US Army Corps
of Engineers®
St. Paul District

WATER CONTROL MANUAL

MISSISSIPPI RIVER NINE FOOT CHANNEL
NAVIGATION PROJECT

LOCK AND DAM NO. 5A

WINONA, MN

APPENDIX 5A OF THE MASTER WATER CONTROL MANUAL

UPDATED MARCH 2003

WATER CONTROL MANUAL

MISSISSIPPI RIVER NINE FOOT CHANNEL

LOCK AND DAM NO. 5A

APPENDIX 5A

UPDATED MAR 2003

US Army Corps of Engineers®
St. Paul District

CEMVP-ED-H (1110-2-240)

7 April 2003
Chamberlin/5619

MEMORANDUM FOR Commander, Mississippi Valley Division, ATTN: CEMVD-ET-EW, Water Control Branch, Directorate of Engineering and Technical Services, P.O. Box 80, Vicksburg, MS 39181-0080

SUBJECT: Draft Water Control Manual, Mississippi River, Lock and Dam No. 5A

1. The draft Water Control Manual for Lock and Dam No. 5A is submitted for your review. The manual was updated in accordance with ER 1110-2-240, ER 1110-2-8156, and DIVR 1110-2-240. It has been reviewed in-house.

2. The manual is an update of the Reservoir Regulation Manual dated August 1970, which was updated from the Operation of Navigation Pools, February 1943. Part of the update includes minor changes to the Gate Regulation Schedule and the Operating Curves. Also, while the operating plan for the Prairie Island Control Structure did not change, it is spelled out in detail.

3. Any questions regarding the manual can be directed to Ferris Chamberlin in the Water Control Section at 651-290-5619.

Encl
(5 copies draft WC Manual)

JOHN J. BAILEN, P.E.
Chief, Engineering Division

CHAMBERLIN ED-H _____
ENGELSTAD ED-H _____
KNOFF ED-H _____

WATER CONTROL MANUAL

LOCK AND DAM No. 5A
WINONA, MINNESOTA

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

APPENDIX No. 5A
of the
MASTER WATER CONTROL MANUAL

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

MARCH 2003

Updated from
Reservoir Regulation Manual, August 1970
Operation of Navigation Pools, February 1943

LOCK AND DAM No. 5A

WINONA, MINNESOTA

Aerial View Looking Upstream – October 1995

5 Roller Gates and 5 Tainter Gates
Project Pool 651.0 feet (1912 Adjustment)

LOCK AND DAM No. 5A

WINONA, MINNESOTA

Lock and Dam No. 5A Control House
Dedicated August 2000

Lock Chamber and Miter Gates in Right 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. This 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. 5A being completed in August 1970. This manual is an update of Appendix No. 5A. 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]
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: 651-290-5602 [redacted]
John J. Bailen	Chief, Engineering Division john.j.bailen@usace.army.mil	Duty: 651-290-5303

Lock and Dam No. 5A
Winona, Minnesota

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

TABLE OF CONTENTS

TABLES

FIGURES

EXHIBITS

PLATES

PERTINENT DATA

Location: Lock and Dam No. 5A is located on the Mississippi River, 728.5 river miles above the mouth of the Ohio River, 9.6 river miles below Lock and Dam No. 5, and 14.2 river miles above Lock and Dam No. 6. The lock is on the right bank of the river at approximate latitude 44° 05' 18" N and longitude 91° 40' 12" W.

Drainage Area: 59,105 square miles

Datum: MSL – 1912 adjustment

Fixed Height Dam:

Type:	Earthen Dike	
Total Length (including spillway)	20,533 feet	
Crest of Earthen Dam	Elevation 664.0 to 665.0 feet	
Top Width of Earthen Dam	20 feet	
Max Height of Earthen Dam	26 feet	
Concrete Spillway		
Length	1,000 feet	
Crest	Elevation 651.0 feet	
Slot	15 ft long by 2 ft deep	

Moveable Dam:

Roller Gates	5 Gates	80 feet by 20 feet
Tainter Gates	5 Gates	35 feet by 15 feet
Roller Gate Sill	Elevation 631.0 feet	
Tainter Gate Sill	Elevation 636.0 feet	

Lock:

Main Lock Chamber	110 feet by 600 feet
Top of Lock Walls	Elevation 663.0 feet
Top of Upper Gate Sill (Main)	Elevation 633.0 feet
Top of Upper Gate Sill (Auxiliary)	Elevation 633.0 feet
Top of Lower Gate Sill	Elevation 633.0 feet
Lock Floor	Elevation 631.5 feet
Height of Upper Miter Gates (Main)	27.0 feet
Height of Upper Miter Gates (Aux.)	27.0 feet
Height of Lower Miter Gates	27.0 feet

Pool:

Normal (Project) Upper Pool	Elevation 651.0 feet	
Normal (Project) Lower Pool	Elevation 645.5 feet	
Total Pool Area (at Project Pool)	7,000 acres	
Primary Control Point	TW of Dam 5	Elev. 651.0 ft
Secondary Control Point	Lock & Dam 5A	Elev. 650.0 ft

Note: Roller gates are submergible to 3.0 feet below Normal Pool (i.e., 648.0 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 No. 5A Reservoir Regulation Manual" dated August 1970 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. Lock and Dam No. 5A was completed on 31 August 1936. A general scheme of operation was developed on 28 March 1935 before construction was complete. An official operation plan was developed in February 1943. 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, U.S. Engineer Office, St. Paul District, St. Paul, Minnesota, 16 February 1943.

d. *Master Regulation Manual for Mississippi River Nine-Foot Channel Navigation Projects*, Department of the Army, St. Paul District, Corps of Engineers, September 1969.

e. *Mississippi River Nine-Foot Channel Navigation Project, Reservoir Regulation Manual, Appendix 5A, Lock and Dam No. 5A, Winona, Minnesota,* Department of the Army, St. Paul District, Corps of Engineers, August 1970.

f. *Creativity, Conflict & Controversy: A History of the St. Paul District, U.S. 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 No. 5A, Winona, Minnesota*, 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, Department of the Army, Waterways Experiment Station, Corps of Engineers, Vicksburg, Mississippi, April 1987.

j. *Commerce and Conservation on the Upper Mississippi River*, by John O. Anfinson, District Historian, U.S. Army Corps of Engineers, St. Paul District, St. Paul Minnesota, 1990.

k. *Gateways to Commerce*, The U.S. 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*, Department of the Army, U.S. Army Corps of Engineers, Washington D. C., July 1992.

m. *Channel Maintenance Management Plan,* Upper Mississippi River Navigation System, U.S. Army Corps of Engineers, St. Paul District, 1996.

n. *Channel Maintenance Management Plan, Final Environmental Impact Statement (FEIS)*, Lead Agency U.S. Army Corps of Engineers, St. Paul District, Volumes I and II, 6 June 1997.

o. *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, U.S. Army Corps of Engineers, June 1997.

p. *Zebra Mussel Response Plan*, U.S. Army Corps, St. Paul District, November, 1997.
q. *Locks and Dams Sounding Reports, Volume 2*, U.S. Army Corps of Engineers, St. Paul District, 1999.
r. *2001 Annual Report – Water Quality Management Program*, U.S. 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. 5A. The US Army Corps of Engineers, St. Paul District, St. Paul Minnesota, is responsible for regulation of Lock and Dam No. 5A.

1-05. Operating Agency. Lock and Dam No. 5A 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. 5A.

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 → → → → → →	507-452-2789
fax 651-290-5841	fax 507-452-5467

The project is attended 24 hours a day, every day of the year. The Chief, Construction and Operations Division (Con-Ops) and the Chief, Engineering Division (ED) 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. 6.

1-06. Regulating Agency. Regulation of Lock and Dam No. 5A 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. 5A is located on the Mississippi River, 728.5 river miles above the mouth of the Ohio River, 9.6 river miles below Lock and Dam No. 5, and 14.2 river miles above Lock and Dam No. 6. The lock is on the right bank of the main channel about 3 river miles above Winona, Minnesota, and about 3 river miles below Fountain City, Wisconsin, at approximate latitude 44° 05' 18" N and longitude 91° 40' 12" W. The project is bordered by Buffalo County on the Wisconsin side and Winona County on the Minnesota side. The project location is shown on **Plate 2-1**.

Access to the central control station is across the bridge deck of the dam. That is, after you park on the Wisconsin side of the river, you must cross the railroad tracks. An underground passage is provided. After that, you climb the enclosed staircase in the storage yard to the top of the bridge deck, walk across the moveable portion of the dam, walk down the staircase in pier number one, and then across the walkway atop the miter gates to the central control station. A unique feature of Lock and Dam No. 5A is the helicopter landing pad located behind the central control station.

Figure 2-1. Helicopter Landing Pad behind the Central Control Station.

2-02. Purpose. Lock and Dam No. 5A 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. 5A are navigation under the River and Harbor 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. 5A consists of a main and uncompleted auxiliary lock, a movable dam section, a concrete fixed-crest spillway, and an earthen dike. The locks and moveable dam are supported on timber piling driven into sand and gravel and include sheet pile cutoff walls. The following describes the hydraulic feature of each component in detail.

Figure 2-2. Lock and Dam No. 5A, October 1995 – Looking Upstream

a. Lock. Lock and Dam No. 5A has a main and an uncompleted auxiliary lock (**Plate 2-1**). Both the upper and lower miter gates of the main lock have a height of 27.0 feet and sill elevation of 633.0 feet (1912 adjustment). A walkway is located atop the miter gates. It extends three feet above the top of miter gates (elevation 660.0 feet) to meet the top of lock walls (elevation 663.0 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 27.0 feet high with a sill elevation of 633.0 feet. The gates of the auxiliary lock have no machinery and therefore are inoperable. However, should either an upper or lower 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. The 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 A-A). 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 eight 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 521 feet upstream of the lock and the lower guide wall extends 504 feet downstream of the lock.

b. Moveable Dam. The moveable dam section extends from the auxiliary lock to the left 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 5 tainter gates, 35-feet wide by 15-feet high (**Figure 2-1**). The sill elevation of the roller gates is 631.0 feet (1912 adjustment), whereas the tainter gates sill elevation is 636.0 feet. The end sill elevations for the roller and tainter gates are 631.0 feet and 634.0 feet respectively. The roller gates can be submerged up to three feet below the normal pool elevation of 651.0 feet. 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, marked in increments of 0.1 feet, is attached to the hoist mechanism. There are five bulkheads stored on site, measuring 4 feet–2 inches by 85 feet–½ inch. The sill elevation is 631.0 feet; therefore, the top of five bulkheads would be at elevation 651.83 feet (i.e. 651 feet–10 inches).

Figure 2-3. Roller Gate Position Indicator

Each tainter gate is equipped with an individual electrically operated hoist. The electric controls consist of push buttons located on the deck rail. A position indicator 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 636.0 feet; therefore, the top of four bulkheads would be at elevation 652.67 feet (i.e. 652 feet–8 inches).

Figure 2-4. Tainter Gate Position Indicator

A service bridge, at elevation 682.0 feet, spans the entire length of the moveable dam and storage yard and provides for the operation of the crane. The original 45-foot boom crane with 25 ton capacity was replaced with a new crane, which has a boom length of 60 feet and a capacity of 25 tons. The under carriage of the new crane was replaced in 2002.

c. Channel Protection. Immediately upstream and downstream of the moveable dam, the channel is protected by a concrete followed by riprap protection. Sections B-B and C-C 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 and 1984, 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 629.0 feet (1912 adjustment). The derrick stone extended 25 feet downstream of the end sill. Upstream protection consisted of a 3-foot thick, 12-foot wide section of derrick stone with a top elevation of 630.0 feet. The scour holes that formed upstream and downstream of the derrick stone were filled in 1983 and 1984 by a horizontal capstone section, underlain by a rockfill section a minimum of 30-inches thick. Upstream, the capstone was 42-inch thick and extended 25 feet upstream from the dam. The rockfill section extended upstream about 280 feet for the roller gate closest to the locks and 65 feet upstream for the remaining roller gates. Downstream of the three roller gates closest to the lock, a 10-foot thick wedge of capstone extended 30 feet downstream of the end sill. Downstream of the two remaining roller gates, a 42-inch thick capstone layer extended 55 feet downstream of the end sill. The rockfill section extended 125 feet downstream of the end sill for all of the roller gates. The rock surface downstream of the horizontal section slopes down at a rate of 1V:3H. The horizontal capstone was placed to the same elevation as the original derrick stone (elevation 629.0 feet downstream and 630.0 feet upstream).

(2) **Tainter Gates.** Downstream protection originally consisted of derrick stone, 4-feet thick with a top of rock elevation of 634.0 feet (1912 adjustment). It extended 25 feet downstream of the two tainter gates closest to the roller gates and 65 feet downstream of the three other tainter gates. Upstream, the derrick stone section was 12-feet wide and 3-feet thick with a top of rock elevation of 635.0 feet. The scour holes upstream

and downstream of the derrick stone were filled in 1983 and 1984 by a horizontal capstone, underlain by a rockfill section a minimum of 30-inches thick. Upstream, the capstone was 42-inches thick and extended 25 feet upstream of the dam. The rockfill extended 65 feet upstream of the dam. Downstream of the two tainter gates closest to the roller gates, a 42-inch thick layer of capstone extended 55 feet from the end sill. The rockfill section extended 125 feet downstream of the end sill. Downstream of the remaining three tainter gates, only minimal scour was observed; therefore, only rockfill, 30-inches thick was placed to a maximum distance of 125 feet. The rock surface downstream of the horizontal section slopes down at a rate of 1V:3H. The horizontal capstone was placed to the same elevation as the original derrick stone (elevation 634.0 feet downstream and 635.0 feet upstream).

(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, 440-foot long section of rock filled cribs was placed on the riverward side of the intermediate lock wall. Derrick stone 3 feet thick and 12 feet wide extended from the auxiliary lock to a point 100 feet downstream on the lower guidewall. The top of rock elevation varied from elevation 629.5 to 630.0 feet (1912 adjustment) at the auxiliary lock to 631.0 feet downstream of the main lock. Upstream of the locks, derrick stone sections 3-feet thick were placed at the intermediate and riverward lock walls, and at the landward lock wall.

Additional scour protection was placed along the upper and lower guide walls in the early 1980's. Upstream rock protection was placed along the entire length of the upper guide wall, as scour had undermined the base of the structure. Filling and shaping of the channel bed was required to bring the existing channel bed adjacent to the structure up to the base of the concrete at elevation 630.0 feet. Along the upper guide wall, scour protection consisted of a 30-inch riprap section with a top of rock elevation of 633.5 feet, which extended horizontally for a distance of 20 feet out from the wall. At that point, the riprap sloped at 1V:2H until it intersected the channel bed. The riprap was underlain by a 12-inch thick bedding layer.

Scour protection downstream was placed along a 267-foot long reach at the downstream end of the lower guide wall, and consisted of a 30-inch thick layer of riprap underlain by a 12-inch thick bedding layer with a top of rock elevation the same as the base of concrete elevation. A combination of excavation and fill was required to provide a suitable base elevation prior to placement of the bedding and riprap. Scour protection extended horizontally for a distance of 20 feet after which it sloped down to meet the channel at a slope of 1V:2H.

(4) Storage Yard. Original scour protection upstream of the storage yard consisted of riprap placed on a 1V:3H slope. Original protection downstream of the storage yard consisted of riprap placed on a 1V:5.5H slope from the top of the berm at elevation 664.0 feet (1912 adjustment) down to approximately elevation 642.0 feet, for a maximum distance of 115 feet. Surface riprap was placed between the downstream riprap and the derrick stone protection below the tainter gates to merge the protective layers. In 1983, additional riprap was placed upstream of the storage yard, on a 1V:3H slope.

d. Earthen Dam. An earthen dam, 20,533 feet in length, starts at the main lock, extends southwest across the river, then angles upstream until it reaches high ground at Minnesota City, Minnesota (**Plate 2-1**). The dam has a crest elevation that varies from 664.0 feet to 665.0 feet (1912 adjustment), a top width of 20 feet, and a maximum height of 26 feet (**Plate 2-2**). The pool side slope is 1V:3H and the tailwater slope is 1V:5.5H. The side slopes are protected by 12-inch riprap. Protection on the pool-side extends to the dam crest, whereas protection on the tailwater slope extends to three-and-a-half feet above the lower project pool (i.e. 645.5 + 3.5 = 649.0 ft).

Within the earthen dam is a 1,000-foot long fixed-crest concrete spillway (**Figure 2-5**). The spillway is supported on timber piling, driven in sand and gravel and has a steel sheet piling cutoff wall (**Plates 2-2**). The spillway, which is located at Straight Slough, has a crest elevation of 651.0 feet (i.e. Project Pool Elevation). In 1947 a slot was cut into the spillway to provide aeration to backwater areas upstream and downstream of the dam. The slot is 15 feet long and 2 feet deep (**Plate 2-2**).

Figure 2-5. Concrete Spillway with Notch.

2-04. Related Control Facilities.

a. Prairie Island Control Structure. In 1947, the City of Winona and the Civil Aeronautics Administration constructed a low levee that cut off Crooked Slough from the Mississippi River. The Prairie Island Control Structure was installed to maintain a predetermined difference in stage between Crooked Slough and the Mississippi River. The operating plan for the structure is presented in **Chapter 7** (Standing Instructions to Lock and Dam No. 5A Staff). The structure was incorporated into the Winona Flood Control Project in 1965-67. The Winona Flood Control Project was to alleviate local flooding on the Mississippi River at Winona, Minnesota. It was authorized by the Flood Control Act of 3 July 1958 (PL 850-500). The project was to be constructed in accordance with the plans recommended by the Chief of Engineers in House Document No. 324, 84^{th} Congress, 2^{nd} Session. The contract was awarded on 19 October 1964; however, the flood of April 1965 resulted in a redesign of the project (i.e. increasing levee heights to protect against higher flows). The contract was awarded 13 September 1965 and was completed in August 1967. See **Plates 2-4** and **2-5**.

Figure 2-6. Prairie Island Control Structure Looking North at Crooked Slough

b. Polander Lake Island Complex. Polander Lake is a 1,000-acre backwater area on the Minnesota side of the Mississippi River, just upstream of the lock and dam's earthen embankment (**Plate 2-7**). The Corps of Engineers constructed a habitat restoration project consisting of island creation in Polander Lake as part of the Environmental Management Program (EMP). Over the years vegetation in the lake had declined for a variety of reasons, including sedimentation, wave action, and turbidity-inducing water velocities. The purpose of constructing the islands was to promote the growth of aquatic vegetation and to increase habitat diversity in the lake. The island complex is located in the center of Polander Lake. It covers about 75 acres in area with the islands comprising approximately 25 acres. The project was substantially completed in 2000.

Figure 2-7. Island Complex at Polander Lake

2-05. Real Estate Acquisition. The Corps of Engineers acquired 3,915 acres of land and water area in fee for the Lock and Dam No. 5A project. The lock and dam site and the boatyard at Fountain City, Wisconsin occupy a total of 30 acres. The remaining land is under permit to the US Fish and Wildlife Service (USFWS) as part of the Upper Mississippi River National Wildlife and Fish Refuge. In addition, the Corps of Engineers holds special rights to 1,196 acres, which is also administered by the USFWS. In addition to the acreage listed above, the Corps holds flowage easements on almost 1,800 acres in the pool.

2-06. Public Facilities. Lock and Dam No. 5A has no public facilities at the site. However, there are numerous other facilities including parks and marinas located throughout the pool. A description of the facilities is presented in **Table 2-1**. By referencing the river mile shown in the table, the facility can be located on **Plates 2-6** and **2-7**.

