020	13050	13080	310.0
14.70	13110	13150	13180	13210	13240	13280	13310	13340	13370	13410	330.0
14.80	13440	13470	13500	13540	13570	13600	13630	13670	13700	13730	330.0
14.90	13770	13800	13830	13870	13900	13930	13970	14000	14030	14070	330.0
15.00	14100*	14150	14200	14240	14290	14340	14390	14440	14480	14530	480.0
15.10	14580	14630	14680	14730	14780	14830	14880	14920	14970	15020	490.0
15.20	15070	15120	15170	15220	15270	15330	15380	15430	15480	15530	510.0
15.30	15580	15630	15680	15730	15790	15840	15890	15940	15990	16050	520.0
15.40	16100	16150	16200	16260	16310	16360	16420	16470	16520	16580	530.0
15.50	16630	16690	16740	16790	16850	16900	16960	17010	17070	17120	550.0
15.60	17180	17230	17290	17340	17400	17460	17510	17570	17620	17680	560.0
15.70	17740	17790	17850	17910	17960	18020	18080	18140	18190	18250	570.0
15.80	18310	18370	18430	18490	18540	18600	18660	18720	18780	18840	590.0
15.90	18900	18960	19020	19080	19140	19200	19260	19320	19380	19440	600.0
16.00	19500*	19570	19640	19710	19790	19860	19930	20000	20070	20150	720.0
16.10	20220	20290	20370	20440	20510	20590	20660	20730	20810	20880	740.0
16.20	20960	21030	21110	21190	21260	21340	21410	21490	21570	21640	760.0
16.30	21720	21800	21880	21950	22030	22110	22190	22270	22350	22430	790.0
16.40	22510	22580	22660	22740	22820	22910	22990	23070	23150	23230	800.0
16.50	23310	23390	23480	23560	23640	23720	23810	23890	23970	24060	830.0
16.60	24140	24230	24310	24390	24480	24560	24650	24740	24820	24910	850.0
16.70	24990	25080	25170	25250	25340	25430	25520	25610	25690	25780	880.0
16.80	25870	25960	26050	26140	26230	26320	26410	26500	26590	26680	900.0
16.90	26770	26860	26960	27050	27140	27230	27330	27420	27510	27610	930.0
17.00	27700*	27810	27920	28030	28140	28250	28360	28470	28590	28700	1110
17.10	28810	28930	29040	29150	29270	29380	29500	29610	29730	29850	1150
17.20	29960	30080	30200	30310	30430	30550	30670	30790	30910	31030	1190
17.30	31150	31270	31390	31510	31630	31760	31880	32000	32130	32250	1230
17.40	32380	32500*	32620	32730	32850	32970	33090	33210	33320	33440	1180
17.50	33560	33680	33800	33920	34040	34170	34290	34410	34530	34650	1220
17.60	34780	34900	35020	35150	35270	35400	35520	35650	35770	35900	1250
17.70	36030	36150	36280	36410	36540	36670	36790	36920	37050	37180	1280
17.80	37310	37440	37580	37710	37840	37970	38100	38240	38370	38500	1330
17.90	38640	38770	38910	39040	39180	39310	39450	39590	39720	39860	1360*
18.00	40000*										

EXHIBIT C

S.F. Root River near Houston Rating Table

1 UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY - WATER RESOURCES DIVISION PAGE 1

EXPANDED RATING TABLE TYPE: LOG

05385500 DATE PROCESSED: 03-19-2001 @ 10:56 BY mitton

SOUTH FORK ROOT RIVER NEAR HOUSTON, MN DD: 7 TYPE: 001 RATING NO: 17.0

OFFSET: .40 START DATE/TIME: 06-01-2000 (0100)

GAGE HEIGHT (FEET)	DISCHARGE IN CUBIC FEET PER SECOND (EXPANDED PRECISION) .00	.01	.02	.03	.04	.05	.06	.07	.08	.09	DIFF IN Q PER TENTH FT
.90	40.00*	41.03	42.07	43.11	44.16	45.22	46.28	47.34	48.41	49.49	10.57
1.00	50.57	51.66	52.75	53.84	54.95	56.05	57.16	58.28	59.40	60.53	11.09
1.10	61.66	62.79	63.93	65.08	66.22	67.38	68.53	69.70	70.86	72.03	11.55
1.20	73.21	74.39	75.57	76.76	77.95	79.14	80.34	81.55	82.75	83.97	11.97
1.30	85.18	86.40	87.62	88.85	90.08	91.31	92.55	93.79	95.04	96.29	12.36
1.40	97.54	98.80	100.1	101.3	102.6	103.9	105.1	106.4	107.7	109.0	12.76
1.50	110.3	111.5	112.8	114.1	115.4	116.7	118.1	119.4	120.7	122.0	13.00
1.60	123.3	124.6	126.0	127.3	128.6	130.0	131.3	132.6	134.0	135.3	13.40
1.70	136.7	138.0	139.4	140.8	142.1	143.5	144.8	146.2	147.6	149.0	13.60
1.80	150.3	151.7	153.1	154.5	155.9	157.3	158.7	160.1	161.5	162.9	14.00
1.90	164.3	165.7	167.1	168.5	170.0	171.4	172.8	174.2	175.7	177.1	14.20
2.00	178.5	180.0	181.4	182.8	184.3	185.7	187.2	188.6	190.1	191.5	14.50
2.10	193.0	194.5	195.9	197.4	198.9	200.3	201.8	203.3	204.7	206.2	14.70
2.20	207.7	209.2	210.7	212.2	213.7	215.2	216.7	218.2	219.7	221.2	15.00
2.30	222.7	224.2	225.7	227.2	228.7	230.2	231.8	233.3	234.8	236.3	15.20
2.40	237.9	239.4	240.9	242.4	244.0	245.5	247.1	248.6	250.2	251.7	15.40
2.50	253.3	254.8	256.4	257.9	259.5	261.0	262.6	264.2	265.7	267.3	15.60
2.60	268.9	270.4	272.0	273.6	275.2	276.7	278.3	279.9	281.5	283.1	15.80
2.70	284.7	286.3	287.9	289.5	291.1	292.7	294.3	295.9	297.5	299.1	16.00
2.80	300.7	302.3	303.9	305.5	307.2	308.8	310.4	312.0	313.6	315.3	16.20
2.90	316.9	318.5	320.2	321.8	323.4	325.1	326.7	328.4	330.0	331.7	16.40
3.00	333.3	334.9	336.6	338.3	339.9	341.6	343.2	344.9	346.5	348.2	16.60
3.10	349.9	351.5	353.2	354.9	356.6	358.2	359.9	361.6	363.3	364.9	16.70
3.20	366.6	368.3	370.0	371.7	373.4	375.1	376.8	378.5	380.2	381.9	17.00
3.30	383.6	385.3	387.0	388.7	390.4	392.1	393.8	395.5	397.2	398.9	17.00
3.40	400.6	402.4	404.1	405.8	407.5	409.3	411.0	412.7	414.4	416.2	17.30
3.50	417.9	419.6	421.4	423.1	424.8	426.6	428.3	430.1	431.8	433.6	17.40
3.60	435.3	437.1	438.8	440.6	442.3	444.1	445.8	447.6	449.4	451.1	17.60
3.70	452.9	454.7	456.4	458.2	460.0	461.7	463.5	465.3	467.1	468.8	17.70
3.80	470.6	472.4	474.2	476.0	477.7	479.5	481.3	483.1	484.9	486.7	17.90
3.90	488.5	490.3	492.1	493.9	495.7	497.5	499.3	501.1	502.9	504.7	18.00
4.00	506.5	508.3	510.1	511.9	513.8	515.6	517.4	519.2	521.0	522.8	18.20
4.10	524.7	526.5	528.3	530.1	532.0	533.8	535.6	537.5	539.3	541.1	18.30
4.20	543.0	544.8	546.7	548.5	550.3	552.2	554.0	555.9	557.7	559.6	18.40
4.30	561.4	563.3	565.1	567.0	568.8	570.7	572.6	574.4	576.3	578.1	18.60
4.40	580.0*	582.1	584.1	586.2	588.2	590.3	592.4	594.4	596.5	598.6	20.60

EXPANDED RATING TABLE TYPE: LOG

SOUTH FORK ROOT RIVER NEAR HOUSTON, MN DD: 7 TYPE: 001 RATING NO: 17.0
05385500 DATE PROCESSED: 03-19-2001 @ 10:56 BY mitton
OFFSET: .40 START DATE/TIME: 06-01-2000 (0100)

