WATER CONTROL MANUAL

UPPER AND LOWER ST. ANTHONY FALLS LOCKS AND DAMS
MINNEAPOLIS, MINNESOTA

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

APPENDIX SAF
of the
MASTER WATER CONTROL MANUAL



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

December 2021

Updated from
Water Control Manual, May 2004
Reservoir Regulation Manual, August 1975
Operation of Navigation Pools, February 1943

FOR OFFICIAL USE ONLY

UPPER AND LOWER ST. ANTHONY FALLS LOCKS AND DAMS

MINNEAPOLIS, MINNESOTA



Aerial View Looking Northwest – 1995

Lower Lock and Dam
Moveable Dam - 3 Tainter Gates
Main and Auxiliary Locks - 1 Tainter Gate Each
Project Pool 750.0 feet (1912 Adjustment)

Upper Lock and Dam
Lock Chamber - 1 Tainter Gate
Project Pool 798.8 feet (1912 Adjustment) with flashboards raised
Project Pool 796.8 feet (1912 Adjustment) with flashboards lowered

UPPER AND LOWER ST. ANTHONY FALLS LOCKS AND DAMS

MINNEAPOLIS, MINNESOTA



Lower St. Anthony Falls Lock and Dam Control House
Lock Chamber in Foreground



Upper St. Anthony Falls Lock and Dam Control House
Lock Chamber in Foreground (Now Closed)

NOTICE TO USERS OF THIS MANUAL

Regulations specify that this Water Control Manual be published in a digital form in the central repository located at the following link: **https://water.usace.army mil/a2w/f?p=100:1:0**: The Water Control Manual at the central repository will be considered the official manual and will be kept current at all times. Instructions and information to upload or document the review status of the Water Control Manual, as per ER 1110-2-240, in the central repository portal can be found under the help tab in the portal. It is not unexpected that USACE Corporate Information may move the central repository link to a new location. This information will be shared with all offices if a situation occurs by the HQUSACE. The St. Paul District prepared the *Preliminary Report on Operation of Navigation Pools* on 16 February 1943. This document provided the operational information for Lock and Dams 1 through 10. It was replaced by a Master Regulation Manual in September 1969. Appendices for each lock and dam were added during the years 1969 through 1975, with Appendix SAF being completed in August 1975. This manual is an update of Appendix SAF from November, 2019. In 2015 the Upper St. Anthony Falls Lock and Dam was closed to navigation, though the authorized purposes remains unchanged.

EMERGENCY REGULATION ASSISTANCE PROCEDURES

In the event that unusual conditions arise (e.g. gate failure, excessive rainfall), the Lockmaster and Water Management should be notified as to the extent of the event. During normal water Management duty hours (i.e. 0600 to 1730 hrs weekdays and 0600 to 1000 hrs weekends and holidays), contact with water management can be made at 651-290-5786. On weekends and holidays, the Mississippi River Duty Regulator number is available on the daily orders. If communication with Water Management cannot be established, the following list can be used as a guide for establishing contact.



E.O.C. 24-hour	Emergency Assistance	651-290-5220
Xcel Energy	Powerhouse Operators	612-330-6166
Saint Anthony Falls	Lock House at Lower (shared with upper)	651-290-5936
Lock and Dam 1	Lock House	651-290-5919

Upper and Lower St. Anthony Falls Locks and Dams
Minneapolis, Minnesota

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

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PERTINENT DATA – LOWER LOCK AND DAM

Location: Lower St. Anthony Falls Lock and Dam is located on the Mississippi River, 853.4 river miles above the mouth of the Ohio River and 5.8 river miles above Lock and Dam No. 1. The lock is on the right bank of the river in Minneapolis, Minnesota at approximate latitude 44° 58' 43" N and longitude 93° 14' 45" W.