Table 2-1
Pool No. 5A Recreation Facilities

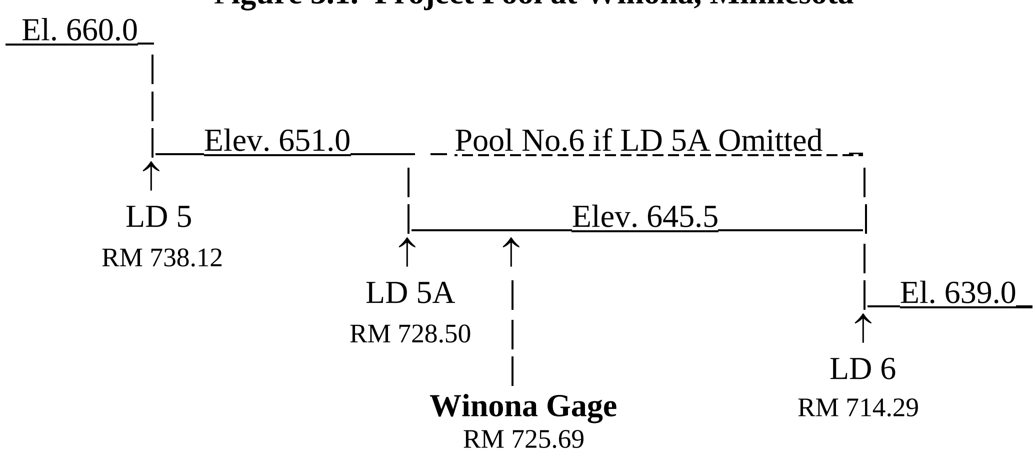
River Mile	Name	Manager	Fee	Slips	Parking	Camp Sites	Toilets	Picnic Tables
738.1 L	Whitman Dam Wildlife	WDNR			2			
737.8 R	Bass Camp	Private	Yes	36	20	Yes	Yes	Yes
737.2 L	Bays End	Private	Yes	15	5		Yes	Yes
737.0 L	Indian Creek Resort	Private		25		Yes	Yes	
736.1 L	Merrick State Park	WDNR			20	Yes	Yes	Yes
735.3 L	Merrick State Park - South	WDNR			20	Yes	Yes	Yes
733.0 L	Fountain City Dock	Fountain City			2			
732.0 L	Fountain City Landing	Fountain City			40			
731.3 R	Minnesota City Boat Club	Private	Yes	120+	20		Yes	Yes
730.8 R	Verchota Landing	USFWS			13			
728.7 R	McNalley Landing	USFWS			25			

III – HISTORY OF PROJECT

3-01. Authorization. The Upper Mississippi River Lock and Dam system 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. Although construction of Lock and Dam No. 5A was not part of the tentative nine-foot channel plan submitted in House Document No. 290, it was added by the time House Document No. 137 was published in 1932.

The City of Winona, Minnesota, located about three miles below the site, necessitated construction of Lock and Dam No. 5A. To minimize inundation at Winona, the maximum feasible pool elevation for Pool No. 6 was 645.5 feet (1912 adjustment); however, the required pool elevation to maintain the nine-foot channel in the reach downstream of Lock and Dam No. 5 was 651.0 feet. As a result, Lock and Dam No. 5A was constructed above Winona so that the lift from the downstream side of Lock and Dam No. 6 to downstream of Lock and Dam No. 5 could be made in two steps; that is, 6.5 feet from Lock and Dam No. 6 to Lock and Dam No. 5A and 5.5 feet from Lock and Dam No. 5A to Lock and Dam No. 5.

Figure 3.1. Project Pool at Winona, Minnesota



3-02. Planning and Design. The lock and dam system is necessary to provide a nine-foot channel during low to moderate flows. 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.

Congress established a project pool elevation of 651.0 feet (1912 adjustment) for Pool No. 5. The primary control point was established at river mile 736.17, which is 1.73 miles downstream of the tailwater gage house of Lock and Dam No. 5. Because of the close proximity, the tailwater of Lock and Dam No. 5 was established as the primary control point for Lock and Dam No. 5A. Elevation 651.0 feet is maintained at the primary control point until discharge is sufficient to allow for a drawdown at the dam. As originally designed, maximum drawdown was 2.5 feet, or elevation 648.5 feet. To maintain a more stable water surface elevation, maximum drawdown was reduced to 1.0 foot in 1959. As discharge increases, the gates are raised to maintain elevation 651.0 feet, at the primary control point, while drawdown at the dam occurs. After maximum drawdown is achieved, and discharge continues to increase, gates are opened to maintain maximum drawdown. Eventually all the gates are raised above the water surface and "open river conditions" exist.

The total number of gates required at each site was based on the allowable swellhead at extreme high water. The project design flood for Lock and Dam No. 5A was the flood of 1880. The design high water was elevation 661.1 feet with a flow rate of 179,600 cfs. For Lock and Dam No. 5A, the swellhead was limited to less than one foot. This 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 double locks occupy a significant portion of the main channel allowing for only five roller gates and five tainter gates. Therefore, to meet the required swellhead limitation, a spillway was required. A 1,000-foot long concrete fixed crest spillway was constructed within the earthen embankment, with a crest height set at the project pool elevation of 651.0 feet. In 1947 a slot, 15 feet wide and 2 feet deep, was cut into the fixed crest spillway. At project pool the slot provides a continuous flow of about 110 cfs ($Q=2.6CLH^{3/2}$).

3-03. Construction. Construction of the lock began on 3 January 1934 and was completed on 15 February 1935. Construction of the dam began on 4 February 1935 and was completed on 31 August 1936. The cost of constructing Lock and Dam No. 5A was $3,164,000. The project was placed in operation on 6 July 1936. At an additional cost, the earthen dike was completed on 19 May 1936. Other structures (at additional costs) related to the lock and dam were a power control and lighting system (completed 3 September 1936) and lockkeeper's dwellings and a garage pumphouse (completed 22 August 1938).

3-04. Related Projects. Lock and Dam No. 5A 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 St.

Anthony Falls Lock and Dam, Lower St. Anthony Falls Lock and Dam, and Lock and Dam Numbers 1 through 10.

3-05. Modifications to Regulation.

a. 1948 Modification. The nine-foot channel depth was only important during the navigation season. Therefore, the pool could be drawn down 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 Mississippi River between Rock Island, Illinois and Minneapolis, Minnesota during the non-navigation season. This law is known as the "Anti-Drwdown Law". The law states that the "…dam structures shall generally operate and maintain pool levels as though navigation was carried on throughout the year."

b. 1959 Modification. The original maximum allowable drawdown for Lock and Dam No. 5A was 2.5 feet and was established in 1936. Maximum drawdown was based on the fact that further drawdown may result in jeopardizing navigation depths upstream of the dam, and would have very little effect on the water surface elevation at the primary control point. In 1959, to reduce the adverse effects of the drawdown on navigation, riverfront property, and conservation interests, the maximum allowable drawdown was reduced to 1.0 foot, or elevation 650.0 feet (1912 adjustment). This remains today as the secondary control elevation.

c. 1973 Modification. The discharge through the dam was reevaluated in 1973. Prior to this, flow was distributed evenly across the dam; however, to achieve this, the recommended tainter gate settings hugged the maximum allowable outflow velocity (4.5 feet per second). Therefore, there was a need to revise the Gate Regulation Schedule. The new Gate Regulation Schedule, distributed flow across the dam based on a more equal distribution of outflow velocities.

d. 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 and 1984. The riprap was designed to remain stable for a 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. 15-20 minutes). Therefore, a new Gate Regulation Schedule was developed showing the new maximum allowable gate openings.

e. 1992 Modification. The motors that operate the lock miter gates were raised in 1992. Before this, the motors were pulled when the pool reached elevation 657.5 feet (1912 adjustment). Since the motors were raised, the lock does not go out of operation until the pool is at or near the top of the upstream miter gates at elevation 660.0 feet (1912 adjustment).

f. 1995 Modification. Historically, winter regulation allowed a 0.3-foot variation in the water surface at the primary control point. That is, the target value for primary control was elevation 651.0 ± 0.3 feet. The additional tolerance 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 trail basis. Therefore, starting in the winter of 1995, an attempt was made to maintain the primary control point at the tailwater of Lock and Dam No. 5 between elevations 651.0 feet and 651.3 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.

g. 2002 Modification. Changes in the Operating Curves and a check of Roller Gate and Tainter Gate end sill velocities necessitated minor modifications to the existing Gate Regulation Schedule. A new Gate Regulation Schedule is presented in **Table 7-4**.

h. 2003 Modification. An outdraft problem exists at Lock and Dam 5A for down bound tows. A permanently mounted sign and light are displayed at the end of the upstream guidewall to alert down bound tows of the situation. Previously the sign was swung out into view and the light turned on, when flows were above 26,000 cfs. Experience has shown that the problem does not become prevalent until a discharge of 32,000 cfs. Therefore, the trigger discharge was changed to 32,000 cfs.

3-06. Principal Regulation Problems.

a. Outdraft. An outdraft problem exists at Lock and Dam 5A for down bound tows. A permanently mounted sign and light are displayed at the end of the guidewall when flows are above 32,000 cfs to alert down bound tows.

b. Zebra Mussels. The infestation of zebra mussels could have significant impact on future operations. Zebra mussel populations 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. When the lock was last dewatered, zebra mussels were found completely covering the bottom of the lock chamber. 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 3-2
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 3-3
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. The drainage area of Pool No. 5A totals 59,105 square miles in Minnesota and Wisconsin. At project pool elevation of 651.0 feet (1912 adjustment), the pool has a total surface area of 7,000 acres. Rollingstone and Waumandee Creeks are the only tributaries to Pool No.5A. These creeks are small have no rated gaging stations.

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.

4-03. Sediment. Part of the nine-foot navigation plan authorized by Congress included periodic dredging of sediment. There are four sites within the Pool No. 5A navigation channel that require periodic dredging. Quantities and frequency of dredging these areas is presented in **Paragraph 5-03**.

4-04. Climate. The National Weather Service (NWS) maintains temperature and precipitation records for Lock and Dam No. 5A area. The data shown in the following tables are from the National Oceanic and Atmospheric Administration's *Climatological Data Annual Summaries*. Temperature data shown in **Table 4-1** were taken from the NWS site at Winona, Minnesota. Precipitation data shown in **Table 4-2** are from Lock and Dam No. 5A except where the data was found to be missing, in which case divisional data were used. The nearest site to Lock and Dam No. 5A where evaporation data was collected is Lock and Dam No. 6. Pan evaporation data was collected at this location until 1997. Pan and pool evaporation data are shown in **Table 4-3**. Pool evaporation was estimated by assuming a pan coefficient of 0.7.

Table 4-1
30-Year Normal Monthly Temperature in F^{o}, Winona, MN

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
14.1	19.5	32.0	46.6	58.5	68.0	73.2	69.7	60.8	49.7	35.3	19.8	45.6

Table 4-2 30-Year Normal Monthly Precipitation in Inches, Lock & Dam No. 5A												
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
0.96*	0.74	1.87	2.86	3.78	3.69	4.01	3.64	3.81	2.30	1.70	1.08	30.44

*value from divisional data

Table 4-3 Pan and Pool Monthly Evaporation in Inches, Lock & 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. 5A. 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-dependent (1-hour) average wind speeds using procedures presented in the US Army Corps of Engineers' *Shore Protection Manual* (1984). Fastest Mile and 1-hour average wind speeds are shown in **Table 4-4**.

Table 4-4 Highest Monthly Wind Speed and Direction in MPH, 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. High inflows from upstream produce flooding of Pool No. 5A. After construction of the lock and dam in 1936, the first significant flood events didn't occur until spring of 1951. On the 18th of April, the Mississippi River at Pool No. 5A crested at 659.87 feet (1912 adjustment). This stage was exceeded the following year when on 20 April 1952, Pool No. 5A peaked with a pool gage elevation of 660.39 feet. Estimated discharge was 190,000 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						
Dam No. 5 Tailwater – Control Pt			**Lock and Dam No. 5A**			
Date	Stage ft	Elev. ft (1912)	Date	Pool ft (1912)	Tailwater ft (1912)	Discharge cfs
18-Apr-51	14.65	663.30	18-Apr-51	659.87	659.26	-
20-Apr-52	15.19	663.84	20-Apr-52	660.41	659.87	~190,000
19-Apr-65	**19.20**	**667.85**	**20-Apr-65**	**663.74**	**663.33**	**270,000**
6-Apr-67	13.91	662.56	7-Apr-67	659.06	658.63	164,000
19-Apr-69	16.45	665.10	19-Apr-69	661.86	661.37	223,000
26-Jun-93	13.53	662.18	27-Jun-93	658.80	658.26	176,900
12-Apr-97	14.93	663.58	12-Apr-97	660.52	659.97	200,500
17-Apr-01	17.05	665.70	17-Apr-01	662.33	661.92	233,600

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 14.5 feet at Winona, Minnesota (flood stage is 13.0 feet) with normal precipitation and a snowmelt of more than three days. The forecast for Winona indicated that the flow in the Mississippi River would peak at 127,000 cfs. The operating curves in use in 1965 at Lock and Dam No. 5A showed that for this flow, Pool No. 5A would reach elevation 656.4 feet (1912 adjustment)). The forecast also cautioned that if rainfall of one inch should occur before or during the crest, the resulting peak stage at Winona would be near the 1952 level. This would result in Pool No. 5A peaking at an elevation around 660.4 feet with an outflow of 190,000 cfs.

Moderate to heavy rains early in April increased the water content of the snow on the ground to a maximum by the 6th of April. On the 9th of April, the Weather Bureau revised the forecast for Winona, predicting a stage of 20.5 feet. The forecast for Pool No. 5A was raised to elevation 662.8 feet with a discharge of 240,000 cfs. Based on this forecast, the lock gate operating motors were removed, and the central control station, dwellings, earth dikes, and access roads were protected by sandbags. Additional rainfall in the period between the 8th and 12th of April caused another upward revision in the forecast for Pool No. 5A. On the 16th of April, the forecast for Winona was raised to 21.5 feet, bringing the forecast for Pool No. 5A to elevation 663.8 feet with a discharge of 255,000 cfs.

The rapid increase of inflow began on the 1st of April when the discharge rose from 11,700 cfs on this date to 64,000 cfs on the 6th of April. By this time, the head at the dam had been reduced to just a swellhead of 0.28 feet and the gates were removed from the water. The motors that operate the lock miter gates had to be pulled when the pool stage reached elevation 658.0 feet. This stage was reached on the 15th of April, thus shutting Lock No. 5A down to navigation. The pool at Lock and Dam No. 5A crested on the 19th of April at elevation 663.74 feet with a peak flow of 270,000 cfs. While the pool fell below elevation 658.0 feet on the 1st of May, the lock was not reopened until the 10th of May. The pool returned to secondary control (elevation 650.0 feet) on the 24th of June and the dam was put back into operation. Primary control was not restored until the 26th of July.

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 19.0 feet at Winona, Minnesota. On the 12th of April, Winona crested at a stage of 18.3 feet. The pool at the dam crested on the 12th of April at elevation 660.52 feet (1912 adjustment) with a peak discharge of 200,500 cfs. The lock was closed to navigation for 6 days from the 10th through the 15th of April.

c. April 2001. The National Weather Service's 2001 Spring Snowmelt Flood Outlook predicted minor to moderate flooding for Pool No. 5A. 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. 5A. On the 17th of April, the pool peaked at elevation 662.33 feet (1912 adjustment) with a discharge of 233,600 cfs. Additional rainfall runoff resulted in a second crest of elevation 661.68 feet on the 29th of April. The pool reached the closure elevation of 660.0 feet on the 15th of April and did not fall below elevation 660.0 feet until the 5th of May. While the lock may have been in operation before the 15th of April and after the 5th 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 657.98 feet.

4-06. Runoff Characteristics. The mean annual discharge at Lock and Dam No. 5A is 32,500 cfs based on a period of record from 1960 to 2002. **Table 4-6** shows the monthly average discharges.

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

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
17,500	18,000	34,400	70,900	56,600	43,400	36,000	25,100	25,600	27,600	28,300	21,200

The maximum discharge of 270,000 cfs occurred at the dam on 20 April 1965 (**Table 4-5**). The lowest discharge during the navigation season occurred during the drought of 1988 when on the 2nd of July a discharge of 6,300 cfs was recorded. A discharge frequency curve for the Mississippi River at Winona, Minnesota, in Pool No. 6, is shown on **Figure 8-1**. **Table 4-7** shows the discharge-duration at the dam.

Table 4-7
Discharge-Duration at Lock and Dam No. 5A
Percent Time At or Above Indicated Discharge (Years 1972-2000)

Discharge	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
200,000				0.1									
195,000				0.5									
190,000				0.6									
185,000				0.8									
180,000				0.9									
175,000				1.3	0.2	0.3							0.2
170,000				1.5	0.4	0.7							0.2
165,000				2.0	0.4	0.7	0.2						0.3
160,000				2.1	0.6	0.7	0.3						0.3
155,000				2.4	0.7	0.7	0.4						0.4
150,000				2.8	0.8	0.8	0.6						0.4
145,000				2.8	0.9	0.8	0.8						0.4
140,000			0.2	3.5	1.0	0.8	0.8		0.2				0.5
135,000			0.4	4.4	1.1	0.8	1.1		0.5	0.2			0.7
130,000			0.9	4.9	1.5	0.9	1.8		0.5	0.3			0.9
125,000			1.0	5.9	2.1	0.9	2.0		0.5	0.4			1.1
120,000			1.3	6.9	2.9	1.0	2.1		0.6	0.6			1.3
115,000			1.6	7.8	3.8	1.0	2.2		0.6	0.6			1.5
110,000			1.9	9.0	4.2	1.0	2.3		0.7	0.7			1.7
105,000			2.1	11.6	4.9	1.2	2.5		0.7	0.8			2.0
100,000			2.5	15.1	6.5	1.8	2.6		0.7	0.9			2.5
95,000			2.8	18.5	8.1	2.4	2.7		0.8	1.1			3.0
90,000			3.9	21.8	10.3	2.8	3.1	0.2	0.8	1.7			3.7
85,000			4.9	24.6	12.9	3.5	3.5	0.3	0.8	2.1			4.4
80,000			5.9	29.2	17.6	4.4	4.1	0.4	0.9	3.0			5.5
75,000			8.1	34.1	23.4	5.4	4.9	0.6	0.9	3.3			6.7
70,000			9.8	40.3	28.4	8.6	6.9	1.6	1.2	4.1	0.5		8.5
65,000			11.9	46.8	36.3	11.3	9.6	3.0	1.6	4.7	0.5		10.5
60,000		0.5	14.5	55.6	43.6	14.6	13.0	4.9	2.1	6.1	2.4		13.2
55,000		1.0	17.9	63.5	50.1	21.4	17.9	6.2	4.5	9.0	4.7	0.1	16.4
50,000		1.1	25.1	72.0	56.1	32.5	28.0	8.8	8.2	13.5	8.6	1.5	21.3
45,000		1.3	30.6	77.4	63.3	43.3	36.9	14.0	15.4	16.9	13.6	3.0	26.4
40,000	0.2	2.4	37.2	80.3	69.0	56.4	46.7	19.9	22.6	22.9	19.4	4.7	31.9
35,000	0.5	3.8	44.6	83.9	74.4	67.6	54.7	27.8	29.8	29.1	33.5	9.5	38.4
30,000	3.3	5.5	54.3	88.5	79.4	75.2	63.6	38.8	38.3	37.7	48.6	22.0	46.4
25,000	19.1	15.7	66.0	94.5	84.7	80.2	70.6	49.9	51.0	49.5	62.1	38.3	57.0
20,000	38.2	37.1	76.0	98.4	91.6	85.3	77.2	66.4	63.1	64.6	76.1	56.6	69.3
15,000	70.6	72.0	93.1	99.5	95.3	92.4	83.8	80.3	78.7	77.6	90.8	76.1	84.2
10,000	94.7	94.8	98.8	100.0	100.0	97.5	93.4	91.4	94.9	94.7	96.2	91.8	95.7
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 elevation-duration tables were developed for the pool, tailwater, and the control point (tailwater of Lock and Dam No. 5). 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 642.40 feet, while gage zero for the control point is elevation 648.65 feet.