GAGE HEIGHT (FEET)	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	DIFF IN Q PER TENTH FT
	DISCHARGE IN CUBIC FEET PER SECOND					(EXPANDED PRECISION)					
4.50	600.6	602.7	604.8	606.9	609.0	611.0	613.1	615.2	617.3	619.4	20.90
4.60	621.5	623.6	625.7	627.8	629.9	632.0	634.1	636.2	638.3	640.4	21.10
4.70	642.6	644.7	646.8	648.9	651.0	653.2	655.3	657.4	659.6	661.7	21.20
4.80	663.8	666.0	668.1	670.2	672.4	674.5	676.7	678.8	681.0	683.1	21.50
4.90	685.3	687.5	689.6	691.8	693.9	696.1	698.3	700.4	702.6	704.8	21.70
5.00	707.0	709.1	711.3	713.5	715.7	717.9	720.1	722.3	724.4	726.6	21.80
5.10	728.8	731.0	733.2	735.4	737.6	739.8	742.0	744.3	746.5	748.7	22.10
5.20	750.9	753.1	755.3	757.5	759.8	762.0	764.2	766.4	768.7	770.9	22.20
5.30	773.1	775.4	777.6	779.9	782.1	784.3	786.6	788.8	791.1	793.3	22.50
5.40	795.6	797.8	800.1	802.4	804.6	806.9	809.1	811.4	813.7	815.9	22.60
5.50	818.2	820.5	822.8	825.0	827.3	829.6	831.9	834.2	836.5	838.7	22.80
5.60	841.0	843.3	845.6	847.9	850.2	852.5	854.8	857.1	859.4	861.7	23.00
5.70	864.0	866.3	868.7	871.0	873.3	875.6	877.9	880.2	882.6	884.9	23.20
5.80	887.2	889.5	891.9	894.2	896.5	898.9	901.2	903.5	905.9	908.2	23.40
5.90	910.6	912.9	915.3	917.6	920.0	922.3	924.7	927.0	929.4	931.7	23.50
6.00	934.1	936.5	938.8	941.2	943.6	945.9	948.3	950.7	953.1	955.4	23.70
6.10	957.8	960.2	962.6	965.0	967.4	969.7	972.1	974.5	976.9	979.3	23.90
6.20	981.7	984.1	986.5	988.9	991.3	993.7	996.1	998.5	1001	1003	24.30
6.30	1006	1008	1011	1013	1015	1018	1020	1023	1025	1028	24.00
6.40	1030*	1033	1036	1039	1042	1045	1048	1050	1053	1056	29.00
6.50	1059	1062	1065	1068	1071	1074	1077	1080	1083	1086	30.00
6.60	1089	1092	1095	1098	1101	1104	1107	1110	1113	1116	30.00
6.70	1119	1122	1125	1128	1131	1134	1137	1140	1143	1146	30.00
6.80	1149	1152	1155	1158	1161	1164	1167	1171	1174	1177	31.00
6.90	1180	1183	1186	1189	1192	1195	1198	1201	1205	1208	31.00
7.00	1211	1214	1217	1220	1223	1226	1229	1233	1236	1239	31.00
7.10	1242	1245	1248	1251	1255	1258	1261	1264	1267	1270	32.00
7.20	1274	1277	1280	1283	1286	1290	1293	1296	1299	1302	32.00
7.30	1306	1309	1312	1315	1318	1322	1325	1328	1331	1335	32.00
7.40	1338	1341	1344	1348	1351	1354	1357	1361	1364	1367	32.00
7.50	1370	1374	1377	1380	1383	1387	1390	1393	1397	1400	33.00
7.60	1403	1407	1410	1413	1416	1420	1423	1426	1430	1433	33.00
7.70	1436	1440	1443	1446	1450	1453	1457	1460	1463	1467	34.00
7.80	1470*	1473	1477	1480	1484	1487	1491	1494	1498	1501	34.00
7.90	1504	1508	1511	1515	1518	1522	1525	1529	1532	1536	35.00

EXPANDED RATING TABLE TYPE: LOG

05385500 DATE PROCESSED: 03-19-2001 @ 10:56 BY mitton

SOUTH FORK ROOT RIVER NEAR HOUSTON, MN DD: 7 TYPE: 001 RATING NO: 17.0

OFFSET: .40 START DATE/TIME: 06-01-2000 (0100)

GAGE HEIGHT (FEET)	DISCHARGE IN CUBIC FEET PER SECOND (EXPANDED PRECISION) .00	.01	.02	.03	.04	.05	.06	.07	.08	.09	DIFF IN Q PER TENTH FT
8.00	1539	1543	1546	1550	1553	1557	1560	1564	1567	1571	36.00
8.10	1575	1578	1582	1585	1589	1592	1596	1599	1603	1606	35.00
8.20	1610	1614	1617	1621	1624	1628	1631	1635	1639	1642	36.00
8.30	1646	1649	1653	1657	1660	1664	1668	1671	1675	1678	36.00
8.40	1682	1686	1689	1693	1697	1700	1704	1708	1711	1715	37.00
8.50	1719	1722	1726	1730	1733	1737	1741	1744	1748	1752	36.00
8.60	1755	1759	1763	1766	1770	1774	1778	1781	1785	1789	38.00
8.70	1793	1796	1800	1804	1807	1811	1815	1819	1822	1826	37.00
8.80	1830*	1835	1839	1844	1849	1854	1858	1863	1868	1873	48.00
8.90	1878	1882	1887	1892	1897	1902	1906	1911	1916	1921	48.00
9.00	1926	1931	1935	1940	1945	1950	1955	1960	1965	1970	49.00
9.10	1975	1979	1984	1989	1994	1999	2004	2009	2014	2019	49.00
9.20	2024	2029	2034	2039	2044	2049	2054	2059	2064	2069	50.00
9.30	2074	2079	2084	2089	2094	2100	2105	2110	2115	2120	51.00
9.40	2125	2130	2135	2140	2146	2151	2156	2161	2166	2171	52.00
9.50	2177	2182	2187	2192	2197	2203	2208	2213	2218	2223	52.00
9.60	2229	2234	2239	2244	2250	2255	2260	2266	2271	2276	53.00
9.70	2282	2287	2292	2298	2303	2308	2314	2319	2324	2330	53.00
9.80	2335	2340	2346	2351	2357	2362	2367	2373	2378	2384	54.00
9.90	2389	2395	2400	2406	2411	2416	2422	2427	2433	2438	55.00
10.00	2444	2450	2455	2461	2466	2472	2477	2483	2488	2494	55.00
10.10	2499	2505	2511	2516	2522	2527	2533	2539	2544	2550	57.00
10.20	2556	2561	2567	2573	2578	2584	2590	2595	2601	2607	56.00
10.30	2612	2618	2624	2630	2635	2641	2647	2653	2658	2664	58.00
10.40	2670*	2678	2685	2693	2700	2708	2716	2723	2731	2739	77.00
10.50	2747	2754	2762	2770	2778	2785	2793	2801	2809	2817	77.00
10.60	2824	2832	2840	2848	2856	2864	2872	2880	2888	2896	80.00
10.70	2904	2912	2920	2928	2936	2944	2952	2960	2968	2976	81.00
10.80	2985	2993	3001	3009	3017	3026	3034	3042	3050	3059	82.00
10.90	3067	3075	3083	3092	3100	3108	3117	3125	3134	3142	84.00
11.00	3151	3159	3167	3176	3184	3193	3201	3210	3219	3227	85.00
11.10	3236	3244	3253	3261	3270	3279	3287	3296	3305	3314	86.00
11.20	3322	3331	3340	3349	3357	3366	3375	3384	3393	3402	88.00
11.30	3410	3419	3428	3437	3446	3455	3464	3473	3482	3491	90.00
11.40	3500*	3511	3522	3532	3543	3554	3565	3576	3587	3598	109.0

EXPANDED RATING TABLE TYPE: LOG

05385500 DATE PROCESSED: 03-19-2001 @ 10:56 BY mitton

SOUTH FORK ROOT RIVER NEAR HOUSTON, MN DD: 7 TYPE: 001 RATING NO: 17.0

OFFSET: .40 START DATE/TIME: 06-01-2000 (0100)

DISCHARGE IN CUBIC FEET PER SECOND (EXPANDED PRECISION)

GAGE HEIGHT (FEET)	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	DIFF IN Q PER TENTH FT
11.50	3609	3620	3631	3642	3653	3664	3675	3687	3698	3709	111.0
11.60	3720	3732	3743	3754	3766	3777	3788	3800	3811	3823	114.0
11.70	3834	3846	3857	3869	3880	3892	3903	3915	3927	3939	116.0
11.80	3950	3962	3974	3986	3997	4009	4021	4033	4045	4057	119.0
11.90	4069	4081	4093	4105	4117	4129	4141	4153	4166	4178	121.0
12.00	4190	4202	4215	4227	4239	4252	4264	4276	4289	4301	124.0
12.10	4314	4326	4339	4351	4364	4376	4389	4402	4414	4427	126.0
12.20	4440	4453	4465	4478	4491	4504	4517	4530	4543	4556	129.0
12.30	4569	4582	4595	4608	4621	4634	4647	4660	4674	4687	131.0
12.40	4700*	4721	4742	4763	4784	4805	4827	4848	4869	4891	213.0
12.50	4912	4934	4956	4978	5000	5022	5044	5066	5088	5110	221.0
12.60	5133	5155	5178	5200	5223	5246	5269	5292	5315	5338	228.0
12.70	5361	5384	5408	5431	5454	5478	5502	5526	5549	5573	236.0
12.80	5597	5621	5646	5670	5694	5719	5743	5768	5792	5817	245.0
12.90	5842	5867	5892	5917	5942	5968	5993	6019	6044	6070	253.0
13.00	6095	6121	6147	6173	6199	6225	6252	6278	6305	6331	263.0
13.10	6358	6384	6411	6438	6465	6492	6519	6547	6574	6602	271.0
13.20	6629	6657	6684	6712	6740	6768	6796	6825	6853	6881	281.0
13.30	6910	6938	6967	6996	7025	7054	7083	7112	7141	7171	290.0
13.40	7200*	7232	7265	7298	7330	7363	7396	7429	7463	7496	330.0
13.50	7530	7563	7597	7631	7665	7699	7733	7768	7802	7837	342.0
13.60	7872	7906	7941	7977	8012	8047	8083	8119	8154	8190	354.0
13.70	8226	8263	8299	8335	8372	8409	8445	8482	8520	8557	368.0
13.80	8594	8632	8669	8707	8745	8783	8821	8860	8898	8937	382.0
13.90	8976	9015	9054	9093	9132	9172	9211	9251	9291	9331	395.0
14.00	9371	9411	9452	9492	9533	9574	9615	9656	9698	9739	410.0
14.10	9781	9823	9864	9907	9949	9991	10030	10080	10120	10160	429.0
14.20	10210	10250	10290	10340	10380	10420	10470	10510	10560	10600	430.0
14.30	10640	10690	10730	10780	10820	10870	10920	10960	11010	11050	460.0
14.40	11100*	11150	11200	11250	11300	11350	11400	11450	11500	11550	500.0
14.50	11600	11650	11700	11750	11800	11860	11910	11960	12010	12060	520.0
14.60	12120	12170	12220	12280	12330	12380	12440	12490	12540	12600	530.0
14.70	12650	12710	12760	12820	12870	12930	12990	13040	13100	13150	560.0
14.80	13210	13270	13320	13380	13440	13500	13550	13610	13670	13730	580.0
14.90	13790	13850	13910	13960	14020	14080	14140	14200	14260	14320	600.0