Drainage Area: 19,680 square miles

Datum: MSL 1912 adjustment
MSL 1912 - 0.41 = NAVD88

Moveable Dam:

Tainter Gates (3 Gates):	56 ft wide by 20.5 ft high
Tainter Gate Sill:	Elevation 731.0 feet
Tainter Gate Seal:	Elevation 728.5 feet

Auxiliary Lock (uncompleted):

Tainter Gate Only:	56 feet by 15.5 feet
Tainter Gate Sill:	Elevation 736.3 feet
Tainter Gate Seal:	Elevation 735.3 feet

Closure Dams:

Type:	Non-Overflow Concrete	Non-Overflow Earthen
Owner:	Corps of Engineers	Xcel Energy
Length:	230 feet	
Crest:	Elevation 755.0 feet	Elevation 757.0 feet
Top Width:	5 feet	

Lock:

Main Lock Chamber:	56 feet by 400 feet
Top of Lock Walls:	Elevation 755.0 feet
Top of Upper Gate Sill:	Elevation 736.3 feet
Depth on Upper Gate Sill:	13.70 feet (U.P. 750.0 feet)
Top of Lower Gate Sill:	Elevation 712.8 feet
Depth on Lower Gate Sill:	12.30 feet (L.P. 725.1 feet)
Lock Floor:	Elevation 711.8 feet
Height of Upper Tainter Gate:	15.2 feet
Height of Lower Miter Gates	39.7 feet

Pool:

Normal (Project) Intermediate Pool	Elevation 750.0 feet
Normal (Project) Lower Pool	Elevation 725.1 feet (flashboards in)
Pool Area (at Project Pool)	50 acres
Primary Control Point	Pool Gage

Notes:

1. Tainter gates at the moveable dam are submergible to 6 feet below Normal Pool (750.0 feet).
2. Tainter gates at the main and auxiliary lock are submergible to the gate sill elevation of 736.3 feet.

PERTINENT DATA – UPPER LOCK AND DAM

Location: Upper St. Anthony Falls Lock and Dam is located on the Mississippi River 0.7 river miles above Lower St. Anthony Falls Lock and Dam at 854.1 river miles above the mouth of the Ohio River and 3.4 miles below the upstream limit of the nine-foot channel project at river mile 857.5. The lock is on the right bank of the river in Minneapolis, Minnesota at approximate latitude 44° 58' 51" N and longitude 93° 15' 26" W.

Drainage Area: 19,680 square miles

Datum: MSL 1912 adjustment
MSL 1912 - 0.41 = NAVD88

Lock:

Lock Chamber Dimensions	56 feet by 400 feet
Top of Lock Walls	Elevation 806.0 feet
Top of Upper Gate Sill	Elevation 783.5 feet
Top of Lower Gate Sill	Elevation 736.3 feet
Lock Floor	Elevation 735.3 feet
Height of Upper Miter Gates	20.0 feet
Height of Upper Tainter Gate	15.7 feet
Height of Lower Miter Gates	67.2 feet

Pool:

Normal (Project) Upper Pool	Elevation 799.2 feet (flashboards in) Elevation 796.8 feet (flashboards out)
Normal (Project) Intermediate Pool	Elevation 750.0 feet
Pool Area (at Project Pool)	358 acres
Control Point	Upper Pool Gage

Horseshoe Dam:

Owner:	Xcel Energy
Type:	Gravity dam – concrete, timber, and rock
Overall Length:	2,045 feet
Length With Flashboards:	1,495 feet (Sections 3 through 8)
Length of Lock Approach:	550 feet (Section 2)
Crest Elevations:	
Sections 3 though 8:	798.8 feet with flashboards raised 796.8 feet with flashboards lowered
Section 2:	801.0 feet (lock approach)
Roll Dam:	
Type	Rock filled timber cribbing
Length	340 feet
Crest Elevation	791.5 feet
Main Spillway:	
Type	Gravity dam – concrete, timber, and rock
Length	425 feet
Crest Elevation	785.2 feet

Note: 1. The tainter gate in the upper lock chamber is maintained in the submerged position except during large flood events that require discharge through the lock.
2. Since 2015 the Upper St. Anthony Falls Lock and Dam was closed to navigation.

I – INTRODUCTION

1-01. Authorization for 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 St. Anthony Falls Upper Lock and Lower Lock and Dam Regulation Manual dated 2004 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, 1 March 1994 and 30 May 2016.
b. Engineering Manual, EM 1110-2-3600, *Management of Water Control Systems*, 30 November 1987 and 10 October 2017.
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*, 30 September 2018.

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 Management Section activities for most foreseeable conditions and occurrences. The manual covers all water management activities as they relate to the hydraulic and hydrologic aspects of the project.