Table 4-8
Elevation-Duration, Lock and Dam No. 5A 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
660.4				0.2									
660.2				0.5									
660.0				0.6									
659.8				0.8									
659.6				0.9	0.1								
659.4				0.9	0.1								
659.2				1.0	0.1								
659.0				1.2	0.1								0.1
658.8				1.2	0.2	0.1							0.1
658.6				1.5	0.3	0.5							0.2
658.4				1.7	0.3	0.6							0.2
658.2				2.0	0.4	0.7	0.1						0.3
658.0				2.1	0.4	0.7	0.2						0.3
657.8				2.3	0.6	0.7	0.2						0.3
657.6				2.3	0.6	0.7	0.3						0.3
657.4				2.6	0.7	0.7	0.4						0.4
657.2				2.6	0.7	0.7	0.4						0.4
657.0				2.8	0.8	0.8	0.6						0.4
656.8				3.3	0.8	0.8	0.7						0.5
656.6			0.2	3.5	0.9	0.8	0.8						0.5
656.4			0.3	4.0	1.0	0.8	0.8		0.2				0.6
656.2			0.7	4.3	1.0	0.8	0.9		0.5				0.7
656.0			0.8	4.6	1.0	0.8	0.9		0.5	0.2			0.7
655.8			0.8	4.9	1.3	0.8	1.3		0.6	0.2			0.8
655.6			1.0	5.9	1.5	0.9	1.8		0.6	0.3			1.0
655.4			1.1	6.3	1.9	0.9	1.9		0.6	0.3			1.1
655.2			1.2	6.7	2.2	0.9	2.0		0.6	0.4			1.2
655.0			1.5	7.1	2.9	0.9	2.0		0.6	0.4			1.3
654.8			1.5	7.7	3.1	1.0	2.1		0.6	0.4			1.4
654.6			1.6	8.2	3.7	1.0	2.1		0.7	0.6			1.5
654.4			1.8	9.1	4.0	1.0	2.2		0.7	0.6			1.6
654.2			1.9	10.0	4.1	1.0	2.2		0.7	0.6			1.7
654.0			2.1	11.3	4.7	1.3	2.3		0.7	0.7			1.9
653.8			2.1	12.9	5.3	1.8	2.3		0.7	0.7			2.2
653.6			2.3	14.8	6.0	2.1	2.5		0.8	0.8			2.4
653.4			2.5	16.6	6.9	2.3	2.6	0.2	0.8	0.8			2.7
653.2			2.8	18.3	7.7	2.6	2.7	0.2	0.8	0.9			3.0
653.0			2.9	20.1	8.3	2.8	2.9	0.3	0.8	1.1			3.3
652.8			3.3	22.3	10.0	2.8	3.0	0.3	0.8	1.6			3.7
652.6			4.0	23.7	11.4	3.0	3.3	0.4	0.8	1.8			4.0
652.4			4.7	25.3	13.0	3.6	3.7	0.4	0.8	2.0			4.5
652.2			5.2	27.4	15.2	3.8	3.8	0.4	0.9	2.2			4.9
652.0			6.0	29.5	17.7	4.3	4.1	0.6	0.9	2.8			5.5
651.8			6.8	31.7	20.2	4.7	4.3	0.6	0.9	3.0			6.0
651.6			8.1	33.7	22.6	4.9	5.0	0.7	0.9	3.1		0.2	6.6
651.4	0.1		8.6	36.3	25.7	5.8	5.3	0.9	1.0	3.6		0.5	7.3
651.2	0.6		10.2	39.5	27.7	6.9	8.9	5.3	3.8	5.9	2.2	0.9	9.4
651.0	7.2	6.3	12.2	43.2	31.6	12.5	16.1	15.8	16.8	21.8	11.2	9.2	17.0
650.8	21.1	18.8	20.5	47.5	39.4	21.7	26.0	32.6	34.3	38.7	27.1	28.4	29.7
650.6	37.2	31.8	27.5	51.3	47.1	28.1	35.3	44.3	47.8	53.7	37.5	44.3	40.5
650.4	45.3	40.4	38.3	57.9	54.4	35.3	41.7	51.8	59.0	64.6	45.6	54.5	49.1
650.2	61.5	60.4	56.3	69.8	67.4	49.8	56.1	65.2	74.5	76.4	60.7	69.7	64.0
650.0	82.7	90.7	83.4	88.5	86.3	82.4	84.0	89.8	90.8	94.9	86.6	85.7	87.1
649.8	97.8	99.5	97.4	99.7	99.7	99.4	99.9	99.7	99.5	99.8	99.2	97.4	99.1
649.6	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, Lock and Dam No. 5A 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
659.8				0.2									
659.5				0.5									
659.0				0.9									
658.5				1.0									0.1
658.0				1.5	0.2	0.5							0.2
657.5				2.0	0.4	0.7	0.2						0.3
657.0				2.4	0.6	0.7	0.4						0.3
656.5				2.8	0.7	0.8	0.6						0.4
656.0			0.2	3.8	0.9	0.8	0.8		0.1				0.6
655.5			0.7	4.5	1.1	0.8	1.1		0.5	0.2			0.7
655.0			1.0	6.0	1.7	0.9	1.9		0.6	0.3			1.0
654.5			1.4	6.9	2.8	1.0	2.0		0.6	0.4			1.3
654.0			1.7	8.5	3.9	1.0	2.2		0.7	0.6			1.6
653.5			2.1	11.4	4.5	2.0	2.3		0.7	0.7			1.9
653.0			2.5	15.3	6.5	2.3	2.5		0.8	0.8			2.5
652.5			3.0	19.7	8.5	2.7	5.8	0.3	0.8	1.1			3.2
652.0			4.7	23.8	12.1	3.1	3.5	0.4	0.8	1.8			4.2
651.5			5.7	28.4	16.6	4.0	4.1	0.6	0.9	2.6		0.1	5.3
651.0			8.0	33.6	23.1	4.8	5.1	0.7	0.9	3.3		0.5	6.7
650.5			9.8	41.4	29.6	8.0	7.0	1.2	1.2	3.9	0.3	0.6	8.6
650.0			12.1	48.5	37.5	11.4	10.6	1.8	1.6	4.9	0.8	0.8	11.0
649.5		0.7	15.0	56.7	44.5	15.5	13.7	5.0	2.1	6.3	2.6	1.2	13.7
649.0		1.2	18.5	63.3	49.7	21.2	19.1	6.7	4.6	9.0	5.1	1.8	16.7
648.5	0.2	1.5	22.6	70.0	54.3	28.6	25.6	9.1	7.3	11.7	7.6	4.8	20.3
648.0	1.1	2.0	28.0	75.1	59.7	37.4	32.0	12.0	13.5	14.6	11.7	9.8	24.7
647.5	5.2	4.2	34.5	78.1	65.4	49.2	38.7	15.2	17.7	18.2	17.2	15.6	30.0
647.0	13.6	13.2	44.6	81.2	71.1	61.0	48.5	22.3	25.8	25.3	24.1	25.6	38.1
646.5	29.3	23.7	58.3	85.3	76.6	70.9	57.6	31.8	33.8	34.2	41.8	36.9	48.4
646.0	57.2	52.2	77.3	94.1	85.1	81.3	71.8	53.5	53.1	56.3	66.4	58.1	67.2
645.5	91.6	95.5	98.1	99.6	97.8	97.6	96.4	93.3	93.3	96.5	96.5	90.9	95.6
645.0	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

Because the control point for Pool No. 5A is the tailwater of Lock and Dam No. 5, **Table 4-10** can also be seen in Appendix 5 of the Master Water Control Manual, *Lock and Dam No.5, Minneiska, Minnesota.*

Table 4-10 **Elevation-Duration, Lock and Dam No. 5 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
663.5				0.2									
663.0				0.7									
662.5				0.9									
662.0				1.2	0.2	0.3							0.1
661.5				1.8	0.4	0.7	0.1						0.3
661.0				2.4	0.6	0.7	0.3						0.3
660.5				2.8	0.7	0.8	0.5						0.4
660.0			0.4	3.8	0.9	0.8	0.8		0.2				0.6
659.5			0.8	4.5	1.1	0.9	1.2		0.6	0.2			0.8
659.0			1.2	6.1	1.6	0.9	1.9		0.6	0.3			1.1
658.5			1.5	7.5	2.9	1.0	2.1		0.7	0.5			1.4
658.0			2.1	10.8	4.1	1.3	2.2		0.8	0.6			1.8
657.5			2.5	15.5	6.1	2.4	2.6	0.2	0.8	0.8			2.6
657.0			3.1	22.1	9.1	2.8	3.1	0.3	0.8	1.3			3.6
656.5			5.1	26.3	14.1	3.9	3.8	0.4	0.9	2.1			5.0
656.0			7.2	32.8	20.2	4.6	4.6	0.6	0.9	3.0			6.2
655.5			9.5	38.4	27.8	6.4	6.5	0.7	1.1	3.7	0.1		7.9
655.0			11.2	45.8	34.9	10.1	9.2	2.1	1.5	4.3	0.3		10.0
654.5			13.3	52.4	41.2	13.7	11.9	4.1	1.7	5.7	1.3	0.2	12.2
654.0		0.5	16.2	60.9	47.6	20.0	16.7	5.6	3.3	8.3	3.7	0.6	15.3
653.5	0.1	0.9	20.8	67.8	53.3	26.6	23.7	8.3	6.7	11.1	6.7	1.2	19.0
653.0	0.3	1.2	26.5	74.6	58.8	36.9	31.0	11.9	11.7	14.6	10.7	4.2	23.6
652.5	2.6	2.4	32.0	78.1	63.5	50.3	37.4	14.9	18.5	19.5	16.2	10.8	28.9
652.0	11.8	11.1	41.1	82.9	69.9	63.0	48.3	22.4	26.9	26.7	25.9	21.4	37.7
651.5	35.7	31.8	59.3	88.2	78.0	73.5	63.0	37.6	38.4	40.8	49.4	40.1	53.0
651.0	89.1	85.6	91.6	98.6	95.3	95.5	93.7	89.4	89.5	92.1	93.1	88.9	91.9
650.5	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 651.0 feet (project pool), the storage volume in Pool No. 5A is 29,800 acre-feet **(Table 4-11)**. At moderate flows, there is a one-foot drawdown at the dam. That is, while the elevation at the dam is 650.0 feet, the elevation at the control point (tailwater of Lock and Dam No. 5) is a minimum of 651.0 feet. When the pool is at these elevations, the storage volume of Pool No. 5A is approximately 25,800 acre-feet. A flow rate of approximately 13,000 cfs would result in a daily exchange in storage. A relationship of storage to discharge is shown on **Plate 4-1**.

Table 4-11
Storage Volume of Pool No. 5A in 1,000 Ac-Ft
Between Tailwater of Dam 5 and Pool of Dam 5A

Pool Elev at Dam 5A	Elevation at Tailwater of Dam 5																				
	665	664	663	662	661	660	659	658	657	656	655	654	653	652	651	650	649	648	647	646	645
661	182	172	163																		
660	174	165	157	148																	
659	167	159	151	142	134																
658	160	152	144	136	128	119															
657	154	146	138	130	122	114	106														
656		140	132	124	116	108	101	93													
655			126	118	110	103	95	87													
654				112	105	97	89	82	74												
653					100	92	85	77	69	62											
652						89	81	73	66	58	52	47									
651							76	68	60	53	47	41	37	33	30						
650								64	55	48	42	37	32	29	26	23					
649									51	44	38	33	29	25	22	20	19				
648										39	34	30	26	23	20	18	16	15			
647											31	27	23	21	18	16	15	14	12		
646												24	21	19	17	15	13	12	11	10	
645													19	17	15	13	12	10	9	10	
644														16	14	12	11	9	8	8	8
643															12	11	9	8	7	7	6
642																11	9	7	6	6	6

4-07. Water Quality. After inundation in the 1930's and into the 1940's, the Polander Lake area (**Plate 2-7**) had an abundance of emergent aquatic plants and provided a good staging area for migrating waterfowl. The area of emergent aquatic vegetation declined over the years such that emergent vegetation was limited to the lake edges. Much of the emergent vegetation had been replaced by submerged vegetation. One of the reasons for the change in vegetation conditions is the reduced water quality due to increased turbidity in the lake. This was the result of sedimentation, wave action, and increased water velocities. A two-stage Habitat Rehabilitation and Enhancement Project began in 1994 to alleviate the situation. Project features included the construction of an island complex, totaling 6,000 linear feet, in the lower portion of the lake (**Figure 2-6.**). The project was completed in 2000 at a cost of around $3.5 million. The project is expected to increase the lake's aquatic plant communities, maintain or enhance the lake's structural diversity, and decrease current velocities in a third of the lake by 50 percent. These conditions will improve this 1,000-acre lake for waterfowl staging and fisheries value. The Minnesota Department of Natural Resources was the non-Federal project sponsor. Costs for operation, maintenance, and repair are the responsibility of the US Fish and Wildlife Service.

4-08. Channel and Floodway Characteristics. The top of the lower lock sill elevation at Lock and Dam No. 5 is elevation 642.0 feet and the top of the upper lock sill elevation at Lock and Dam No. 5A is elevation 633.0 feet. Therefore, there is a 9.0-foot drop in sill elevation along the pool, which has a length of 9.6 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 2-6 and 2-7**.

4-09. Upstream Structures. Lock and Dam No. 5 is located 9.6 miles upstream of Lock and Dam No. 5A. The drainage area above Lock No. 5 is 58,845 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. 6 is located 14.2 river miles downstream of Lock and Dam No. 5A. The drainage area above Lock No. 6 is 60,030 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 and Dam No. 10.

4-11. Economic Data. Pool No. 5A lies on the Minnesota-Wisconsin border. Winona County lies on the western side and Buffalo County lies on the eastern side. **Table 4-12** was based on the US Census Bureau, county and city populations. **Table 4-13** gives a break down of the employment by industry. The data were taken from the US Census Bureau's 1997 Industry Report.

Table 4-12
County and City Populations Near Pool No. 5A

	1990	2000	Difference	Change
County				
Winona, MN	47,828	49,985	2,157	4.5 %
Buffalo, WI	13,584	13,804	220	1.6 %
City				
Winona, MN	25,399	27,069	1,670	6.6 %
Goodview, MN	2,878	3,373	495	17.2 %
Minnesota City, MN	258	235	-23	-8.9 %
Fountain City, WI	938	938	0	0 %

Table 4-13
Employment by Industry – Counties on Pool No. 5A (1997)

Industry	Winona	Buffalo
Manufacturing	7,115	-
Wholesale Trade	682	180
Retail Trade	2,506	305
Real Estate, Rental, Leasing	129	17
Professional, Scientific, Tech Services	569	39
Admin & Support, Waste Management	567	77
Education Services	10	-
Health Care & Social Services	705	169
Arts, Entertainment & Recreation	134	28
Accommodations & Food Services	1,725	350
Other Services	296	38
Totals	15,038	1,403

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. Inflow to Pool No. 5A from Dam No. 5 is computed as part of the regulation program, using pool and tailwater elevations, and the gate settings. When the gates are raised clear of the water, a rating table is used. The gage at the control point located downstream of Lock and Dam No. 5 is shown in **Figure 5-1**.

Figure 5-1. Control Point Gage House – Tailwater of Lock and Dam No. 5

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 (**Figures 5-2 and 5-3**). 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 5-4**). Staff gages are mounted inside the downstream gage house and outside the upstream gage house and serve as backup or are used for verification of the tape in the well. The locations of these gage sites are shown on **Plate 5-1**.

Figure 5-2. Pool Gage House

Figure 5-3. Tailwater Gage House

A water temperature sensor, reading in degrees Fahrenheit, is located in the upper ladder recess in the lock chamber. A standard eight-inch precipitation gage is located just outside the front door of the control house. The site is equipped with a measuring rod for snow depth and a snow tube and scale for determining snow-water content. An anemometer is located atop pier number one. Data types and equipment are listed in **Table 5-1**.

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

Table 5-1 Hydrometeorological Stations			
Location	**Data Type**	**Equipment**	**Notes**
Lock & Dam No. 5 Tailwater (Control Point)	Water Surface Elevation	Stevens PAV-C Recorder, Stilling Well, Staff Gage	Continuous Strip Chart record of TW elevations. Gage zero: 648.65 ft
Lock & Dam No. 5A Upper Guide Wall	Pool Elevation	Stevens PAV-C Recorder, Stilling Well, Staff Gage	Continuous Strip Chart record of pool elevations. Gage zero: 642.40 ft
Lock & Dam No. 5A Lower Guide Wall	Tailwater Elevation	Stevens PAV-C Recorder, Stilling Well, Staff Gage	Continuous Strip Chart record of TW elevations. Gage zero: 642.40 ft
Lock & Dam No. 5A	Snow Depth & Water Content	Snow Rod, Snow Tube, Scale	Maintained by Water Control Gage Crew.
Lock & Dam No. 5A Near Central Control Station (CCS)	Precipitation	Standard 8-inch Rain Gage	Recorded daily. Send data monthly to NWS La Crosse.
Lock & Dam No. 5A Roller Gate Pier Closest to CCS	Wind Speed & Direction	Anemometer	Maintained by site personnel.
Lock & Dam No. 5 Upper Ladder Recess	Water Temperature	Water Temperature Sensor	Electronically transmitted to Central Control Station.

b. Reporting. Daily log sheets of data are kept at the lock and dam site (**Appendix B**). Data include water surface elevations at the pool, tailwater, and Winona gage site, roller and tainter gate settings, air and water temperatures, 24-hour precipitation, and wind speed and direction. A more complete description of the log sheet is given in **Section 7-04. Standing Instructions to Lock and Dam No. 9 Staff**. In addition to the log sheet, site personnel also enter these data via a remote computer to a program called "sig-na-term". Each morning Water Control collects the 0600-hour data and compiles it with data from the past 24-hours. These data are formatted on to the Regulation Sheets. An example of the data presentation for Lock and Dam No. 9 is shown on **Page 7-13**.

The data reported to Water Control via remote computer is input to a computer generated log sheet, which is available from the Water Control web site at www.mvp-wc.usace.army.mil. Data includes and pool, tailwater and

Winona gage elevations, gate settings, and total discharge on four-hour intervals beginning at 0400-hours. Total river discharge is calculated internally based the differential head and the gate openings. When the gates are out of the water, a tailwater rating table is used. A constant flow of 200 cfs is added to the total to account for flow through the slotted spillway. During winter months, site personnel report the tainter valve opening. The computer automatically translates this opening to discharge and it is added to the total. Air temperature and wind speed and direction are entered on eight-hour intervals beginning at 0800-hours. The 24-precipitationtotal and water temperature are at 0800-hours. Maximum and minimum air temperature are enter at 2400-hours. It should be noted that all 0800-hour date are actually taken at 0600-hours and max-min air temp is actually taken at 1900-hours.

During the winter months, percent of ice coverage over the lower pool and upper tailwater, ice thickness (observed), snow depth, and snow-water content (all in inches) are reported to Water Control once a week on Sundays. This information is available from the Water Control web site.

The Stevens PAV-C strip charts are mailed to Water Control every year where they are then periodically micro-filmed.

c. **Maintenance.** Operation and maintenance of the pool and tailwater gages are the responsibility of the Water Control Gage Crew. 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. Repair or replacement of the snow survey equipment is the responsibility of the Gage Crew.