EXPANDED RATING TABLE TYPE: LOG

05385500 DATE PROCESSED: 03-19-2001 @ 10:56 BY mitton

SOUTH FORK ROOT RIVER NEAR HOUSTON, MN DD: 7 TYPE: 001 RATING NO: 17.0

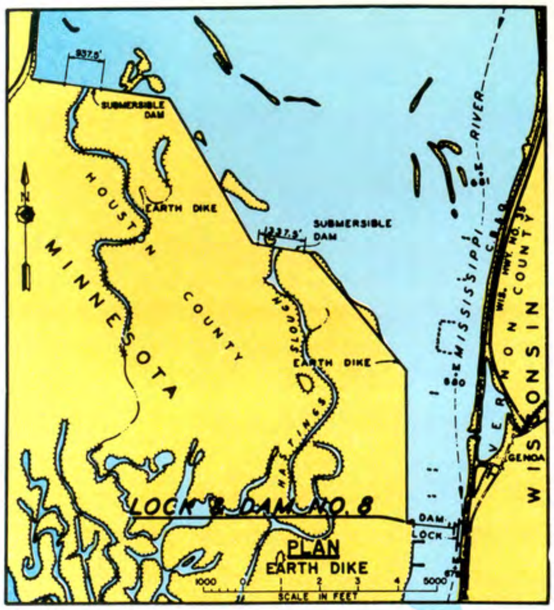
OFFSET: .40 START DATE/TIME: 06-01-2000 (0100)

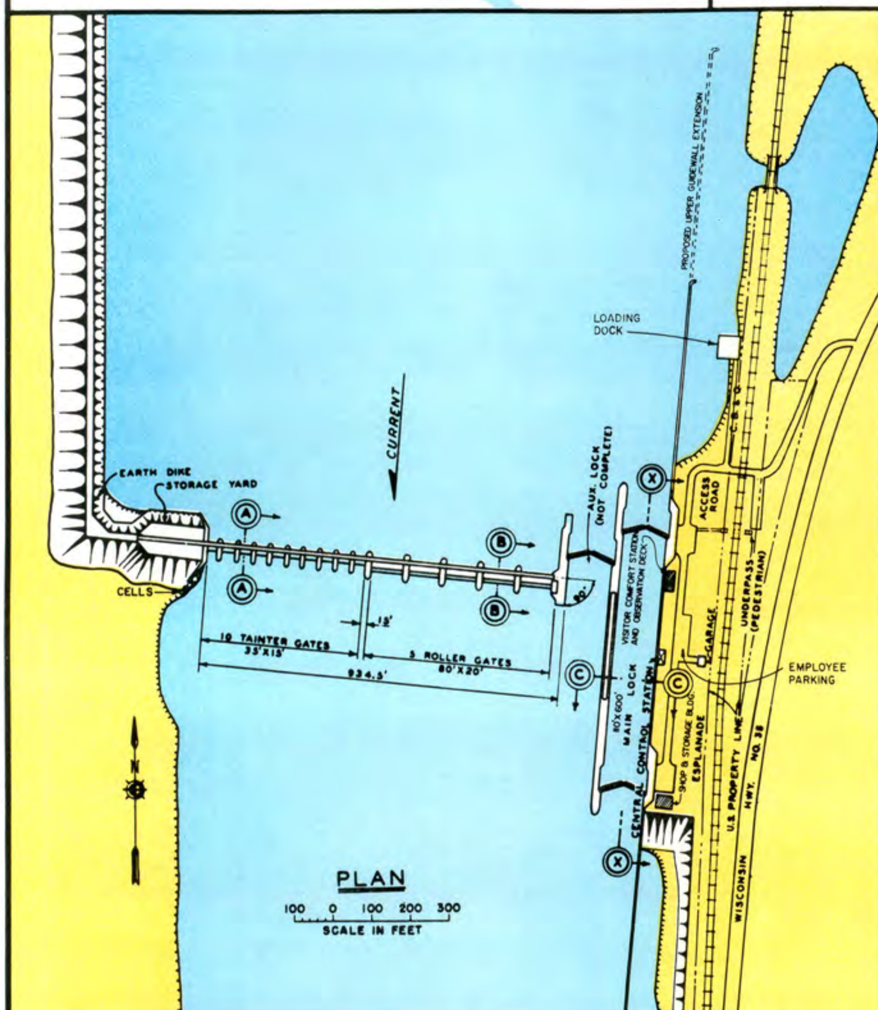
GAGE HEIGHT (FEET)	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	DIFF IN Q PER TENTH FT
	DISCHARGE IN CUBIC FEET PER SECOND					(EXPANDED PRECISION)					
15.00	14390	14450	14510	14570	14630	14690	14750	14820	14880	14940	620.0
15.10	15010	15070	15130	15200	15260	15320	15390	15450	15520	15580	640.0
15.20	15650	15710	15780	15840	15910	15980	16040	16110	16180	16240	660.0
15.30	16310	16380	16450	16520	16580	16650	16720	16790	16860	16930	690.0*
15.40	17000*										

EXHIBIT D

LA CROSSE RIVER AT WEST SALEM, WISCONSIN
RATING TABLE
Developed by St. Paul District

Stage (feet)	Discharge (cfs)
0.00	0
2.50	60
3.00	100
3.50	170
4.00	270
4.50	380
5.00	500
5.50	630
6.00	760
6.50	900
7.00	1,180
8.00	1,620
9.00	2,300
10.00	3,200
11.00	4,700
12.00	7,300





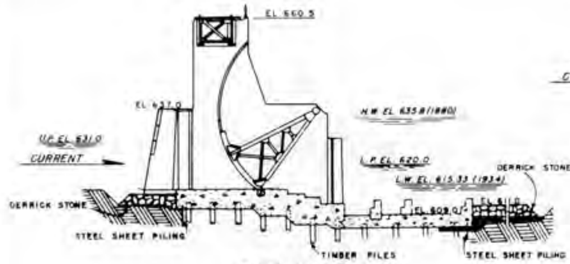
TOTAL LENGTH OF EARTH DIKE - 15 720.0 FT.
DEPTH ON UPPER GATE SILL - 22.0FT. (U.P. EL.631.0)
DEPTH ON LOWER GATE SILL - 14.0FT. (L.P. EL.620.0)
ELEVATION UPPER GATE SILL - 609.0
ELEVATION LOWER GATE SILL - 606.0

ELEVATIONS ARE REFERRED TO M.S.L. (1912 ADJ.)

Upper Mississippi River
Nine-Foot Navigation Project

Lock and Dam No. 8
Project Location Map

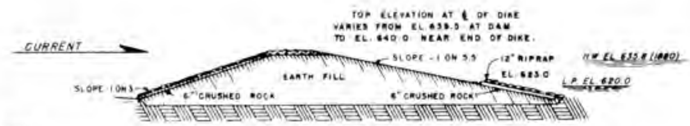
US Army Corps of Engineers
St. Paul District - 30 Sept 1988