5-02. Water Quality Stations. There are no Corps of Engineers' water quality stations in Pool No. 5A; 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. No suspended sediment data is collected in Pool No. 5A; however, routine dredging of sediment is part of the nine-foot navigation plan. There are several sites in Pool No. 5A 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 5-2** gives a summary of dredging in Pool No. 5A since 1970.

Table 5-2
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
Island 58	734.0 to 735.2	7,704 yd	29,854 yd	26 %	1982
Fountain City	733.3 to 733.8	1,304 yd	40,411 yd	3 %	1972
Betsey Slough	731.0 to 732.0	22,718 yd	28,171 yd	81 %	2000
Wilds Bend	730.2 to 730.7	14,233 yd	25,953 yd	55 %	1996

5-04. Recording Hydrologic Data. Daily log sheets containing pool and tailwater elevations, roller and tainter gate settings, air temperature, precipitation, max-min air temperatures, water temperature, and wind speed and direction are kept at the dam site. All daily data received by Water Control from the dam site is compiled and archived using Hydraulic Engineering Center's Data Storage System (HEC-DSS) and is accessible from the Water Control web site at *www.mvp-wc.usace.army.mil*. In 2001, log sheets were made available on the Water Control web site. By using the lock and dam data stored in DSS files, log sheets were generated dating back to January 1993. 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 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 and 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). 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. 5A every morning at approximately 0800-hours with the exception of weekends and holidays during the non-navigation season when orders are sent out around 0730-hours. 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 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 this web site, the public can access current water surface elevations and discharges 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 10 percent of the total 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. 5A personnel should notify Lock No. 6 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 and the embankment, the dam offers little obstruction to the flow. The storage capacity created by the dam is relatively small 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 660.0 feet (1912 adjustment) at which time water is at 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. Additionally, the timing of the receding limb of the hydrograph aids in estimating when the lock will 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. 5A is Winona, Minnesota. 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 closest NWS forecast site for Pool No. 5A is the control point for Lock and Dam No. 6 at Winona, Minnesota.

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. 5. 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. The run is completed every day 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. Therefore, during low flow periods, the project pool elevation is maintained. This 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 MBMS 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. 5A, without inducing higher stages during flood events. Project pool elevation for Lock and Dam No. 5A is 651.0 ± 0.2 feet (1912 adjustment). The theoretical "primary control point" (the intersection of the ordinary high water line and the project pool elevation) is located only 1.73 miles below the Lock and Dam No. 5 tailwater gage house. Because of the close proximity of the two points, the tailwater gage of Lock and Dam No. 5 was established as the primary control point. 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 651.0 ± 0.2 feet (1912 adjustment) at the primary control point located at the tailwater of Lock and Dam No. 5. This is "project pool" or "normal pool" for Lock and Dam No. 5A 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 2.5 feet below project pool level. This was reduced to 1.0 foot in 1959 due to adverse effects on navigation, riverfront property, and conservation interests. Therefore, drawdown at the dam is constrained to elevation 650.0 ± 0.2 feet.

b. Maximum Outflow Velocity. Downstream scour protection limits outflow velocities from the roller and tainter gates. The original 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 and 1984, 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 60,000 cfs. When gates are put back in the water, the total gate openings are 75 feet on roller gates and 45 feet on tainter gates.

d. Closure of the Lock to Navigation. Prior to 1992, 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 657.5 feet (1912 adjustment). As part of the major rehabilitation work in 1992, 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 at elevation 660.0 feet. While this is the physical constraint, closure will often happen before the water level gets this high due to wave action over the miter gates. In addition, it is not unusual for the Coast Guard to close the river to navigation 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 often becomes thin enough for some tow traffic and the lock is opened. The ice thickness on Lake Pepin (Pool No. 4) is monitored weekly. When the ice is down to about six inches of blue ice, tow traffic can soon be expected. **Table 7-1** shows some of the recent history of opening and closing dates for Lock and Dam No. 5A.

Table 7-1
Spring Opening and Fall Closing Dates

Year	Opening Date	Closing Date	Year	Opening Date	Closing Date
1972	23 Mar	10 Dec	**1987**	09 Mar	01 Dec
1973	17 Mar	06 Dec	**1988**	19 Mar	01 Dec
1974	14 Mar	12 Dec	**1989**	27 Mar	24 Nov
1975	20 Mar	14 Dec	**1990**	13 Mar	29 Nov
1976	04 Mar	05 Dec	**1991**	21 Mar	24 Nov
1977	22 Mar	09 Dec	**1992**	08 Mar	01 Dec
1978	05 Apr	30 Nov	**1993**	21 Mar	27 Nov
1979	30 Mar	04 Dec	**1994**	24 Mar	29 Nov
1980	25 Mar	04 Dec	**1995**	17 Mar	28 Nov
1981	07 Mar	04 Dec	**1996**	25 Mar	25 Nov
1982	24 Mar	08 Dec	**1997**	26 Mar	25 Nov
1983	03 Mar	09 Dec	**1998**	10 Mar	17 Dec
1984	03 Mar	30 Nov	**1999**	19 Mar	10 Dec
1985	17 Mar	03 Dec	**2000**	03 Mar	29 Nov
1986	21 Mar	05 Dec	**2001**	03 Mar	05 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 Water Control. The maximum number of gates allowed to be closed will be at the discretion of Water Control based on conditions, as they exist. The following table 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	Flow (cfs)	No. of Tainter Gates Closed
Below 11,000	5	Below 33,000	5
11,000 – 18,000	4	33,000 – 36,000	4
18,000 – 25,000	3	36,000 – 39,000	3
25,000 – 32,000	2	39,000 – 42,000	2
33,000 – 40,000	1	42,000 – 46,000	1
Above 40,000	0	Above 46,000	0

7-03. Overall Plan for Water Control.

a. **General Plan.** The navigation channel of Pool No. 5A 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. 5A, 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 10,000 cfs, the pool is fairly flat. To meet depth requirements in the upper pool requires the pool elevation at the "primary control point" (tailwater of Dam No. 5) to be at elevation 651.0 feet (1912 adjustment). Because it is not possible to maintain an exact elevation, there is a two-tenths of a foot tolerance. Therefore, "project pool" elevation for Lock and Dam No. 5A is 651.0 ± 0.2 feet at tailwater of Dam No. 5. As discharges increase, gates are opened at the dam to maintain project pool at the primary control point. This results in a drawdown in the water surface elevation at the dam. Maximum allowable drawdown is one foot below project pool level or elevation 650.0 ± 0.2 feet. When the water surface at the dam is lowered to its maximum drawdown elevation, the lock and dam is now in "secondary control." As discharges continue to rise, gates are opened to maintain secondary control. When discharges get up to around 60,000 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 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 based on historical flow and the new Gate Regulation Schedule presented in **Table 7-4**. The following table summarizes the control conditions at the lock and dam.

Table 7-3
Control Conditions at Lock and Dam No. 5A

Control Conditions	Approximate Discharge	Control Point Gage Elevation	Lock and Dam 5A Pool Elevation
Primary	< 10,000 cfs	651.0 ft	≤ 651.0 ft
Primary to Secondary	10,000 to 30,000 cfs	> 651.0 ft	< 651.0 ft > 650.0 ft
Secondary	30,000 to 60,000 cfs	> 651.0 ft	650.0 ft
Open-River	> 60,000 cfs	> 651.0 ft	> 650.0 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 and the tailwater-rating curve, computed outflows are transitioned to the tailwater rating. The rating curves for the spillway are shown in **Plate 7-2**.

Discharge ratings for the gates were originally developed based on laboratory tests on 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 (see **Plate 7-3**). The analysis also showed a slight change in the tailwater rating. These changes were presented in a new Gate Regulation Schedule (revised November 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.

As part of the current updates to this manual, the Operating Curves (**Plate 7-1**) were updated using recent data. The data indicate a slight shift in the pool and tailwater-rating curves at higher flows. This required the Gate Regulation Schedule to be checked and updated where necessary to provide the correct distribution of flow based on equalizing the outflow velocities. For example, consider a flow of 20,000 cfs and a respective head across the dam of 4.85 feet with a tailwater elevation of 645.9 feet. The discharge per foot opening for roller and tainter gates are 1235 cfs and 611 cfs respectively. By setting the roller gates at a total opening of 12.0 feet (12.0 x 1235 = 14,800 cfs) and the tainter gates at 8.5 feet (8.5 x 611 = 5,200 cfs) gives a total discharge of 20,000 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 end sill elevation for the roller gate is 631.0 feet and the tainter gate is 634.0 feet. Therefore, the flow velocities are:

<u>Roller Gate</u>
$Q = VA$
(12.0 ft/5 roller gates) 1235 cfs/ft = V (80 ft + 15 ft) (645.9 ft – 631.0 ft)
V = 2.09 ft/sec

<u>Tainter Gate</u>
$Q = VA$
(8.5 ft/5 tainter gates) 611 cfs/ft = V (35 ft + 8 ft) (645.9 ft – 634.0 ft)
V = 2.03 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 20,000 cfs and a differential head of 4.85 feet with a tailwater elevation of 645.9 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>
$Q = VA$
1235 cfs/ft (max gate opening in ft) = 6.0 fps (80 ft + 15 ft) (645.9 ft – 631.0 ft)
Max Gate Opening = 6.9 ft

<u>Tainter Gate</u>
$Q = VA$
611 cfs/ft (max gate opening in ft) = 6.0 fps (35 ft + 8 ft) (645.9 ft – 634.0 ft)
Max Gate Opening = 5.0 ft

Table 7-4 shows the new Gate Regulation Schedule.

Table 7-4
Gate Regulation Schedule
5 Roller Gates and 5 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
8,000	4.5	3.0	651.00	645.58	5.42	1329	641	6,000	1,900	6.3	4.7
9,000	5.0	3.5	651.00	645.59	5.41	1328	641	6,650	2,250	6.3	4.7
10,000	5.5	4.0	651.00	645.60	5.40	1326	640	7,300	2,550	6.3	4.7
11,000	6.5	4.0	650.98	645.63	5.35	1318	638	8,550	2,550	6.3	4.7
12,000	7.0	4.5	650.96	645.66	5.30	1311	636	9,150	2,850	6.4	4.7
13,000	7.5	5.0	650.94	645.69	5.25	1302	633	9,700	3,150	6.4	4.8
14,000	8.5	5.0	650.92	645.72	5.20	1293	630	11,000	3,150	6.5	4.8
15,000	9.0	5.5	650.90	645.75	5.15	1285	628	11,550	3,450	6.5	4.8
16,000	9.5	6.5	650.87	645.78	5.09	1275	625	12,100	4,050	6.6	4.9
17,000	10.0	7.0	650.84	645.81	5.03	1265	622	12,650	4,350	6.7	4.9
18,000	11.0	7.0	650.81	645.84	4.97	1255	618	13,800	4,350	6.7	4.9
19,000	11.5	8.0	650.78	645.87	4.91	1245	615	14,300	4,900	6.8	5.0
20,000	12.0	8.5	650.75	645.90	4.85	1235	611	14,800	5,200	6.9	5.0
21,000	13.0	8.5	650.70	645.93	4.77	1222	606	15,900	5,150	7.0	5.1
22,000	14.0	8.5	650.64	645.96	4.68	1207	601	16,900	5,100	7.1	5.1
23,000	14.5	9.5	650.59	645.99	4.60	1194	596	17,300	5,650	7.2	5.2
24,000	15.5	9.5	650.53	646.02	4.51	1180	591	18,300	5,600	7.3	5.3
25,000	16.5	10.0	650.45	646.05	4.40	1161	584	19,150	5,850	7.4	5.3
26,000	17.5	10.5	650.35	646.08	4.27	1139	576	19,950	6,050	7.5	5.4
27,000	18.5	11.0	650.25	646.11	4.14	1118	568	20,700	6,250	7.7	5.5
28,000	19.5	12.0	650.15	646.14	4.01	1097	561	21,400	6,750	7.9	5.6
29,000	20.5	12.5	650.08	646.17	3.91	1081	553	22,150	6,900	8.0	5.7
30,000	21.5	13.0	650.00	646.20	3.80	1062	543	22,850	7,050	8.2	5.8

Table 7-4
Gate Regulation Schedule
5 Roller Gates and 5 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
31,000	22.5	13.5	650.00	646.27	3.73	1051	537	23,650	7,250	8.3	5.9
32,000	23.5	14.5	650.00	646.34	3.66	1039	531	24,400	7,700	8.4	6.0
33,000	24.0	16.0	650.00	646.41	3.59	1027	525	24,650	8,400	8.5	6.1
34,000	25.0	16.5	650.00	646.48	3.52	1016	520	25,400	8,550	8.7	6.2
35,000	26.5	16.5	650.00	646.55	3.45	1005	514	26,600	8,450	8.8	6.3
36,000	27.0	18.0	650.00	646.62	3.38	993	507	26,800	9,150	9.0	6.4
37,000	28.5	18.0	650.00	646.69	3.31	982	502	28,000	9,050	9.1	6.5
38,000	29.5	19.0	650.00	646.76	3.24	970	496	28,600	9,400	9.3	6.6
39,000	30.5	20.0	650.00	646.83	3.17	958	490	29,250	9,800	9.4	6.8
40,000	31.5	21.0	650.00	646.90	3.10	947	484	29,850	10,150	9.6	6.9
41,000	33.0	21.5	650.00	647.01	2.99	928	474	30,600	10,200	9.8	7.1
42,000	35.0	22.0	650.00	647.12	2.88	911	465	31,900	10,250	10.1	7.3
43,000	36.5	23.0	650.00	647.23	2.77	892	456	32,550	10,500	10.4	7.5
44,000	38.0	24.0	650.00	647.34	2.66	874	446	33,200	10,700	10.7	7.7
45,000	39.5	25.5	650.00	647.45	2.55	856	437	33,800	11,150	11.0	7.9
46,000	41.5	26.5	650.00	647.56	2.44	838	428	34,750	11,350	11.3	8.2
47,000	43.0	28.0	650.00	647.67	2.33	820	418	35,250	11,700	11.6	8.4
48,000	45.0	29.0	650.00	647.78	2.22	801	409	36,050	11,850	11.9	8.7
49,000	47.0	30.5	650.00	647.89	2.11	784	400	36,850	12,200	12.3	9.0
50,000	49.0	32.0	650.00	648.00	2.00	765	390	37,500	12,500	12.7	9.3
51,000	51.5	33.5	650.00	648.14	1.86	742	377	38,200	12,650	13.2	9.7
52,000	54.0	36.0	650.00	648.28	1.72	719	365	38,850	13,150	13.7	10.1
53,000	57.0	38.0	650.00	648.42	1.58	696	349	39,700	13,250	14.3	10.7

Table 7-4 Gate Regulation Schedule 5 Roller Gates and 5 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
54,000	60.0	40.0	650.00	648.56	1.44	672	340	40,350	13,600	14.9	11.0
55,000	63.5	42.0	650.00	648.70	1.30	649	327	41,250	13,750	15.5	11.6
56,000	67.0	44.5	650.00	648.84	1.16	627	315	42,000	14,000	16.2	12.2
57,000	71.0	47.0	650.00	648.98	1.02	603	302	42,800	14,200	17.0	12.8
58,000	77.0	51.0	650.00	649.12	0.88	563	289	43,350	14,750	18.3	13.5
59,000	82.5	55.0	650.00	649.26	0.74	530	279	43,750	15,350	19.6	14.1
60,000	Out of Control – Gates raised clear of water. Put gates back in at 75 ft Roller Gates and 45 ft Tainter Gates.										

c. Regulation Procedure. Each morning at 0635-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. 5A 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. After regulating Lock and Dam 5, inflow to Pool No. 5A is determined. Inflow consists of outflow from Lock and Dam No. 5 and any miscellaneous inflow. Outflow from Lock and Dam No. 5 is computed as part of the daily regulation. This discharge must be adjusted by any gate change given that morning for Lock and Dam No. 5. Miscellaneous inflow will vary seasonally but for simplicity it is assumed to be a constant 300 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 300 cfs is added to the miscellaneous inflow. Inflow is totaled and the 24-hour change is noted. Also noted are 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 400 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 7,000 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, or (4) cut a given amount. A “no change at present” order is followed by an “if statement”. For example, “if the pool falls to elevation 650.8 feet, cut 2 feet 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 651.0 ± 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. 5A. The portion printed in black represents the daily regulation sheet while that printed in blue represents regulation notes.

Regulation of Lock and Dam No. 5A for 23 September 2001

```
        Orders to LD 5: Open 3 ft on TG. Increase 2,600 to 21,000 cfs.
        Note:  There were no gate changes in the past 24 hours.

                                          5-RG    5-TG    [primary = 651.00
gates in/out:  75/45 @ 57,000             Total   Total   for flow < 25,000]
               | sec:  |                  Roller  Tainter     CP5A
LOCK 5A        |650.00|   Tail     Flow   Gate    Gate        (TW 5)
          ------------------------------------------
22SEP01  0800   650.85   645.83   16800    8.0     10.0        651.16
         1200   650.82   645.84   16800    8.0     10.0
         1600   650.86   645.83   16800    8.0     10.0
         2000   650.87   645.84   16800    8.0     10.0
         2400   650.90   645.89   16800    8.0     10.0
23SEP01  0400   650.90   645.87   16800    8.0     10.0
         0630   650.94   645.84   17000    8.0     10.0        651.21
               up 0.09          up 200                       up 0.05
phone    HEAD     5.1
##029    Q/foot   1280/625
         temp.        55
         precip.    0.97
         wind (dir&speed)     360   @   8
         INFLOW:
           L/D 5     -   21000               Orders:
           400 CFS   -                       Open 2.5 ft on RG
           Misc.     -     300               Inc. Flow 3,000 to 20,000 cfs
                        ------               Hold 650.80 ± 0.2 ft
                         21300+300=21,600           AFW HS
                                up 2,900
```

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 5A.
Computed inflow from LD 5 was 18,400 cfs.
LD 5 orders were to open up 2,600 cfs to 21,000 cfs.
Miscellaneous inflow is 300 cfs.
Rainfall was 0.97 inches, so add 300 cfs to inflow.
Total Inflow = 21,600 cfs (up 2,900 cfs from yesterday).

Step 2. Note change in outflow.
Up 200 cfs due to pool elevation change.

Step 3. Note change in pool elevation.
Pool is up 0.09 feet at the dam.
Pool is up 0.05 feet at TW 5.
Wind is 8 mph out of the north, so 0.08 ft increase due to wind.

Step 4. Primary or Secondary Control?
Flow is less than 25,000 cfs; therefore, Primary Control.
For Primary Control, maintain TW 5 at 651.00 ± 0.2 ft.

Step 5. Estimate needed change in discharge.
Inflow is up 2,900 cfs from yesterday.
The pool has increased 0.09 ft – 0.08 ft (due to wind) = 0.01 ft.
Pool is fairly steady but is out of the band on the high side.
Need to increase outflow, the opening made at LD 5 (2,600 cfs)
Plus 1/10 foot on the pool (400 cfs) for a total of 3,000 cfs.
Total Outflow Needed: 17,000 + 3,000 = 20,000 cfs.

Step 6. Set gate change.
Gate Reg Schedule shows ideal gate settings for 20,000 cfs:
12.0 ft on RG and 8.5 ft on TG.
Therefore, the gate opening will be on the Roller Gates.
A one-foot opening on RG's would increase outflow ~1250 cfs.
Because the pool is on the high side,
"Open 2.5 ft on RG. Increases flow 3,000 to 20,000."

Step 7. Set the pool band.
The pool is a little high (i.e. target at TW 5 is 651.0 ± 0.2 ft).
We want an opening if the pool goes up; therefore,
"Hold elevation 650.80 ± 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 Winona, Minnesota. “Average October Flow” and “Average November Flow” was 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; however, they 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. 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 two to four feet each to prevent the formation of a solid sheet of ice in the lock chamber. It was estimated in the 1970 Regulation Manual that the discharge through a tainter valve was equal to 1/10th of the normal discharge under a roller gate with the same head (pool - tailwater) and same gate opening. No further investigation of this estimate has been performed. Rating curves were developed based on values in **Table 7-5** and were incorporated into the

Regulation Program such that lock personnel enter the total gate opening and the program computes the discharge on a four-hour interval.

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
651.0	6.0	330	710	1080	1400	1640	1930
	5.0	310	660	1020	1330	1570	1880
650.9	6.0	310	680	1040	1350	1580	1860
	5.0	290	640	980	1280	1510	1810
650.8	6.0	300	650	1000	1300	1510	1790
	5.0	280	610	940	1230	1450	1740
650.7	6.0	280	620	960	1250	1450	1720
	5.0	260	590	900	1190	1390	1670
650.6	6.0	270	600	920	1200	1390	1640
	5.0	250	560	860	1140	1330	1590
650.5	6.0	250	580	890	1160	1340	1570
	5.0	230	530	830	1090	1280	1520
650.4	5.0	210	520	800	1050	1230	1460
	4.0	180	470	730	980	1160	1400
650.3	5.0	-	500	770	1010	1180	1390
	4.0	-	450	700	940	1110	1330
650.2	5.0	-	480	750	970	1130	1330
	4.0	-	430	680	900	1070	1280
650.1	5.0	-	460	720	940	1080	1330
	4.0	-	410	650	870	1010	1220
650.0	5.0	-	450	700	910	1030	1220
	4.0	-	400	630	840	970	1160
649.9	5.0	-	-	680	880	1000	1170
	4.0	-	-	615	810	930	1110
649.8	5.0	-	-	660	850	950	1120
	4.0	-	-	600	780	890	1060
649.7	5.0	-	-	645	825	920	1070
	4.0	-	-	585	755	850	1020
649.6	5.0	-	-	630	800	880	1020
	4.0	-	-	570	730	820	960

During the non-navigation season, on the weekends and holidays, shifts are limited to one person at the dam site. There is a one half hour over lap in the morning between 0730 and 0800-hours. Therefore, Water Control makes an effort to get orders out by 0730-hours. 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 control point at the tailwater of Dam No. 5 is to be maintained at elevation

651.0 ± 0.3 feet. Because of the added benefit to fish habitat, Water Control makes an effort to operate on the high side of the band during winter months to reduce oxygen depletion in the backwater areas. Therefore, the target for primary control during the winter months is elevation 651.0 feet to 651.3 feet.

e. **Regulation of Prairie Island Control Structure.** The Winona Flood Control levee extends from Winona to the lock and dam earthen dike. The levee cuts off the natural flow out of Crooked Slough; therefore, the Prairie Island Control Structure was constructed to maintain a specified head differential between the Mississippi River and Crooked Slough (**Figure 2-5.**). Operation of the structure is to ensure safety of the lock and dam's earthen dike. For the design flood of 290,000 cfs, which is 6 percent larger than the 1965 flood of record (270,000 cfs), it is expected that gate operations will limit the maximum elevation of Crooked Slough to approximately 656.1 ft. If Crooked Slough reaches elevation 654.4 feet, **or** if the flood crests, **which ever occurs first**, the gate is completely closed. The gate remains closed until the riverside gage recedes to 0.1-foot below the Crooked Slough elevation. Based on the design flood, the time of gate closure during which seepage water would be stored in Crooked Slough would be about 12 days. In addition to the gages at the Prairie Island Control Structure, there are also gages on each side of the lock and dam's earthen dike at the Minnesota City Boat Club. The maximum differential head allowed at this location is 11.4 feet. Detailed gate regulation for operation is presented in the following section.

7-04. Standing Instructions to Lock and Dam No. 5A Staff.

a. **Data Collection and Operation of the Dam.** Lock and dam personnel are to maintain daily log sheets (**Appendix B**). The log sheet begins at 0400-hours. The data entry interval varies from once a day to every four hours. Four-hour data include elevations at the pool, tailwater, and the Winona gage site. While the Winona gage is the control point for Lock and Dam No. 6, Lock No. 5A personnel record the gage elevation because it is a local call to the gage's voice modem. Also, while the tailwater of Lock and Dam No. 5 is the control point for Lock No. 5A, the elevation is recorded by Lock No. 5 personnel. Gate settings, total discharge, air temperature and wind speed and direction are recorded every eight hours beginning at 0800-hours. All 0800-hour data are actually collected at 0600-hours as are all the daily data, which includes 24-hour precipitation total, water temperature, and max-min air temperatures. During the winter months the log sheet also includes percent of ice coverage over the upper pool and lower tailwater, ice thickness, snow depth, and snow-water equivalent (in inches). These date are collected once week on Sundays. The snow-water content is determined by instructions contained in the National Service Observing Handbook No. 2.

In addition to the log sheets, site personnel are also to enter data via a remote computer to a program called “sig-na-term”. These data are the same as the daily log sheet with minor exceptions. Gate settings are input on four-hour intervals and during winter months, tainter valve openings are to be entered. As with the log sheet, all 0800-hour readings are to be taken at 0600-hours and are to be entered to the computer no later than 0630-hours. The Stevens PAV-C strip charts are to be mailed to Water Control every year.

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 the 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 later in the day, 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 in **Table 7-6**. The weekend pager number is 612-660-8053. Lock personnel contacting Water Control personnel during non-duty hours 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.

Table 7-6
Water Control Personnel Telephone Numbers

Name	Non-Duty Telephone	Office Telephone
Scott Bratten	651-436-6135	651-290-5624
Dennis Holme	651-483-4003	651-290-5614
Ted Pedersen	715-639-2625	651-290-5253
Ferris Chamberlin	651-653-7981	651-290-5619
Robert Engelstad	651-459-6343	651-290-5610

If lock personnel have any questions regarding the Water Control order, they are to contact the river 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 or FM radio.

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.

b. Data Collection and Operation of the Prairie Island Control Structure. In addition to operating the dam, lock personnel are also responsible for the operation of the Prairie Island Control Structure. The structure is operated to maintain a specified differential head during high water to insure safety of the flood control levee and the lock and dam's earthen dike. While the City of Winona makes the actual gate changes, it is the responsibility of the Lockmaster to insure the gate is being operated according to the schedule as best possible. Staff gages are located on both the Mississippi River side and Crooked Slough side of the Prairie Island Control Structure. Gages are also located on each side of the lock and dam's earthen dike at the Minnesota City Boat Club (**Plate 2-7**). When the Winona gage rises above a stage of 13.0 feet (elevation 653.12 feet), lock personnel are to inspect the levee and record elevations at both sites. Inspections are to continue until the Winona gage falls below elevation 655.5 feet. Inspections and gage recordings will be made a minimum of twice a day with more frequent measurements near the flood crest. The gage recording sheets for both locations are to be faxed to Water Control daily (651-290-5841). Water Control will monitor compliance with the scheduled gate operation and will provide input as needed. Should compliance by the City of Winona become a problem, Water Control will contact the City Engineer and make clear the Cities' responsibility regarding operation of the gate. The following instructions for gate operation are to be followed for flood control and levee safety:

(1) Gate will remain open for all riverside elevations, at the control structure, below 648.0 feet.

(2) Close the gate when the riverside elevation reaches 648.0 feet.

(3) Keep the gate closed until the stage differential at the control structure is 5.5 feet.

(4) When the stage differential reaches 5.5 feet, gradually open the gate to maintain the 5.5-foot differential until the riverside gage rises to elevation 656.0 feet.

(5) When the river stage exceeds elevation 656.0 feet, operate the gate as necessary to obtain the differential head shown in the **Table 7-7**.

Table 7-7
Operation of Prairie Island Control Structure

When Mississippi River Side is at Elevation (ft)	Differential Head Should be (ft)	Operate Gate to Maintain Crooked Slough at Elevation (ft)
656.0	5.5	650.5
656.5	6.0	650.5
657.0	6.2	650.8
658.0	6.8	651.2
659.0	7.5	651.5
660.0	8.1	651.9
660.5	8.4	652.1
661.0	8.4	652.6
661.5	8.4	653.1
662.0	8.4	653.6
662.8	8.4	654.4

(6) If Crooked Slough reaches elevation 654.4 ft, **or** when the flood reaches its crest, **which ever occurs first**, the gate shall be closed and shall remain closed until the river recedes to about 0.1 foot below the Crooked Slough water surface elevation. At this time, the gate is to be opened to allow Crooked Slough to drain.

(7) In addition to the staff gages at the control structure, the staff gages at the Minnesota City Boat Club are also monitored. These gages are used to measure the difference in Crooked Slough and Mississippi River stages upstream of Lock and Dam No. 5A. The maximum stage differential must not exceed 11.4 feet at this location. When this differential is reached, the gage on the riverside will read around elevation 665.8 feet, while the gage on the Crooked Slough side will be approximately elevation 654.4 feet. **Note:** Gate operation required to keep the stage differential at the dike gages from exceeding 11.4 feet shall supersede the gate operation detailed in subparagraphs **(1)** through **(6)** and **Table 7-7**.

Note that these are the established guidelines for operation of the Prairie Island Control Structure. These guidelines were established to assure safety of the flood control levee and the lock and dam's earthen dike. Should safety of either levee become evident, the gate shall be opened to preserve the levee's integrity. Should the integrity of the levee come under suspicion, lock personnel are to contact the Chief, Geotechnical Section at 651-290-5644 who will in turn provide technical assistance in making the determination concerning the levee's condition.

7-05. Flood Control. Lock and Dam No. 5A has no flood control benefits. It is operated strictly for navigation. While it may seem possible that the pools be drawn down 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 of Pool No. 5A are fishing, hunting, boating and bird watching. Construction of the lock and dam inundated the numerous wing dams that were constructed as part of the six-foot channel project. The wing dams as well as some of the backwater areas provide excellent fish and waterfowl habitat. There were over 10,000 recreation boat lockages in 2000. **Table 7-8** shows a comparison of recreational boating to commercial traffic. In addition, numerous people drive to pool for wildlife viewing, in particular, during the waterfowl migration.

Table 7-8 Commercial & Recreational Lockages at Lock No. 5A					
Year	Towboats & Barges	Recreation Boaters	Other Lockages	Total Lockages	Percent Recreation
1991	1,490	10,102	186	11,778	85.8
1992	1,368	9,704	130	11,202	86.6
1993	947	4,953	141	6,041	82.0
1994	1,112	10,000	143	11,255	88.8
1995	1,257	10,005	366	11,628	86.0
1996	1,338	8,867	249	10,454	84.8
1997	1,229	11,474	174	12,877	89.1
1998	1,384	11,195	149	12,728	88.0
1999	1,420	11,300	177	12,897	87.6
2000	1,294	10,133	89	11,516	88.0

7-07. Water Quality. The Corps of Engineers does not perform any water quality analysis in Pool No. 5A. 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. Prior to 1947, during low to moderate flows, the only water flowing into Pool No. 6 from Pool 5A was passed through the dam. In 1947, a slot 15-feet long by 2-feet deep was cut into the fixed concrete spillway (**Figure 2-5.**). At project pool, a continuous flow of 110 cfs is maintained as a result of the slot. This flow aids fish habitat by aerating the water downstream.

Because the lock and dam was constructed for the purpose of navigation, the pool would sometimes be drawn down in non-navigation season. The 1934 “Anti-Drawdown” Act, as amended in 1948, prevented any winter drawdown of the pool. The pool is to be regulated the same as during navigation season. A higher stage in the backwater areas reduces the oxygen depletion; therefore, Water Control typically operates on the high side of the band during the winter months.

7-09. **Water Supply.** The cities of Winona and Goodview, Minnesota, and Fountain City, Wisconsin, obtain their water from wells. Pool No. 5A does not provide water supply. The community of Minnesota City, Minnesota does not have a municipal water supply.

7-10. **Hydroelectric Power.** There is no hydroelectric power at Lock and Dam No. 5A.

7-11. **Navigation.** The primary purpose of Lock and Dam No. 5A 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 ten 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.

7-12. **Emergency Action Plans.** The Emergency Action Plan is a stand-alone document entitled *Emergency Plan for Lock and Dam 5A, Winona, Minnesota*, 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. 5A include excessive seepage, sabotage, extreme storm, failure of earth dikes, and failure due to scouring.

There are several protective measures taken at Lock and Dam No. 5A when a flood occurs. When the pool level is forecasted to go above elevation 653.0 feet (1912 adjustment), drain plugs are installed in the machinery pits. As the pool rises, other actions are required. The following gives a brief summary of the steps to be taken as water levels go higher:

Table 7-9
Emergency Flood Action Plan

Pool Elevation	Action Taken
653.0 feet	Install drain plugs in machinery pits. Activate pumps in manhole#2.
653.5 feet	Sandbag 100 ft of dike to protect area around fuel tank.
654.2 feet	Lock doors to underpass.
658.0 feet	Stockpile sandbags. Put up retaining wall on north side of CCS along fence and on spillway wingwall.
660.0 feet	Sandbag machinery grating and make arrangements for additional personnel.
661.5 feet	Sandbag lockhouse, fuel transfer tank, miter gate machinery, tainter valve machinery, lower control station, communication center, lay felt and sandbag all manholes, security gate and fence in storage yard, garage, gas fuel and diesel tanks.
663.0 feet	All items on the lock wall should be protected.
666.0 feet	Minnesota City Dike protection.

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

651.0 ± 0.2 feet at the primary control point (Tailwater of Dam No. 5) as best as possible. Secondary control was established by the St. Paul District and was approved by the division office. Therefore, while in secondary control the pool at the dam is maintained at 650.0 ± 0.2. The pool is not to be intentionally raised above or lowered below these elevations; 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 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 must 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.

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 10 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. 5A is to maintain a nine-foot depth in the navigation channel of Pool No. 5A. Lock and Dam No. 5A 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 60,000 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. 5A 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. 5A 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 10,000 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. 5A. 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 9-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.

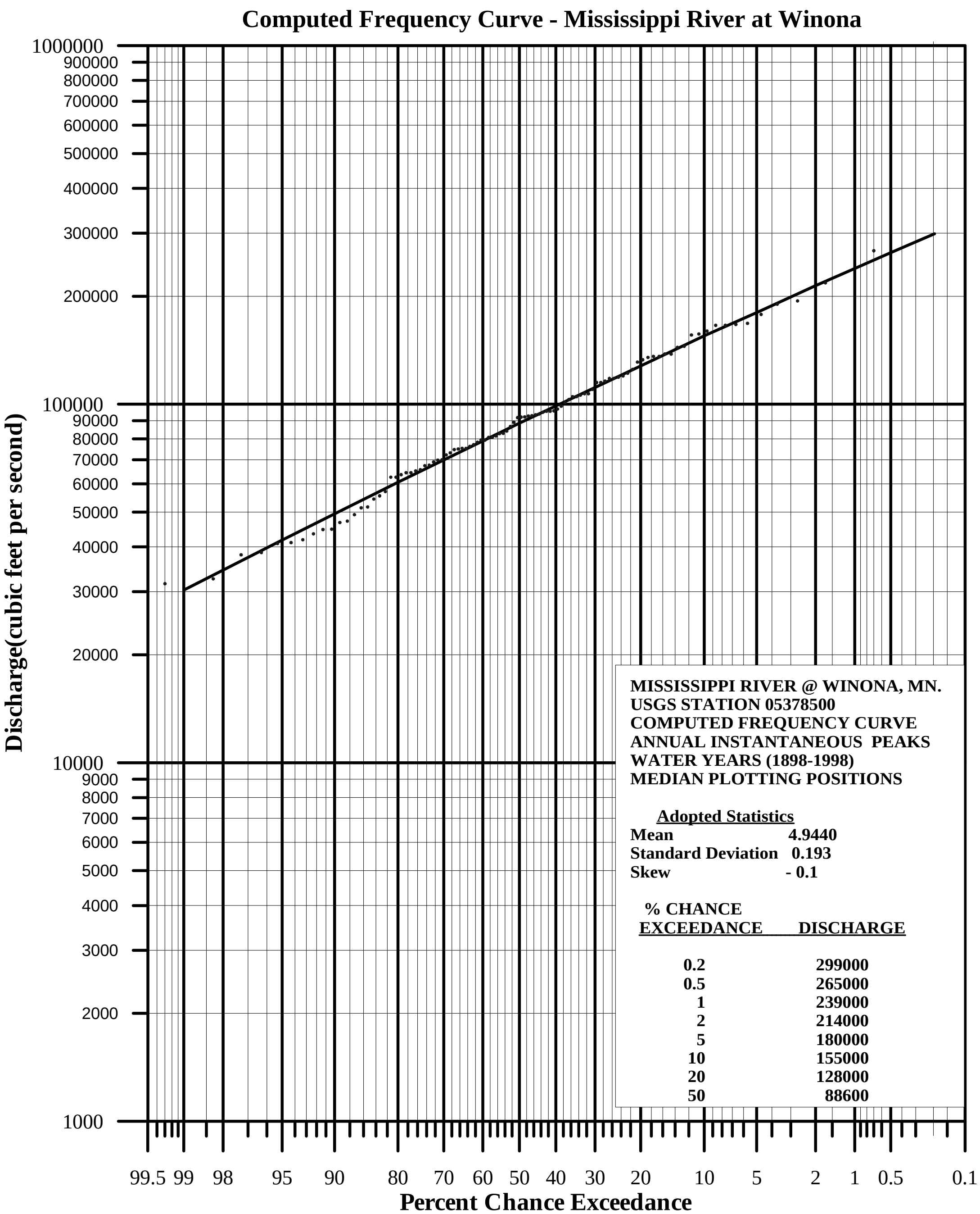
8-05. Navigation. The Upper Mississippi River Nine-Foot Channel Project originated in the 1920's when it was promoted as a way to alleviate the Nation's worsening farm crisis. It was also aimed at allaying the inequities in commercial rail and water freight rates. The project was authorized by the Rivers and Harbors Act of 1930, with most of the locks and dams, including Lock No. 5A, being constructed in the 1930's. The project was not without controversy. For example, railroads claimed damage to their right-of-ways and conservationists feared 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. 5A. 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. 5A   Tonnage – Commodities

Year	Coal	Petroleum Products	Chemical Products	Crude Materials	Manuf Goods	Farm Products	Equip Mach	Misc Product	Total Tonnage
1991	1,087,500	601,400	1,387,500	740,300	402,000	8,358,000	9,000	0	12,585,700
1992	869,500	280,400	1,692,300	825,200	464,900	9,199,300	11,400	10,500	13,353,500
1993	915,500	186,000	1,669,600	725,700	294,400	4,360,700	30,700	27,600	8,210,200
1994	1,121,100	259,400	2,055,000	832,600	407,200	5,544,600	2,400	58,100	10,280,400
1995	683,200	537,200	1,635,800	897,100	382,000	6,234,200	25,900	121,000	10,516,400
1996	772,700	450,500	1,608,000	909,900	227,700	7,207,900	18,700	67,000	11,262,400
1997	791,000	561,500	1,432,200	1,117,400	302,800	6,243,300	22,700	121,300	10,592,200
1998	950,500	897,800	1,582,300	983,500	516,900	6,686,800	14,300	53,100	11,685,200
1999	1,019,200	640,800	1,386,700	961,000	656,300	8,004,400	1,200	91,700	12,761,300
2000	853,025	605,554	1,666,941	992,428	567,071	7,212,908	16,800	214,020	12,128,747