SECTION A-A

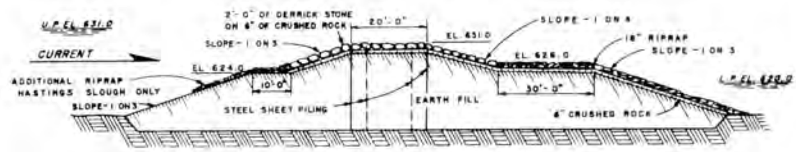
TAINTER GATE
NON-SUBMERGIBLE TYPE SHOWN

10 0 10 20 30
SCALE IN FEET



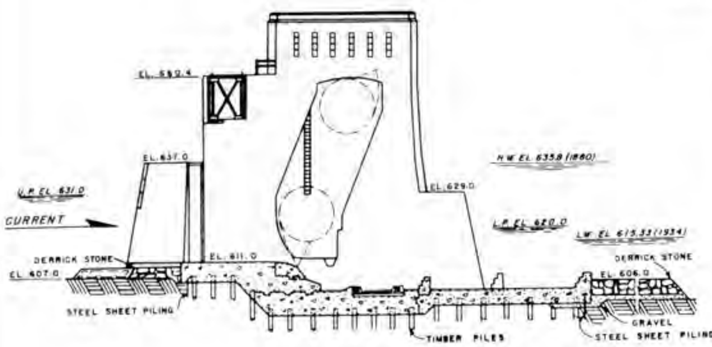
EARTH DIKE SECTION

20 0 20 40 60
SCALE IN FEET



SUBMERSIBLE DAM SECTION

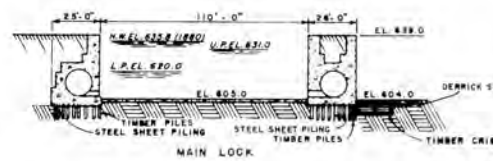
10 0 10 20 30
SCALE IN FEET



SECTION B-B

ROLLER GATE

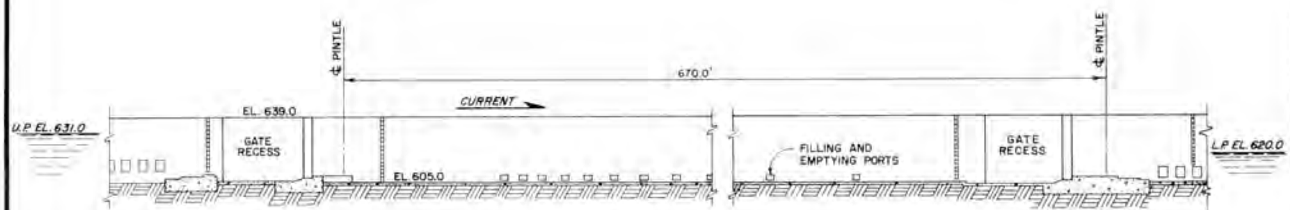
10 0 10 20 30
SCALE IN FEET



SECTION C-C

LOCK

20 0 20 40 60
SCALE IN FEET



SECTION X-X

MAIN LOCK

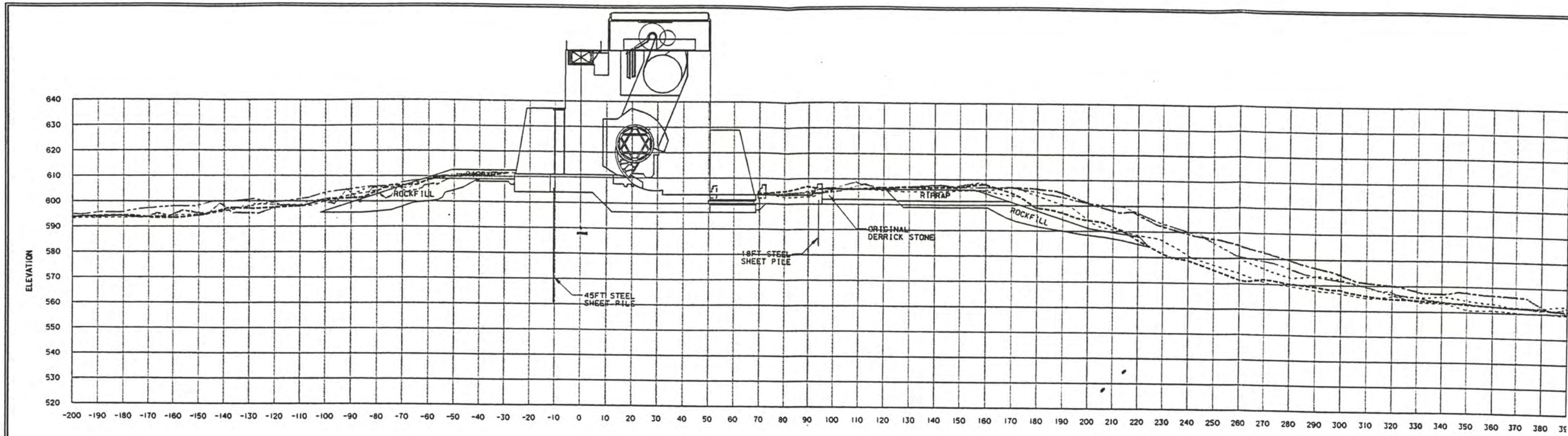
20 0 20 40 60
SCALE IN FEET

ELEVATIONS ARE REFERRED TO M.S.L. (1912 ADJ.)

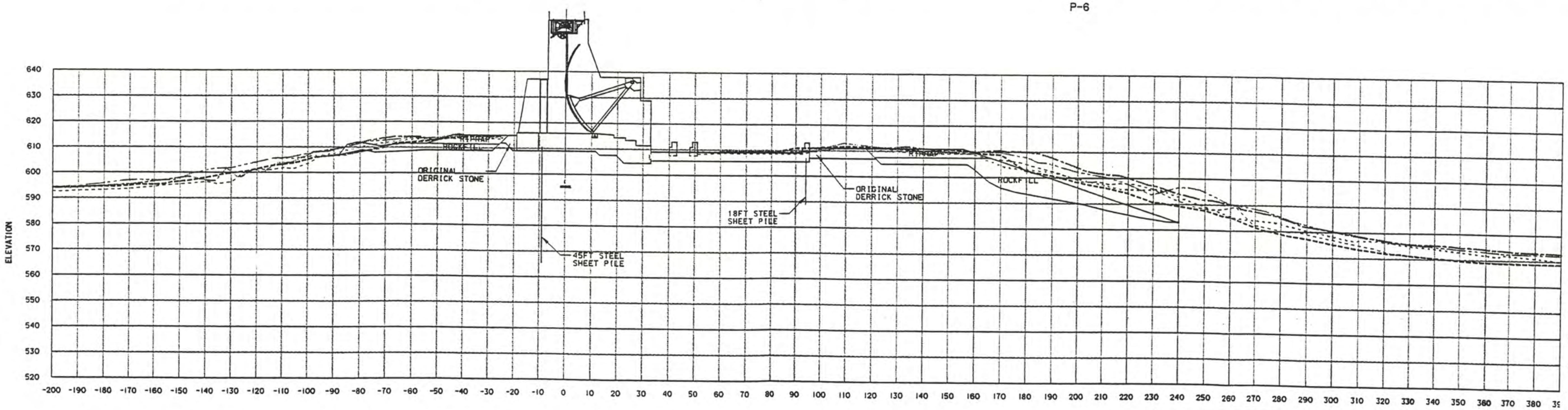
Upper Mississippi River
Nine-Foot Navigation Project