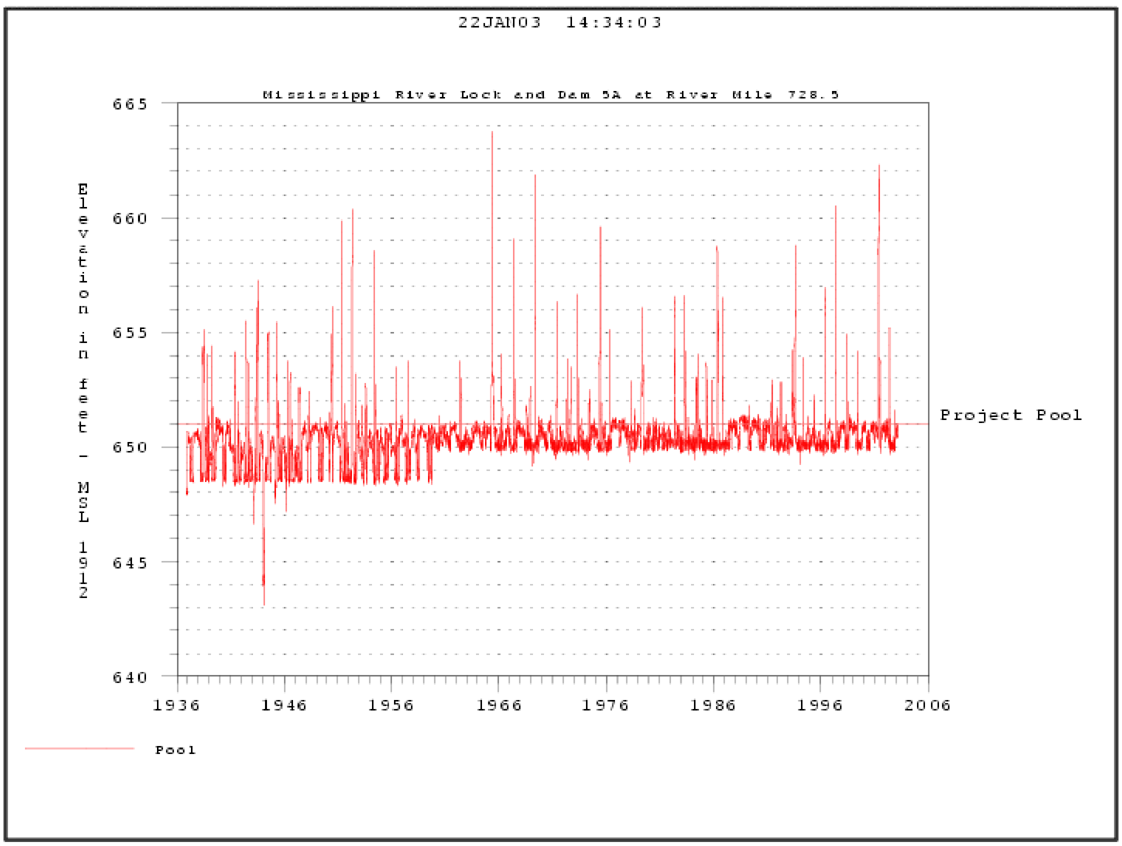
8-06. Frequencies. The Corps of Engineers recently developed discharge-frequency curves for several points along the Mississippi River. The nearest curve to Lock and Dam No. 5A is Winona, Minnesota, which is located about three miles downstream of the dam. The curve was developed in 1999 for water years 1898 to 1998.

Figure 8-1.



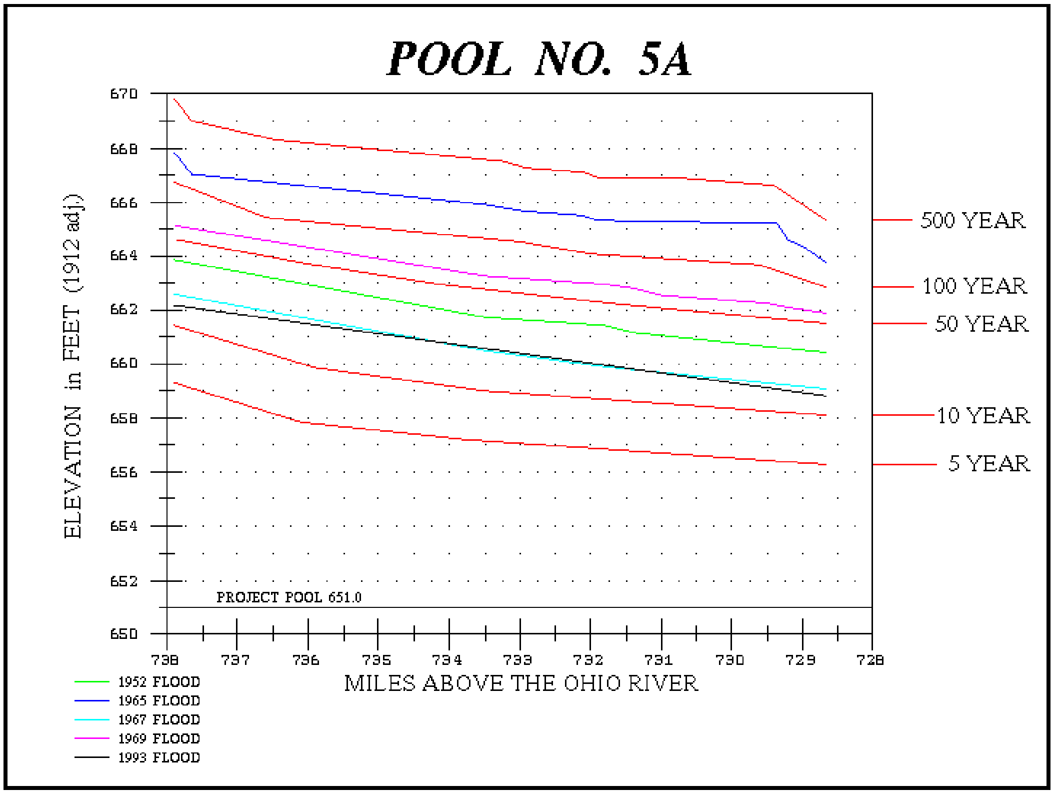
Construction of the dam was completed in August 1936. By November 1936, project pool elevation was achieved. The following shows a history of the pool elevation. The high elevations represent flood events and the lows represent drawdown at the dam (typically secondary control). When in secondary control, the pool elevation at the dam was allowed to be drawn down 2.5 feet below project pool level to elevation 648.5 feet (1912 adjustment) until 1959 when it was reduced to elevation 650.0 feet or 1.0 foot below project pool level. Prior to the Anti-Drawdown Law, passed by Congress in 1948, the pools were sometimes drawn down well below primary and secondary elevations during the winter months. The greatest drawdown occurred in January 1944 when the pool was drawn down to elevation 643.10 feet at the dam.

Figure 8-2. History of Pool Elevation



Water surface profile frequencies were developed in 1979 for Pool No. 5A. 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. 5A. 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) regularly forecasts stage heights for Winona, Minnesota, located about three miles downstream of the dam. On occasion, the NWS will forecast for Lock and Dam No. 5A. 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 Fish and Wildlife Service (USFWS) maintains the Mississippi River National Wildlife and Fish Refuge, part of which is located in Pool No. 5A.

9-02. Interagency Coordination.

a. Local Press and Corps Bulletins. Information concerning regulation of Lock and Dam No. 5A 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. 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 Lock and Dam No. 5A.

c. **US Fish and Wildlife Service.** The St. Paul District, in a cooperative effort with the US Fish and Wildlife Service (USFWS) and the Minnesota Department of Natural Resources, constructed the Polander Lake, Habitat Rehabilitation and Enhancement Project in Pool No. 5A. The project consisted of constructing islands to promote the growth of aquatic vegetation and to increase habitat diversity in the lake. In addition, the St. Paul District, in coordination with the USFWS, and other Federal, State and local agencies, is currently evaluating ways to reduce dredging, increase river safety, develop long-term plans for managing dredge material, enhance fish and wildlife habitat and enhance recreation in Pool No. 5A.

d. **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, Minnesota Department of Natural

Resources, Wisconsin Department of Natural Resources, Minnesota Department of Transportation, Wisconsin Department of Transportation, 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 dam 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 once a year.

EXHIBIT A
SUPPLEMENTARY PERTINENT DATA

General Information

Location:	Mississippi River Mile 728.5 Lat 44° 05' 18" N Long 91° 40' 12" W Left Descending Bank - Wisconsin 4 miles Downstream of Fountain City, Wisconsin 3 miles Upstream of Winona, Minnesota 9.6 miles below Lock and Dam No. 5 14.2 miles above Lock and Dam No. 6
Type of Project:	Lock and Dam for Navigation Purposes
Project Owner:	Corps of Engineers
Operating Agency:	St. Paul District; Construction-Operations Division 24 hrs a day, 7 days a week
Regulating Agency:	St. Paul District; Water Control Section
Completion Date:	August 1936
Datum:	MSL – 1912 adjustment

Hydrology

Drainage Area:	59,105 square miles
Design Flood:	Flood of 1880 Design High Water: Elevation 661.1 ft Design Discharge: 179,600 cfs
Minimum Flow:	December 1980: 2,000 cfs
Maximum Flow:	20 April 1965: 270,000 cfs
Average Annual Flow:	Years 1959-1993: 31,900 cfs
Maximum Monthly Flow:	April 1965: Discharge 153,800 cfs
Maximum Daily Flow:	19 April 1965: Discharge 266,000 cfs
Key Stream Flow Locations:	Mississippi River @ TW of Lock and Dam No. 5 (control point)

Data Recorded at Dam Site:	Pool & Tailwater Elevations (4-hr) Roller and Tainter Gate Settings (4-hr) Total Tainter Value Opening (4-hr, winter only) Wind Speed & Direction (8-hr) Air Temperature (8-hr) Water Temperature (daily) Precipitation (daily) Maximum and Minimum Air Temperature (daily) Snow Depth & Water Content (weekly) Pool & Tailwater Ice Coverage (observed weekly) Pool & Tailwater Ice Thickness (observed weekly)
Precipitation Gages:	Lock & Dam No. 5 and 5A
Snow Survey:	At LD No. 5A (weekly by site personnel)

Physical Features

Moveable Dam:	Roller Gates:	5 Gates	80 feet by 20 feet
	Tainter Gates:	5 Gates	35 feet by 15 feet
	Roller Gate Sill:		Elevation 631.0 ft
	Tainter Gate Sill:		Elevation 636.0 ft
	Roller Gate End Sill:		Elevation 631.0 ft
	Tainter Gate End Sill:		Elevation 634.0 ft
	Roller Gate Submergence:		3 feet below Project Pool
	Bulkheads:	Roller Gates: 5 @	4’-2” by 85’-½”
		Tainter Gates: 4 @	4’-2” by 37’-6”
	Top of Bridge Deck:		Elevation 682.0 ft
Lock:	Main Lock Chamber:		110 ft by 600 ft
	Top of Lock Walls:		Elevation 663.0 ft
	Top of Upper Gate Sill (main):		Elevation 633.0 ft
	Top of Upper Gate Sill (aux):		Elevation 633.0 ft
	Top of Lower Gate Sill:		Elevation 633.0 ft
	Lock Chamber Floor:		Elevation 631.5 ft
	Height of Upper Miter Gates (main):		27.0 feet
	Height of Upper Miter Gates (aux):		27.0 feet
	Height of Lower Miter Gates:		27.0 feet
	Lift:		5.5 feet
	Upper Guidewall Length:		521 feet
	Lower Guidewall Length:		504 feet
	Freeboard @ Project Pool:		12 feet
	Average Filling/Emptying Time		8 minutes
	Average Double Lockage Time:		1.5 hours

Earthen Dam:	Length:	20,533 feet
	Crest Elevation:	664.0 to 665.0 ft
	Top Width:	20.0 feet
	Maximum Height:	26 feet
	Pool Side Slope:	1V:3H
	Tailwater Side Slope:	1V:5.5H
	Slope Protection:	12 inch riprap
	To crest on poolside.	
	To elevation 649.0 ft on tailwater side.	
	Concrete Spillway:	
	Length:	1,000 feet
	Crest Elevation:	651.0 ft (1912)
	Notch:	2 ft deep 15 ft long
Pool:	Normal (Project) Upper Pool:	Elevation 651.0 ft
	Normal (Project) Lower Pool:	Elevation 645.5 ft
	Maximum Pool:	Elevation 663.33 ft 20 April 1965
	Total Pool Area (at Project Pool):	7,000 acres
	Primary Control Point (TW, Dam 5):	Elevation 651.0 ft
	Length in River Miles:	9.6 miles
	Navigation Channel Width:	
	Straight Reaches:	300 feet
	Curved Reaches:	300-550 feet
	Most Frequent Dredge Site:	Betsey Slough

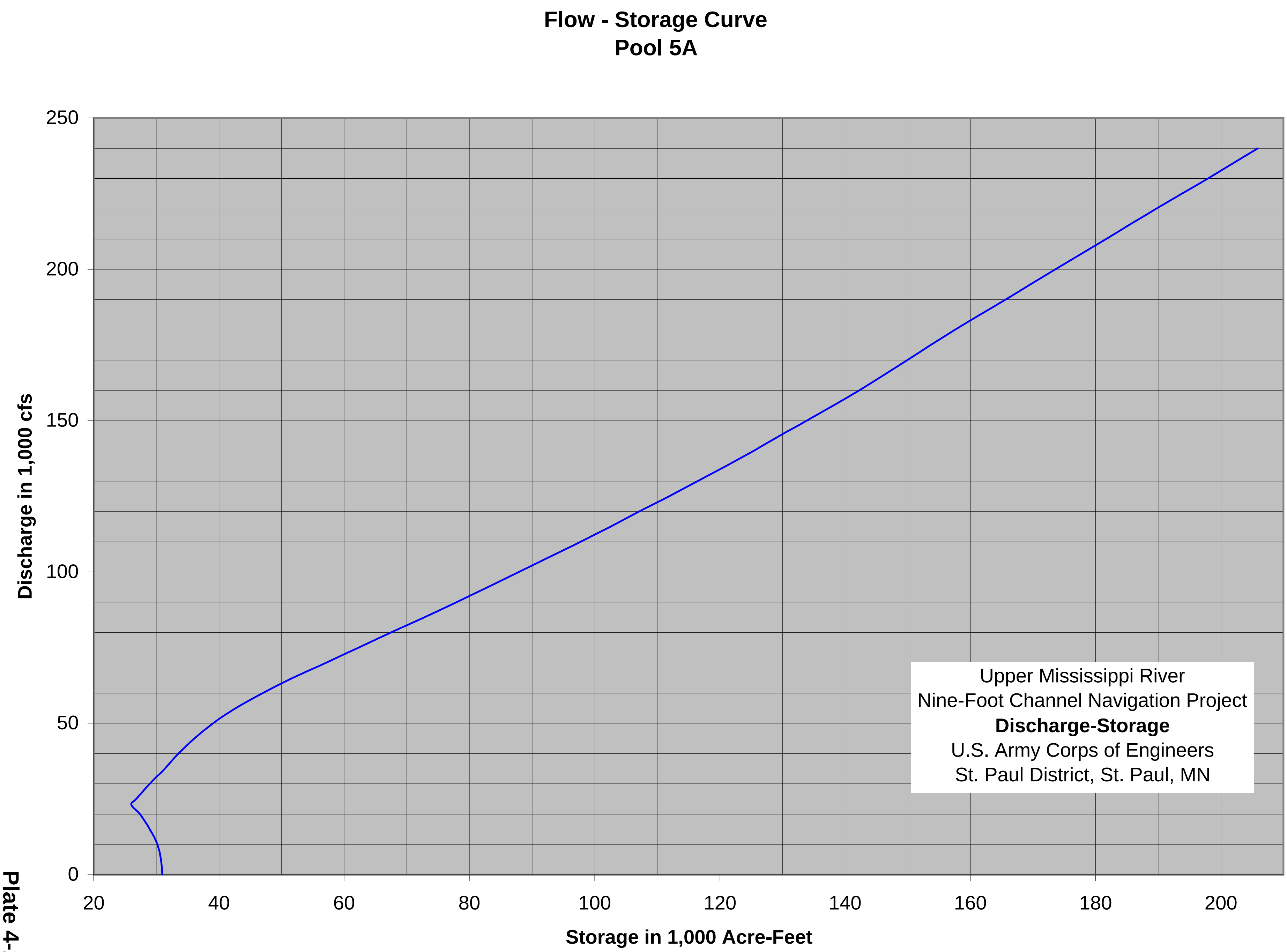
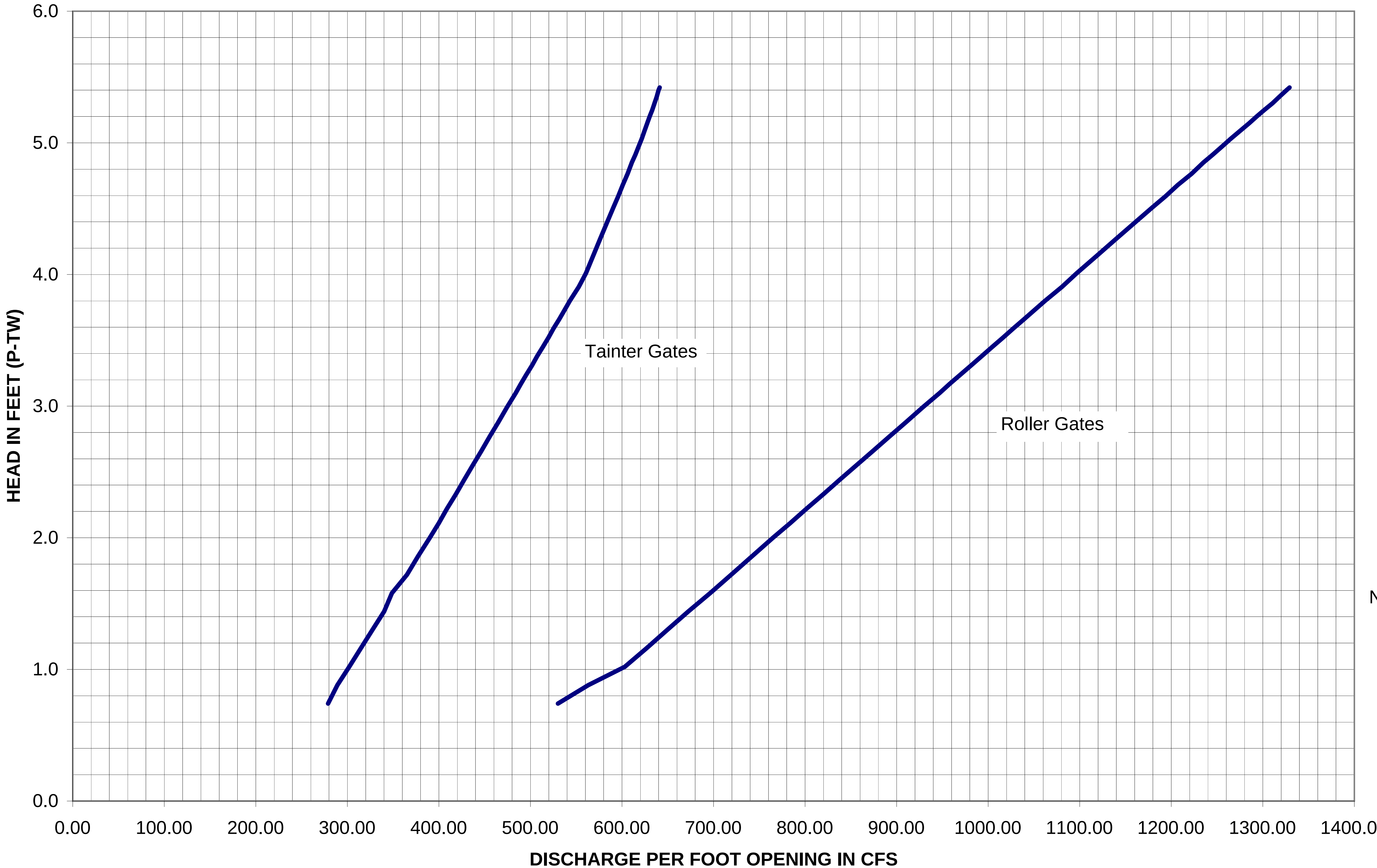

Flow - Storage Curve
Pool 5A
Discharge in 1,000 cfs
250
200
150
100
50
0
20
40
60
80
100
120
140
160
180
200
Storage in 1,000 Acre-Feet
Upper Mississippi River
Nine-Foot Channel Navigation Project
Discharge-Storage
U.S. Army Corps of Engineers
St. Paul District, St. Paul, MN

Plate 4-1

Lock & Dam No. 5A
Roller & Tainter Gate Discharge

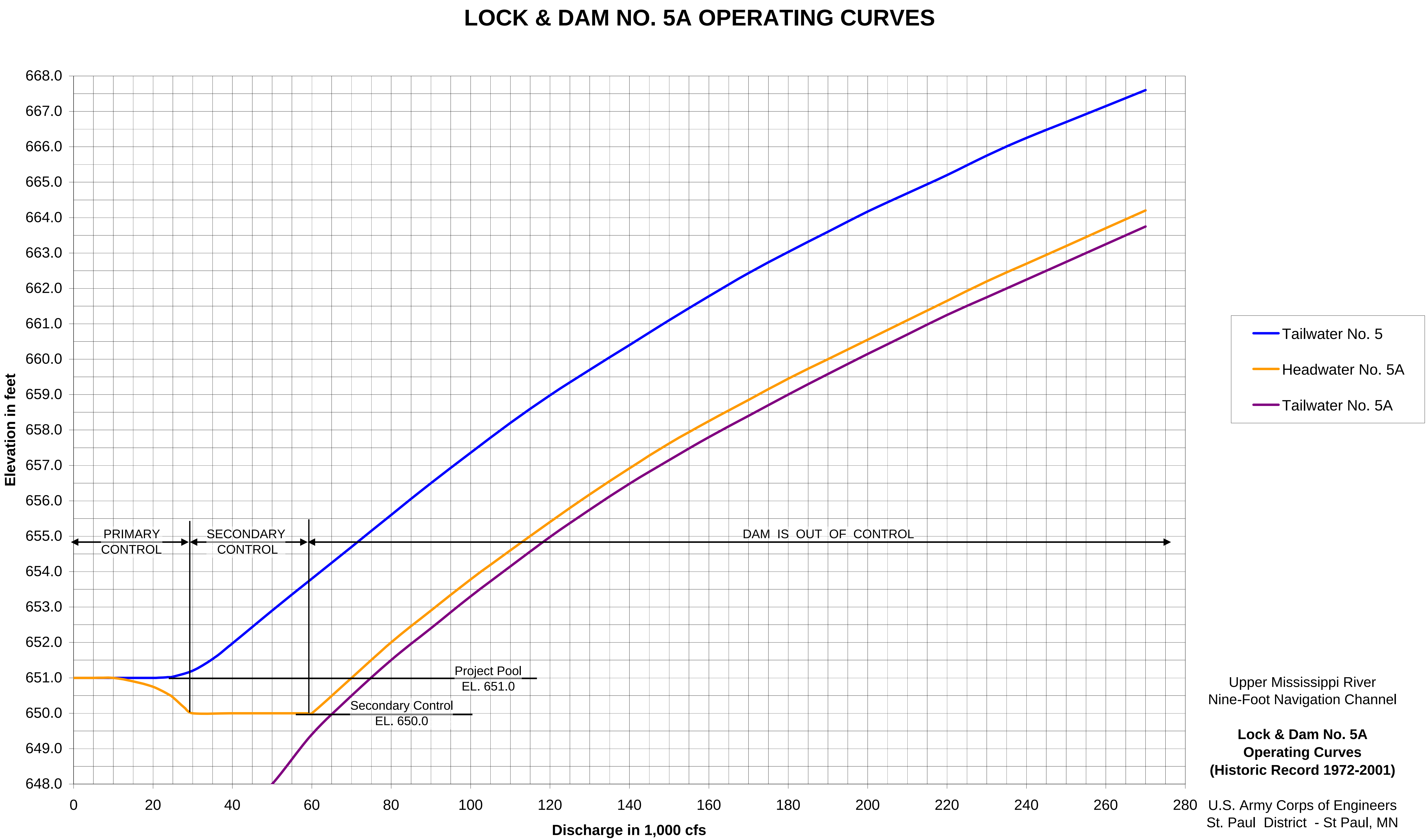


Upper Mississippi River
Nine-Foot Channel Navigation Project

Lock & Dam No. 5A
Roller & Tainter Gate Discharge
For a Single Gate

U.S. Army Corps of Engineers
St. Paul District - St. Paul, MN
USGS Measurements 1973

Plate 7-3

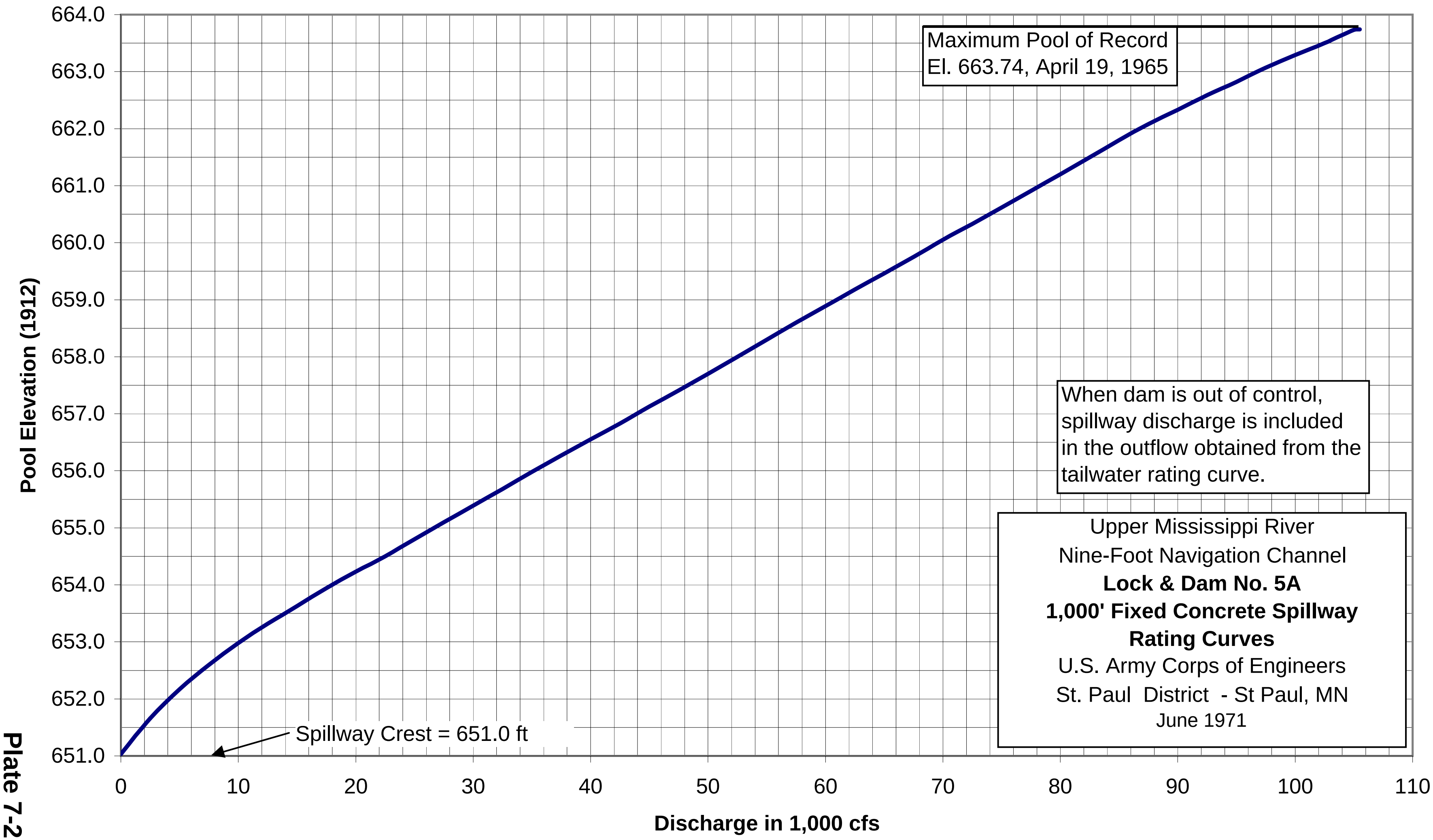


Upper Mississippi River
Nine-Foot Navigation Channel

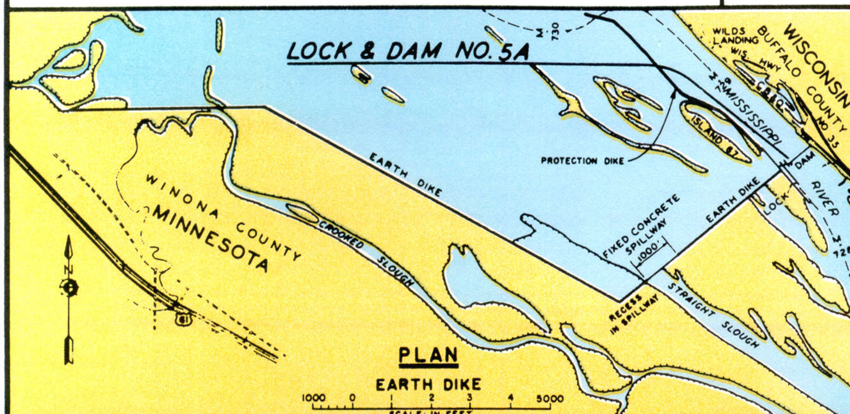
Lock & Dam No. 5A
Operating Curves
(Historic Record 1972-2001)

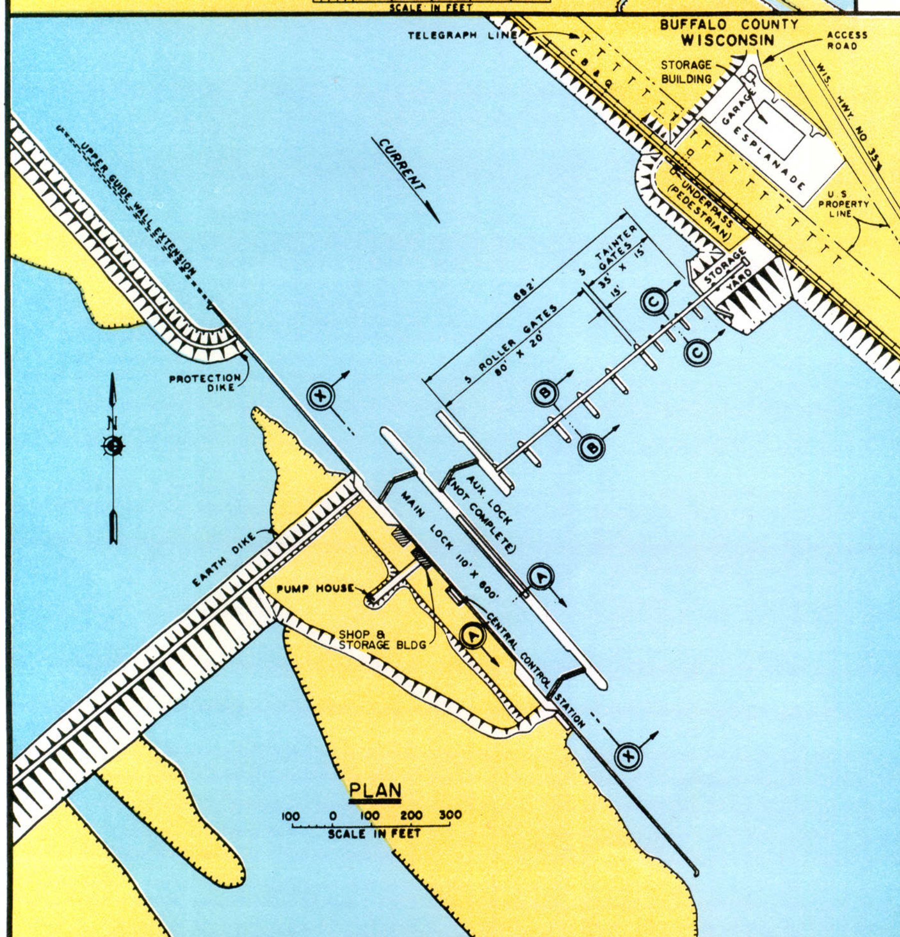
U.S. Army Corps of Engineers
St. Paul District - St Paul, MN

Submerged Crest Discharge
(use only when dam is out of control)



26





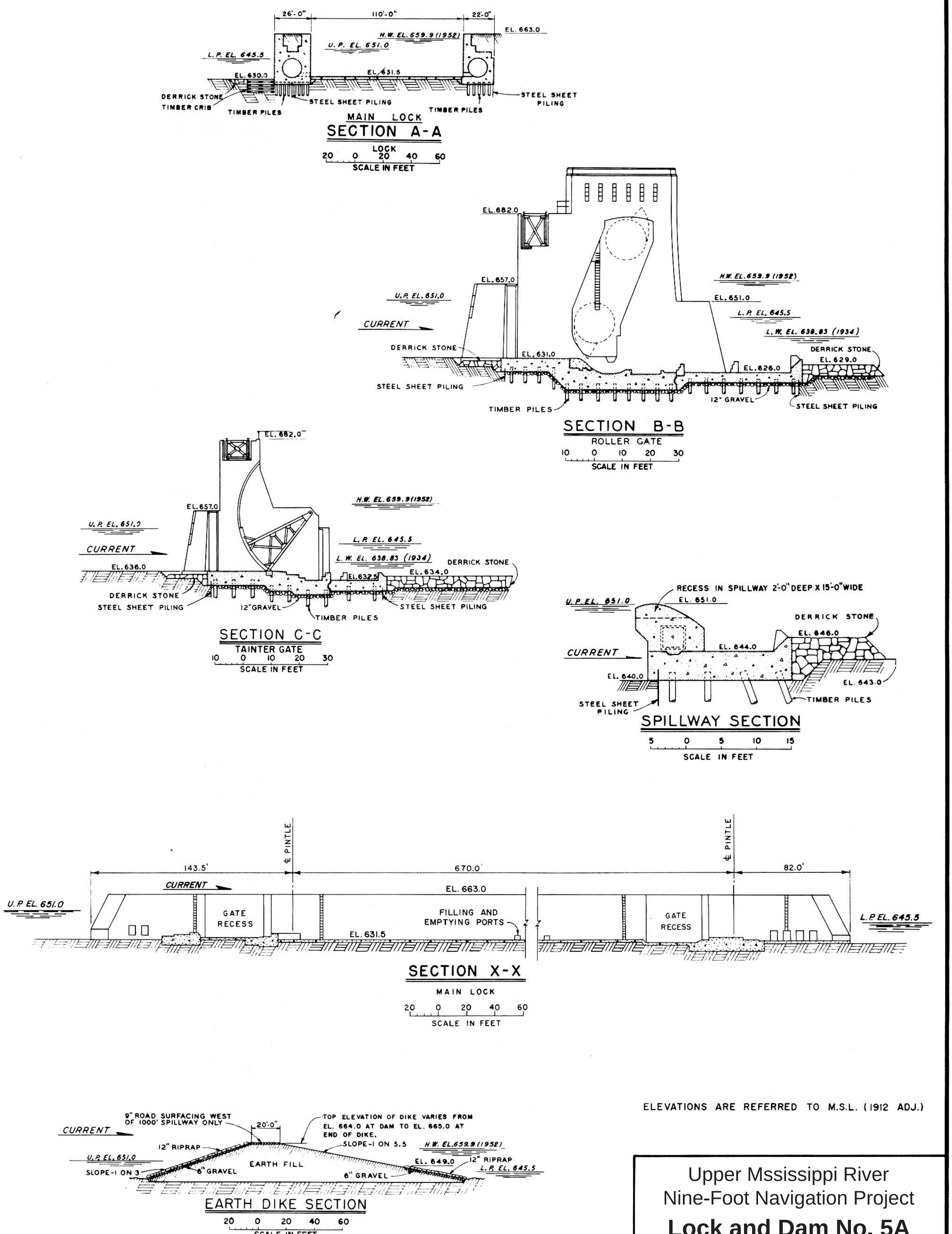
TOTAL LENGTH OF EARTH DIKE - 20533.0 FT.
DEPTH ON UPPER GATE SILL - 18.0 FT. (U.P. EL. 651.0)
DEPTH ON LOWER GATE SILL - 12.5 FT. (L.P. EL. 645.5)
ELEVATION UPPER GATE SILL - 633.0
ELEVATION LOWER GATE SILL - 633.0

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

Upper Mssissippi River
Nine-Foot Navigation Project

Lock and Dam No. 5A
Project Location Map

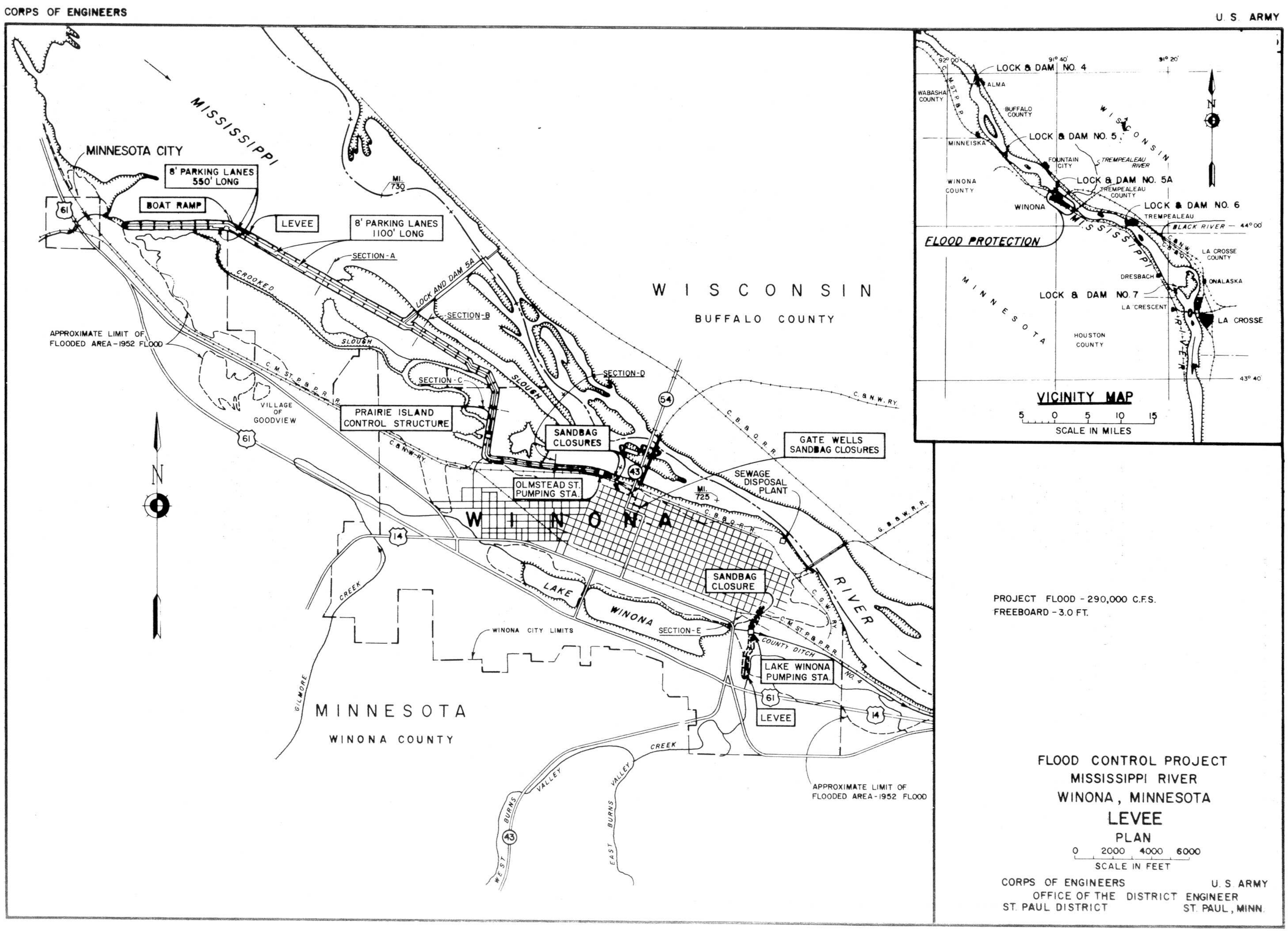
US Army Corps of Engineers
St. Paul District - 30 Sept 1988