Lock and Dam No. 8
Cross Sections

US Army Corps of Engineers
St. Paul District - 30 Sept 1977



P-6



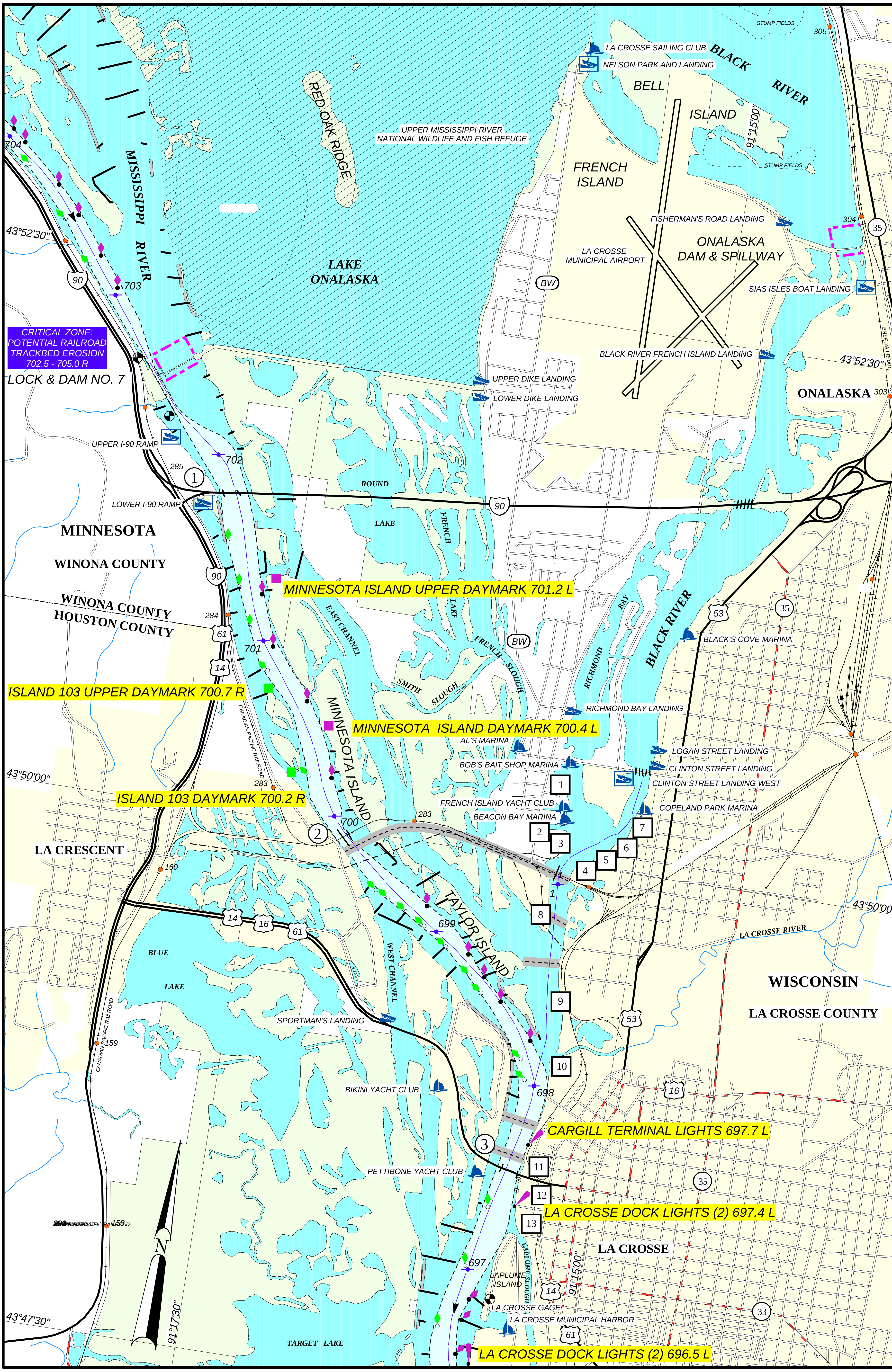
P-7

KEY	
- - - - - - - -	2000
- - - - - - - -	1999
- · - · - · - ·	1998
—·—·—·—	1997
· · · · · · · ·	1996

Upper Mississippi River
Nine-Foot Navigation Project

Scour Protection
Upstream and Downstream of Dam
Riprap and Rockfill Placed in 1983

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



2001

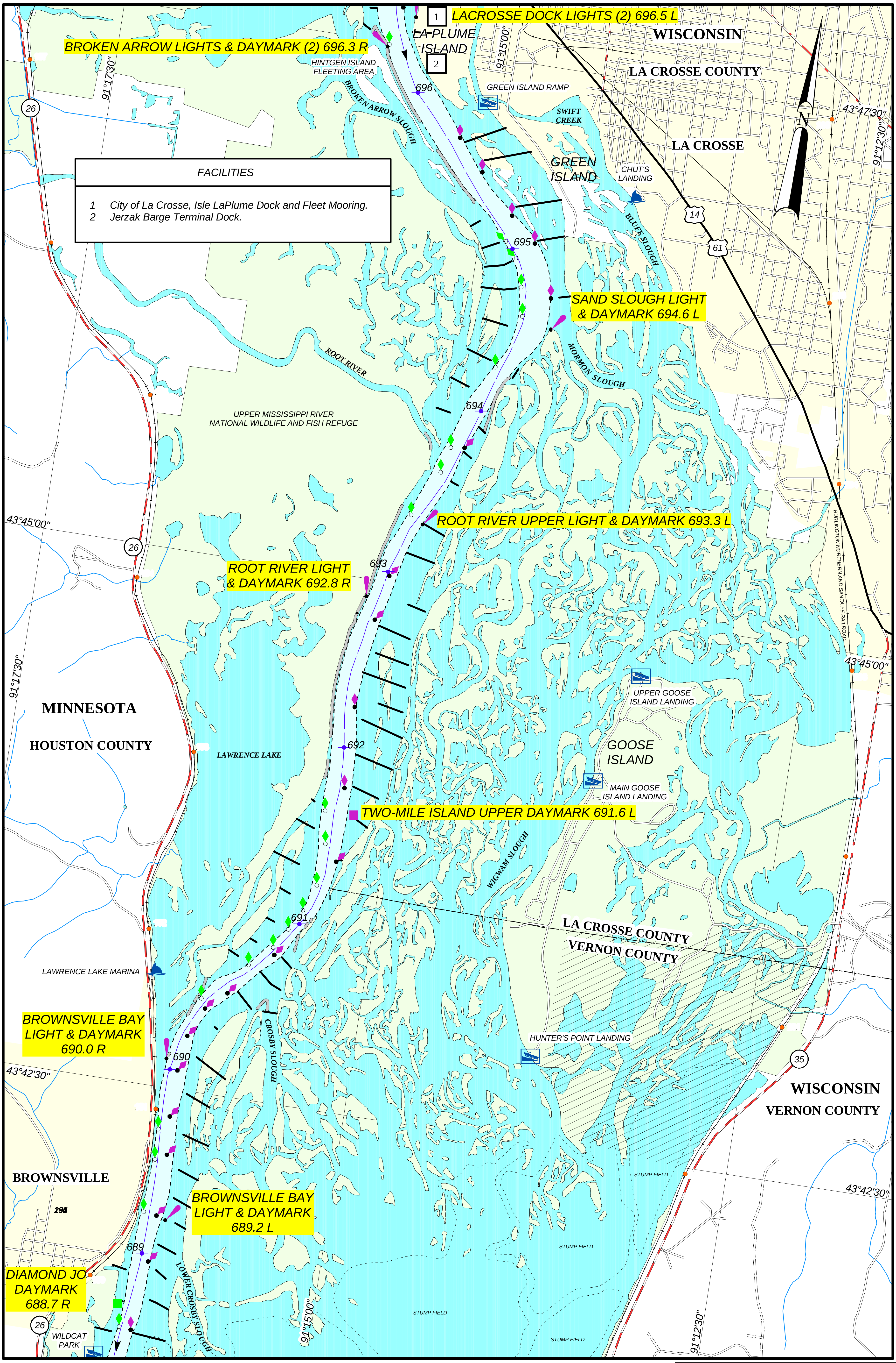
BUOY POSITIONS ON CHARTS ARE APPROXIMATE, SEE NOTICE ON LEGEND NO. 1

SCALE 1:31,680
1 INCH = 1/2 MILE

1 0.5 0 1 MILES

1 0.5 0 1 KILOMETERS

Upper Mississippi River
Nine-Foot Channel Navigation Project
Navigation Chart
River Mile 697 to 704
U.S. Army Corps of Engineers
St. Paul District - St. Paul, MN



2001

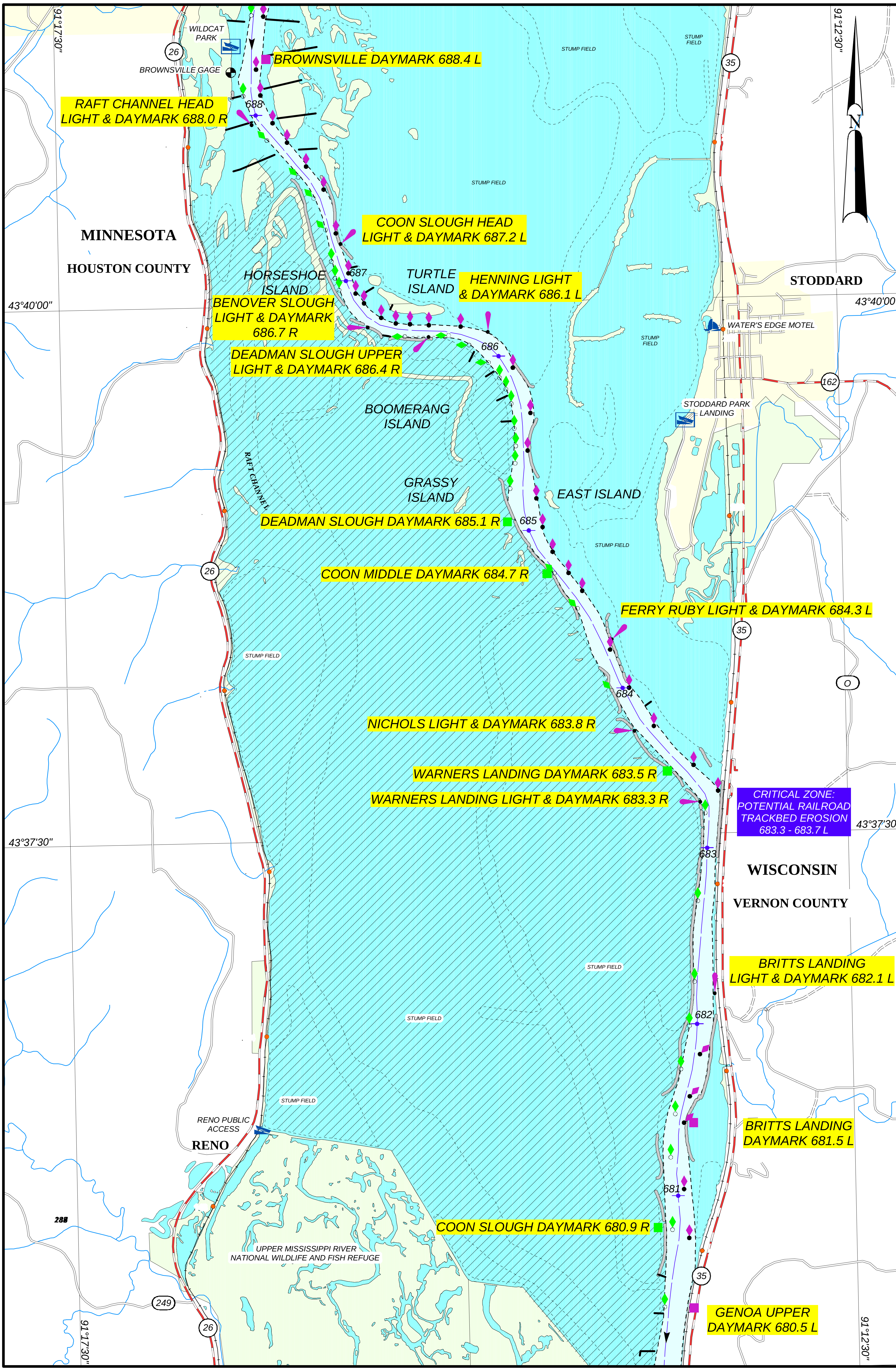
BUOY POSITIONS ON CHARTS ARE APPROXIMATE, SEE NOTICE ON LEGEND NO. 1

SCALE 1:31,680
1 INCH = 1/2 MILE

1 0.5 0 1 MILES

1 0.5 0 1 KILOMETERS

Upper Mississippi River
Nine-Foot Channel Navigation Project
Navigation Chart
River Mile 689 to 696
U.S. Army Corps of Engineers
St. Paul District - St. Paul, MN



2001

BUOY POSITIONS ON CHARTS ARE APPROXIMATE, SEE NOTICE ON LEGEND NO. 1

SCALE 1:31,680
1 INCH = 1/2 MILE

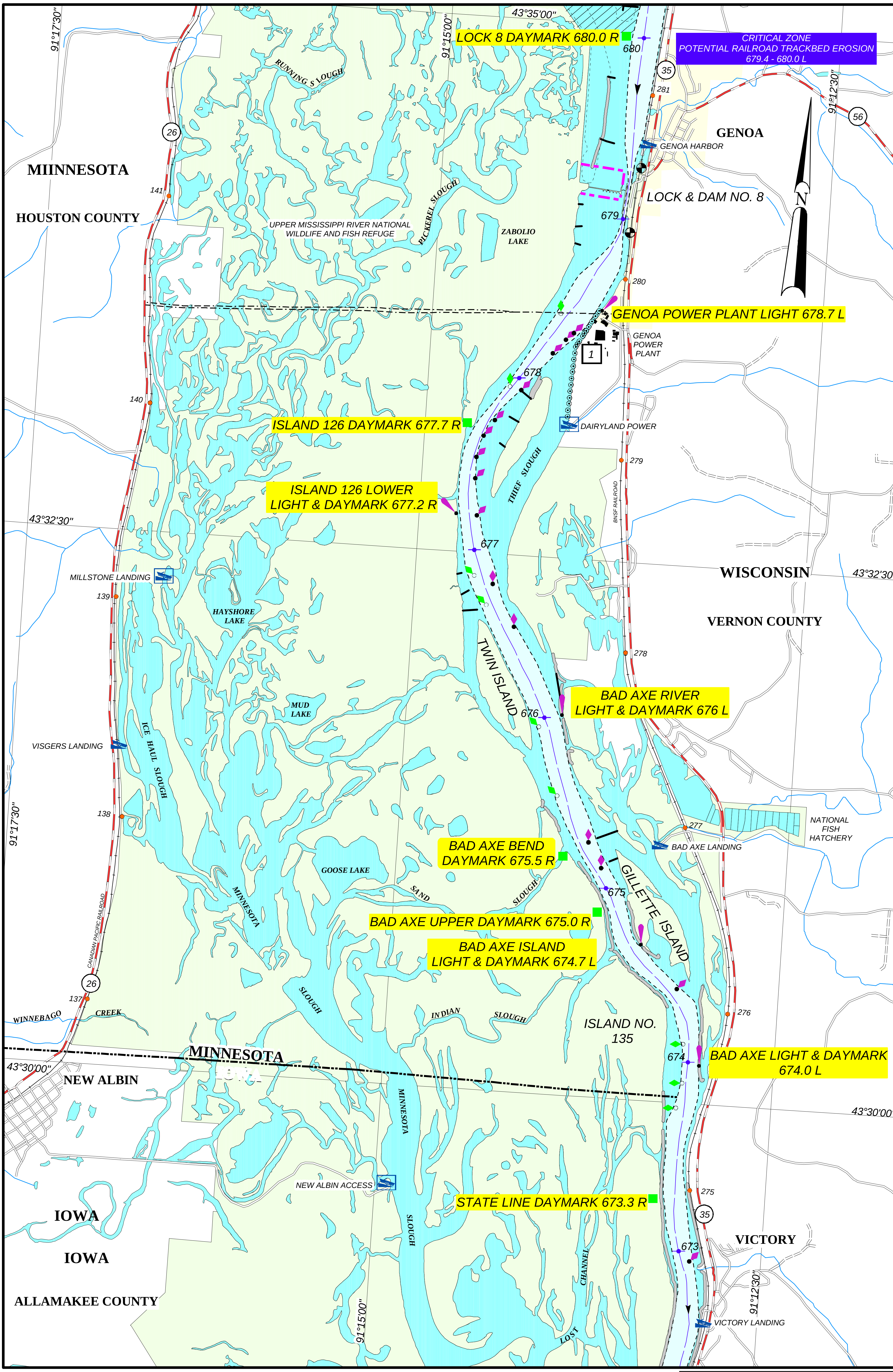
1 0.5 0 1 MILES

1 0.5 0 1 KILOMETERS

Upper Mississippi River
Nine-Foot Channel Navigation Project

Navigation Chart
River Mile 681 to 688

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



2001

BUOY POSITIONS ON CHARTS ARE APPROXIMATE, SEE NOTICE ON LEGEND NO. 1

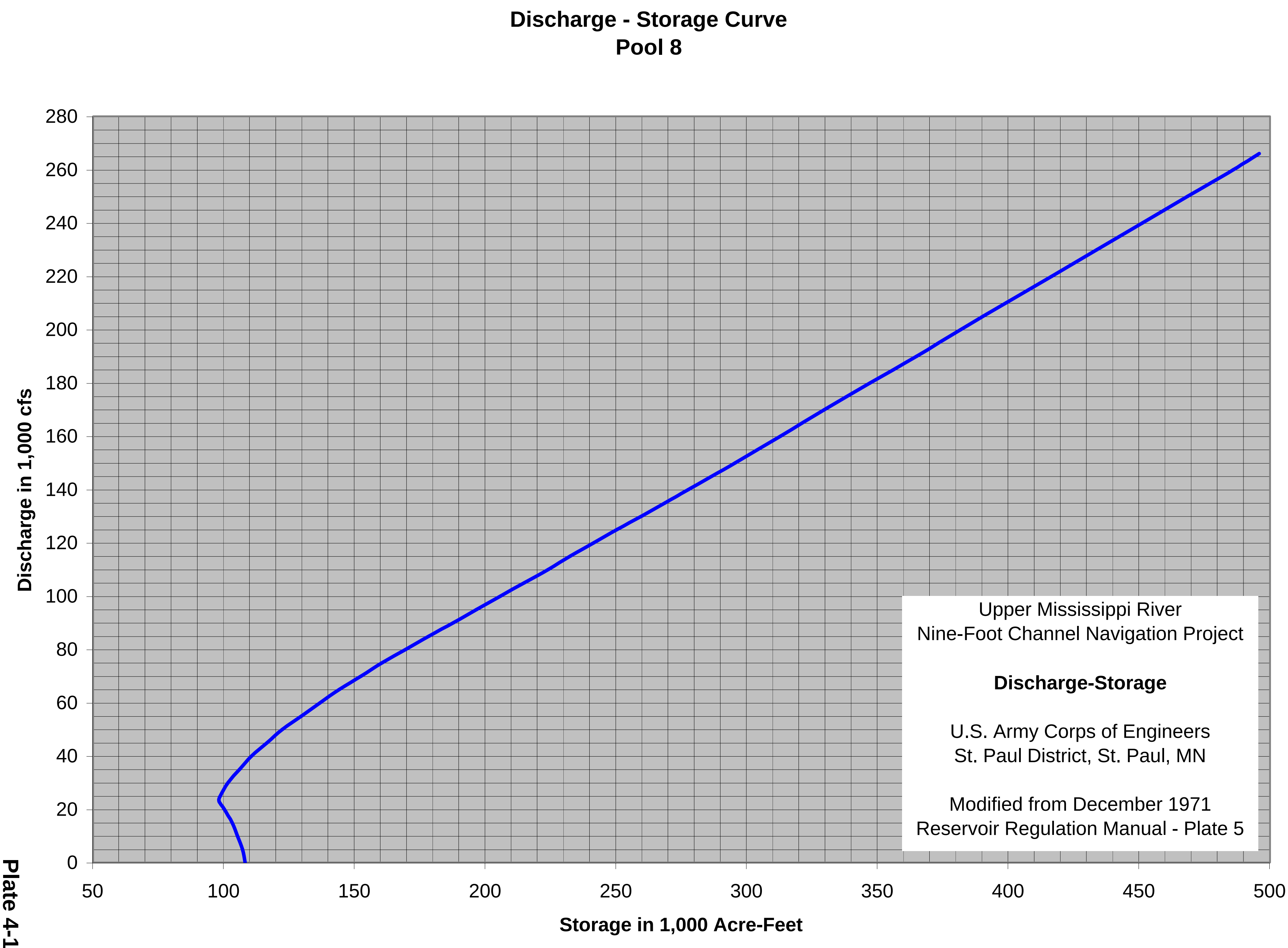
SCALE 1:31,680
1 INCH = 1/2 MILE

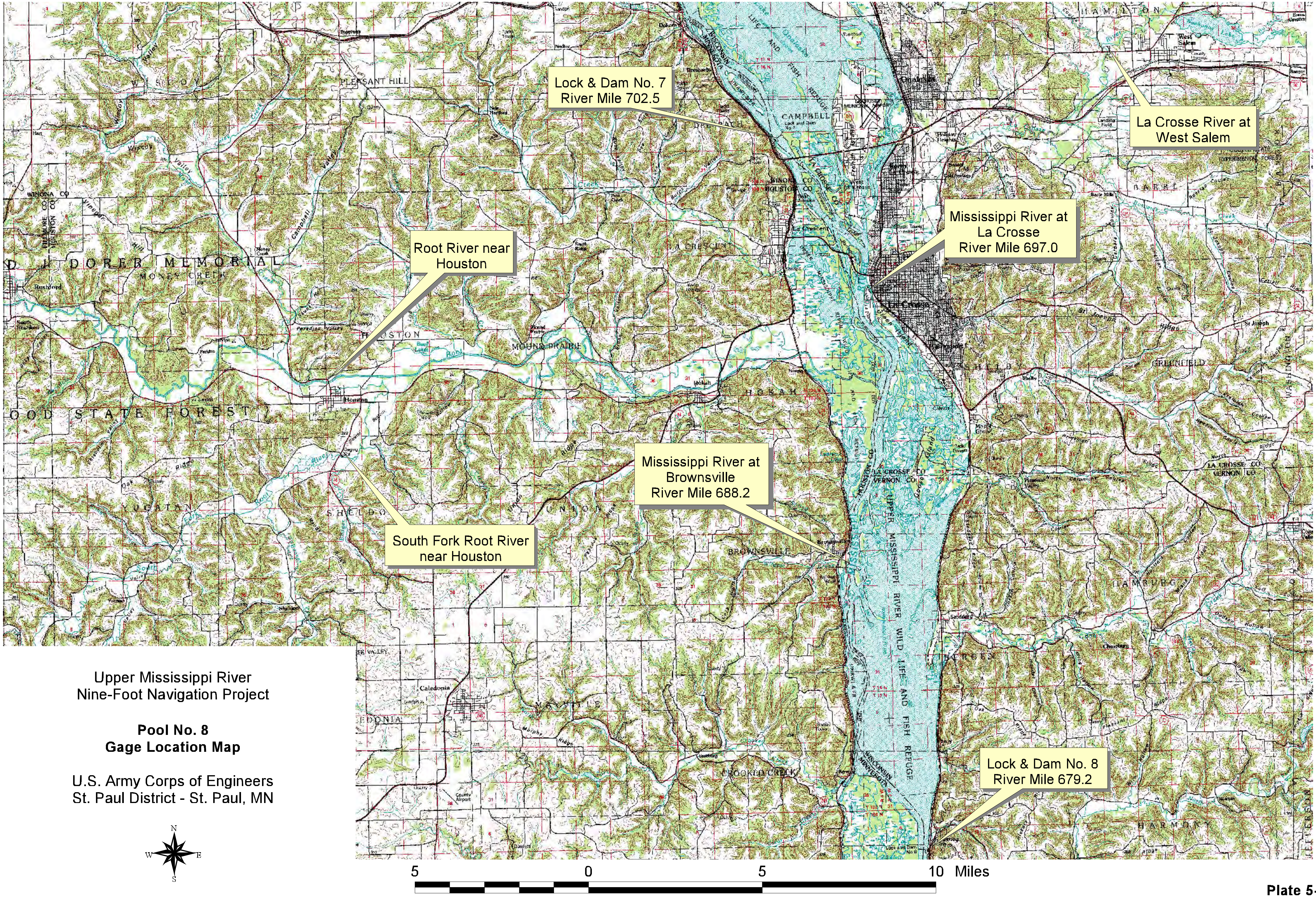
Upper Mississippi River
Nine-Foot Channel Navigation Project