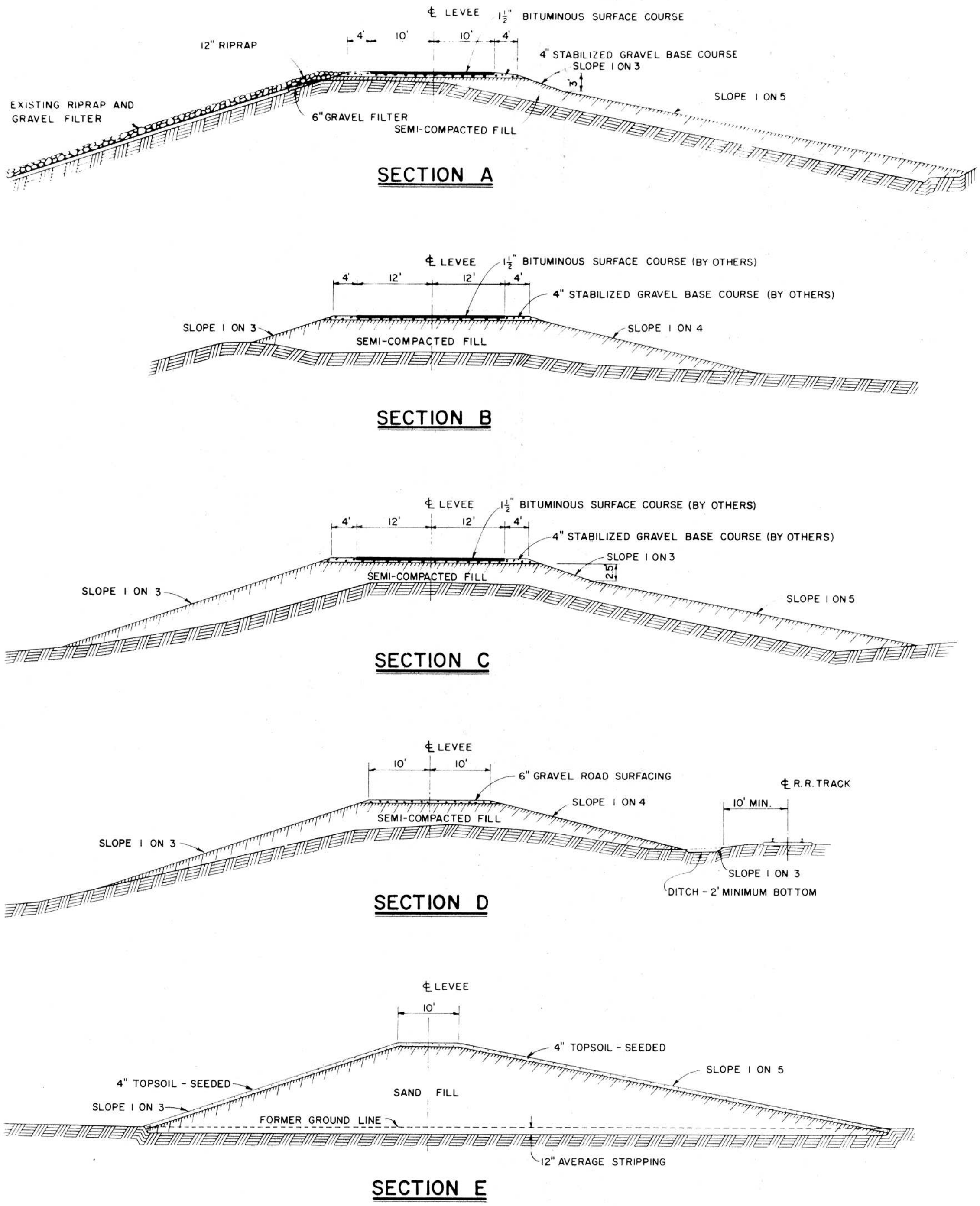


Upper Mssissippi River
Nine-Foot Navigation Project

Lock and Dam No. 5A
Cross Sections

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

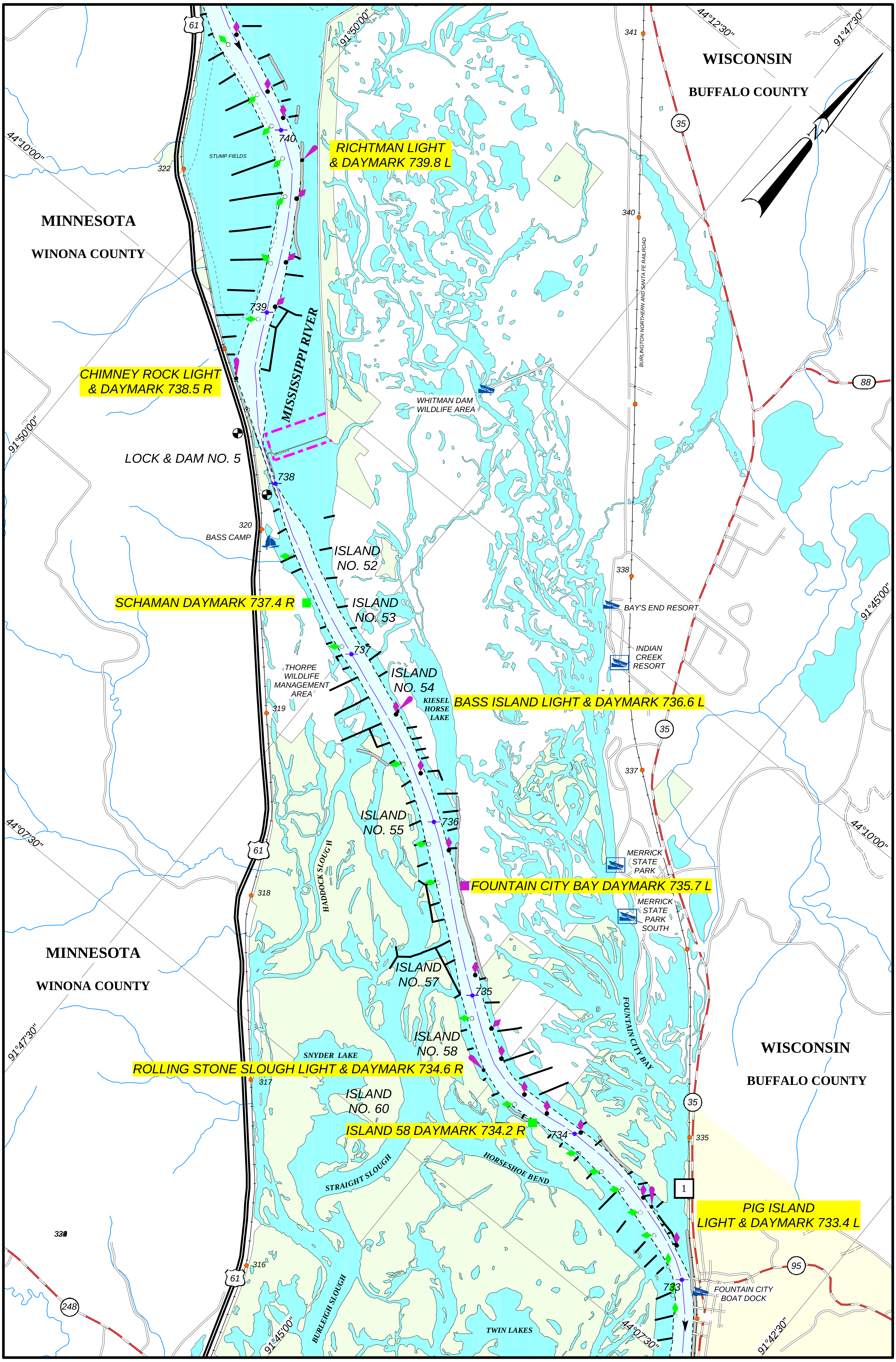

CORPS OF ENGINEERS
U. S. ARMY
MISSISSIPPI
MINNESOTA CITY
8' PARKING LANES 550' LONG
BOAT RAMP
LEVEE
8' PARKING LANES 1100' LONG
MI. 730
SECTION - A
LOCK AND DAM 5A
SECTION - B
CROOKED
SLOUGH
SECTION - C
SECTION - D
PRAIRIE ISLAND CONTROL STRUCTURE
SANDBAG CLOSURES
GATE WELLS SANDBAG CLOSURES
SEWAGE DISPOSAL PLANT
OLMSTEAD ST. PUMPING STA.
MI. 725
WINONA
WISCONSIN
BUFFALO COUNTY
C. & N.W. RY.
C. B. & Q. R.R.
G. B. & W. R.R.
C. M. ST. P. & P. R.R.
C. G. W. RY.
RIVER
SANDBAG CLOSURE
LAKE
WINONA
SECTION - E
COUNTY DITCH
LAKE WINONA PUMPING STA.
LEVEE
WINONA CITY LIMITS
APPROXIMATE LIMIT OF FLOODED AREA - 1952 FLOOD
VILLAGE OF GOODVIEW
MINNESOTA
WINONA COUNTY
GILMORE
CREEK
BURNS VALLEY
EAST BURNS VALLEY
WEST BURNS
LOCK & DAM NO. 4
ALMA
WABASHA COUNTY
BUFFALO COUNTY
LOCK & DAM NO. 5
MINNEISKA
FOUNTAIN CITY
TREMPEALEAU RIVER
LOCK & DAM NO. 5A
TREMPEALEAU COUNTY
WINONA COUNTY
LOCK & DAM NO. 6
TREMPEALEAU
BLACK RIVER
FLOOD PROTECTION
LA CROSSE COUNTY
DRESBACH
ONALASKA
LOCK & DAM NO. 7
LA CRESCENT
LA CROSSE
HOUSTON COUNTY
VICINITY MAP
5 0 5 10 15
SCALE IN MILES
PROJECT FLOOD - 290,000 C.F.S.
FREEBOARD - 3.0 FT.
FLOOD CONTROL PROJECT
MISSISSIPPI RIVER
WINONA, MINNESOTA
LEVEE
PLAN
0 2000 4000 6000
SCALE IN FEET
CORPS OF ENGINEERS U. S. ARMY
OFFICE OF THE DISTRICT ENGINEER
ST. PAUL DISTRICT ST. PAUL, MINN.



FLOOD CONTROL PROJECT
MISSISSIPPI RIVER
WINONA, MINNESOTA
LEVEE SECTIONS

10 5 0 10 20
SCALE IN FEET

CORPS OF ENGINEERS U.S. ARMY
OFFICE OF THE DISTRICT ENGINEER
ST. PAUL DISTRICT ST. PAUL, MINN.

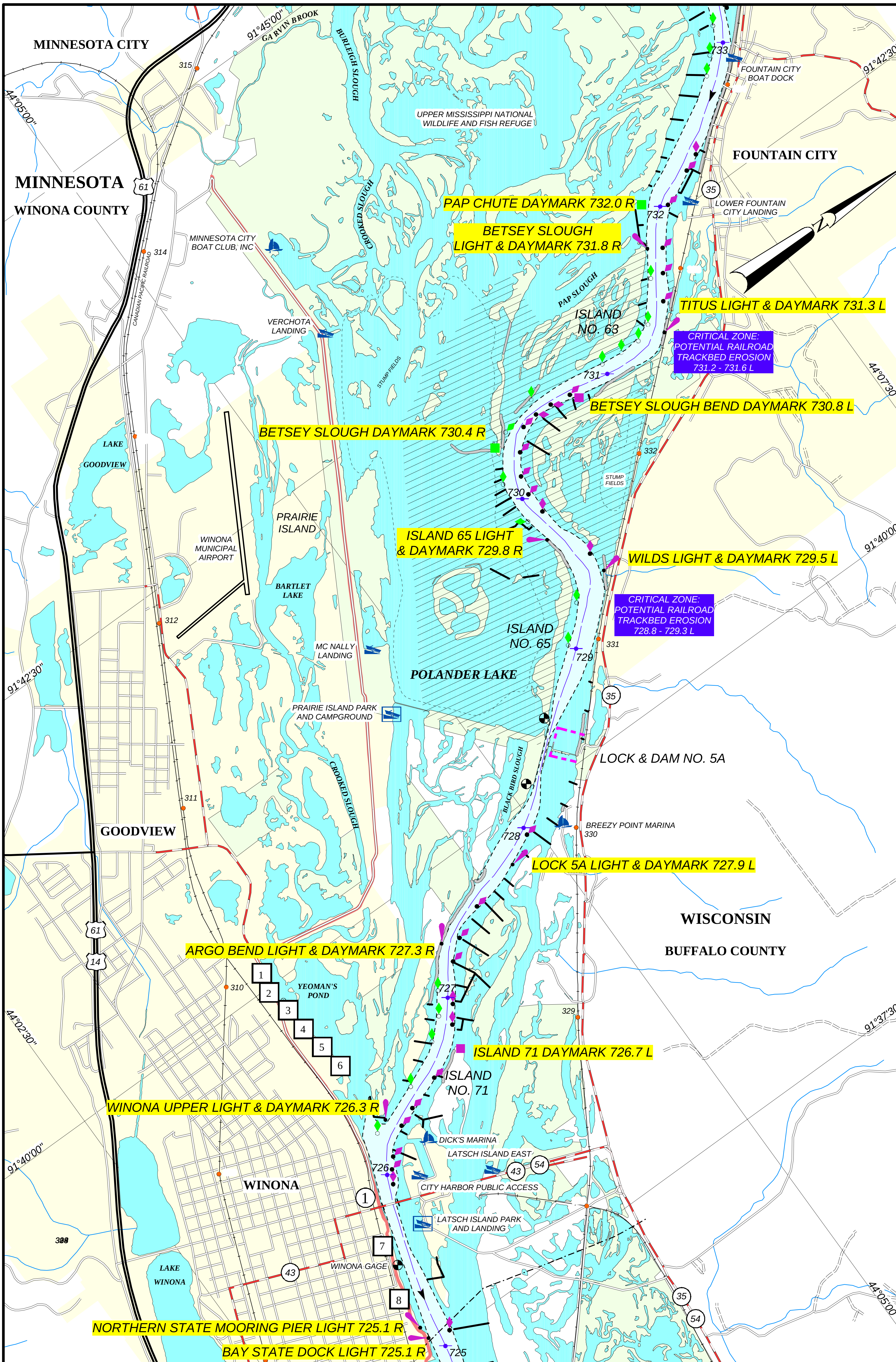


2001

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 733 to 740
U.S. Army Corps of Engineers
St. Paul District - St. Paul, MN

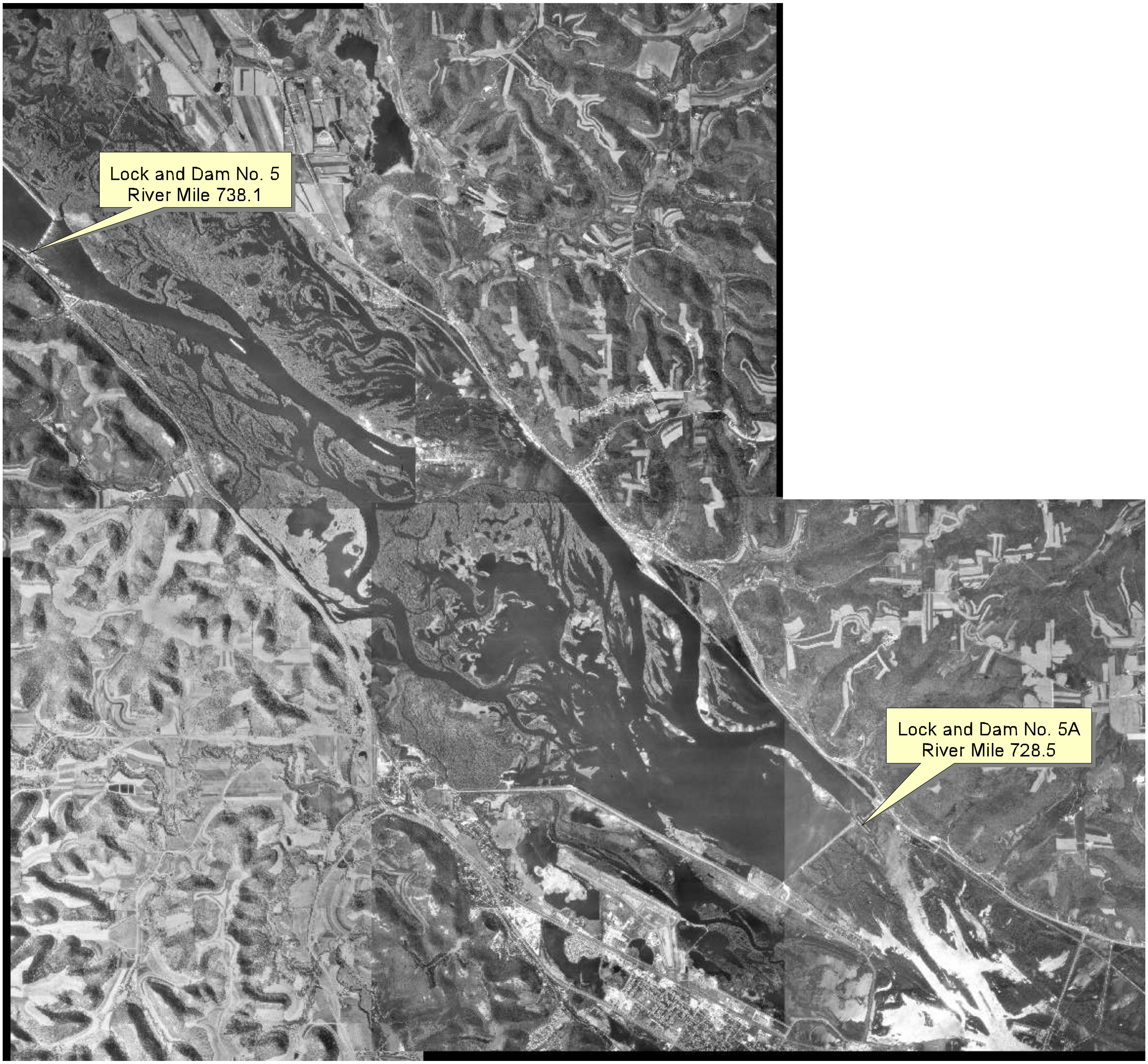


2001

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 725 to 733
U.S. Army Corps of Engineers
St. Paul District - St. Paul, MN



Upper Mississippi River
Nine-Foot Navigation Project

Pool No. 5A
Gage Location Map

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

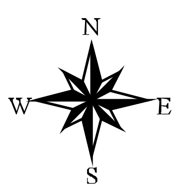


Plate 5-1