Navigation Chart
River Mile 673 to 680

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

Plate 2-7


Discharge - Storage Curve
Pool 8
Discharge in 1,000 cfs
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
50
100
150
200
250
300
350
400
450
500
Storage in 1,000 Acre-Feet
Upper Mississippi River
Nine-Foot Channel Navigation Project
Discharge-Storage
U.S. Army Corps of Engineers
St. Paul District, St. Paul, MN
Modified from December 1971
Reservoir Regulation Manual - Plate 5



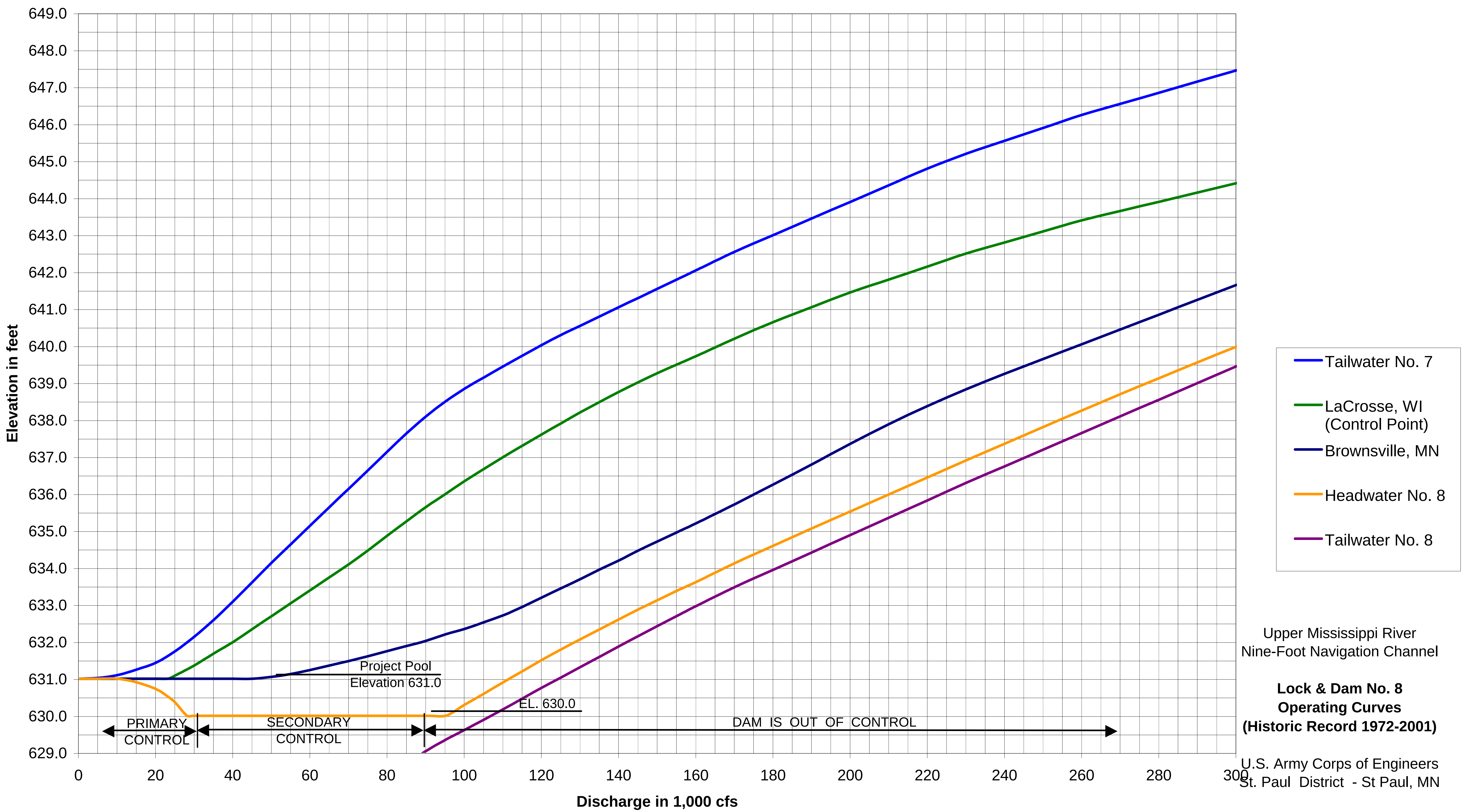
Upper Mississippi River
Nine-Foot Navigation Project

Pool No. 8
Gage Location Map

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

Plate 5-1

LOCK & DAM NO. 8 OPERATING CURVES

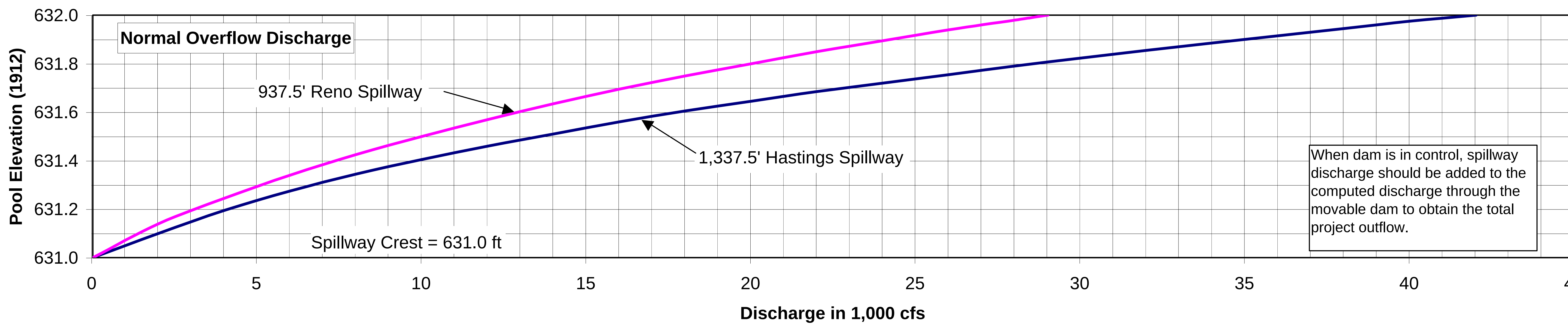


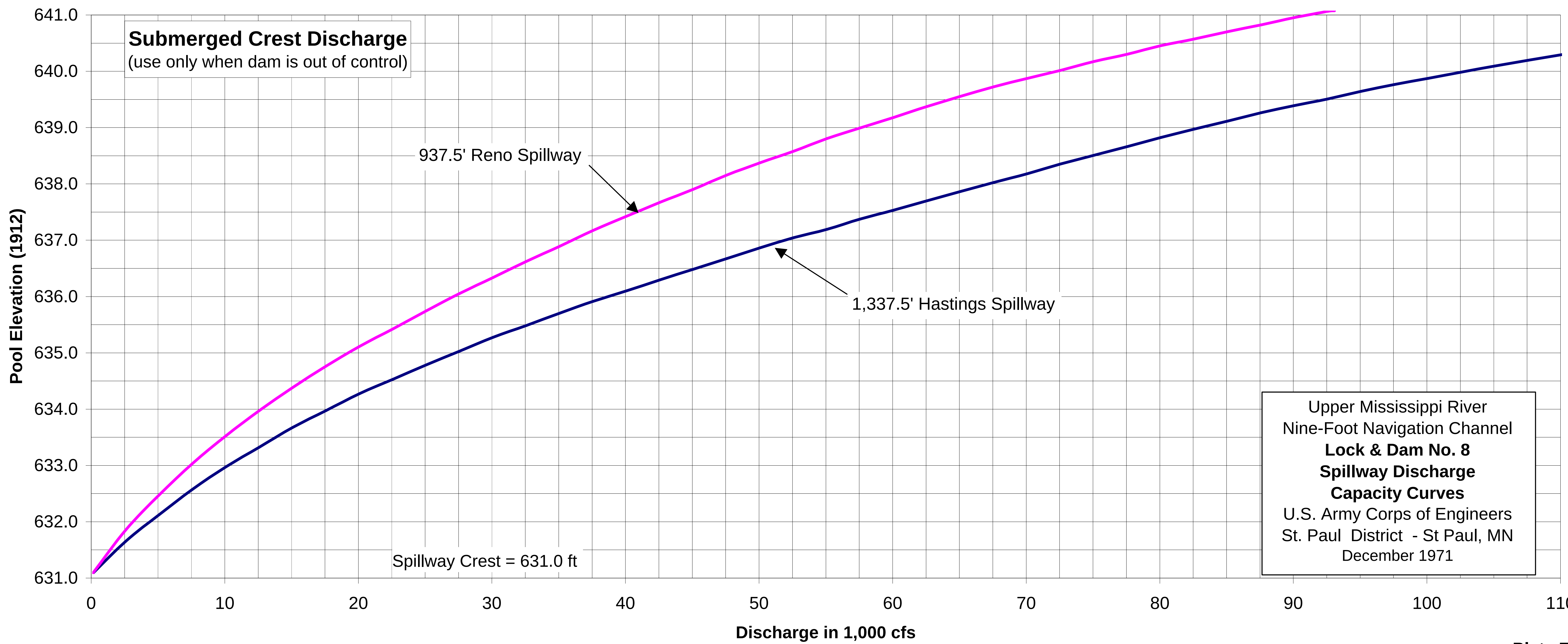
Upper Mississippi River
Nine-Foot Navigation Channel

Lock & Dam No. 8
Operating Curves
(Historic Record 1972-2001)

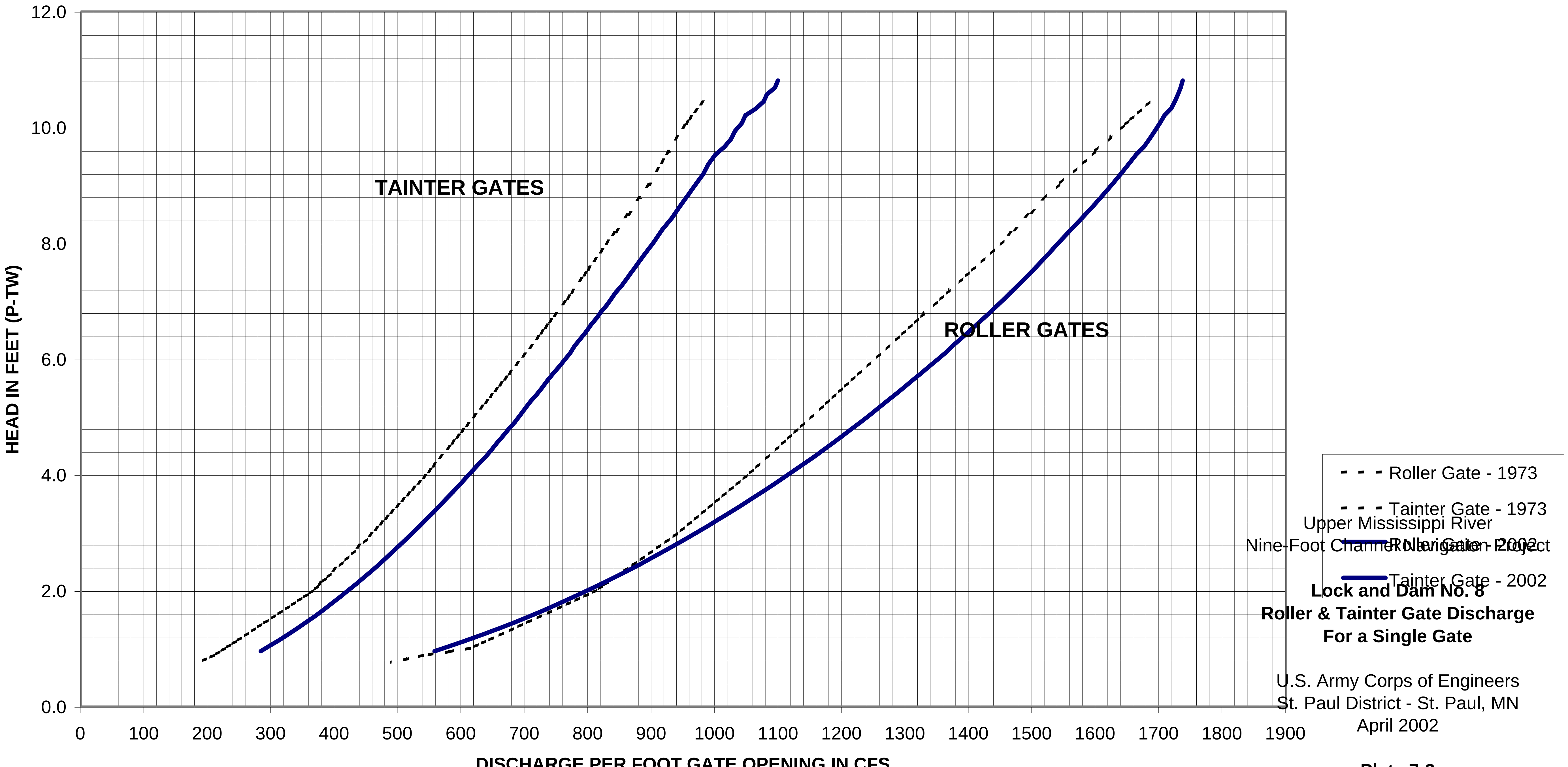
U.S. Army Corps of Engineers
St. Paul District - St Paul, MN

Plate 7-1


Normal Overflow Discharge
937.5' Reno Spillway
1,337.5' Hastings Spillway
When dam is in control, spillway discharge should be added to the computed discharge through the movable dam to obtain the total project outflow.
Spillway Crest = 631.0 ft
Pool Elevation (1912)
632.0
631.8
631.6
631.4
631.2
631.0
0
5
10
15
20
25
30
35
40
45
Discharge in 1,000 cfs


Submerged Crest Discharge
(use only when dam is out of control)
937.5' Reno Spillway
1,337.5' Hastings Spillway
Spillway Crest = 631.0 ft
Pool Elevation (1912)
641.0
640.0
639.0
638.0
637.0
636.0
635.0
634.0
633.0
632.0
631.0
0
10
20
30
40
50
60
70
80
90
100
110
Discharge in 1,000 cfs
Upper Mississippi River
Nine-Foot Navigation Channel
Lock & Dam No. 8
Spillway Discharge
Capacity Curves
U.S. Army Corps of Engineers
St. Paul District - St Paul, MN
December 1971

LOCK AND DAM NO. 8
ROLLER AND TAINTER GATE DISCHARGE



Upper Mississippi River
Nine-Foot Channel Navigation Project

Lock and Dam No. 8
Roller & Tainter Gate Discharge
For a Single Gate

U.S. Army Corps of Engineers
St. Paul District - St. Paul, MN
April 2002

Plate 7-3