1-03. Related Manuals and Reports. The Upper Mississippi River Lock and Dam system was authorized when Congress approved the nine-foot channel on 3 July 1930. A general scheme of operation was developed on 28 March 1935. In the River and Harbor Acts of 1937, Congress authorized a 4.6-mile extension of the nine-foot channel to ascend St. Anthony Falls in two steps. The following is a list of related Manuals and Reports in chronological order.

a. *Survey of Mississippi River Between Missouri River and Minneapolis*, Letter from The Secretary of War, 72 Congress, 1st Session, House Document No. 137, Part 1 – Report, 9 December 1931.

b. *Report on General Scheme of Operation for the Dams of the 9-Foot Channel Project*, by J. A. Grant, Senior Engineer, War Department, Office of the Chief of Engineers, 28 March 1935.

c. *Preliminary Report on Operation of Navigation Pools,* War Department, US Engineer Office, St. Paul District, St. Paul, Minnesota, 16 February 1943.

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

e. *Final Environmental Impact Statement for Operation and Maintenance of the 9-Foot Navigation Channel, Upper Mississippi River, Head of Navigation to Guttenburg, Iowa,* US Army Corps of Engineers, St. Paul District, 1974.

f. *Mississippi River Nine-Foot Channel Navigation Project, Reservoir Regulation Manual, Appendix SAF, St. Anthony Falls, Upper Lock and Lower Lock and Dam, Minneapolis, Minnesota,* US Army Corps of Engineers, St. Paul District, August 1975.

g. *Creativity, Conflict & Controversy: A History of the St. Paul District, US Army Corps of Engineers*, by Raymond H Merritt, 1979.

h. *Final Environmental Impact Statement: Great River Environmental Action Team I, Study of the Upper Mississippi River, Guttenberg, Iowa to the Head of*

Navigation at Minneapolis, Minnesota, Great River Environmental Action Team (GREAT), Volume 9, 1980.

i. *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.

j. *Emergency Plan for the Locks and Dams at St. Anthony Falls, Minneapolis, Minnesota*, US Army Corps of Engineers, St. Paul District, March 1987.

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

l. *Gateways to Commerce*, The US Army Corps of Engineers' 9-Foot Channel Project on the Upper Mississippi River, National Park Service, Rocky Mountain Region, 1992.

m. *Authorized and Operating Purposes of Corps of Engineers Reservoirs*, US Army Corps of Engineers, Washington D. C., July 1992.

n. *Operation and Maintenance Manual Flood Control Project, Bassett Creek Watershed, Hennepin County, Minnesota,* US Army Corps of Engineers, St. Paul District, May 1993.

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

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

q. *Record of Decision (ROD) for Final Environmental Impact Statement, Channel Maintenance Management Plan,* Major General Robert B. Flowers, Commander and Division Engineer, Mississippi Valley Division, US Army Corps of Engineers, June 1997.

r. *Zebra Mussel Response Plan*, Environmental Section, St. Paul District, US Army Corps of Engineers, November 1997.

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

t. *Biological Opinion for the Operation and Maintenance of the 9-Foot Navigation Channel on the Upper Mississippi River System,* US Fish and Wildlife Service, 15 May 2000.

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

v. Engineering Regulation, ER 200-1-5, *Policy for Implementation and Integrated Application of the US Army Corps of Engineers' Environmental Operating Principles and Doctrine,* 30 October 2003.

w. *Headwaters of the Mississippi River, Hydrology Study and Report,* US Army Corps of Engineers, St. Paul District, August 2018.

1-04. Project Owner. The United States Government is the owner of the Upper Lock at Upper St. Anthony Falls (USAF) and the Lower Lock and Dam at Lower St. Anthony Falls (LSAF). At USAF, this includes the lock as well as the short transition to the dam. At LSAF, it includes the lock, the dam, and concrete portion of the non-overflow dam on the left bank (**2.03. c. Non-Overflow Dam**). Xcel Energy is the owner of the St. Anthony Falls Hydroelectric Project at USAF. This includes the horseshoe dam, powerhouse, and related facilities. At LSAF, Xcel Energy is the owner of the earthen dam portion of non-overflow dam on the left bank.

1-05. Operating Agency. The US Army Corps of Engineers, St. Paul District, Operations Division is responsible for the operation and maintenance of both the Upper St. Anthony Falls (USAF) Lock and Lower St. Anthony Falls (LSAF) Lock and Dam. The project is attended 24 hours a day, every day of the year. The chain of command flows from the District Engineer to the Chief, Operations Division (both located in the St. Paul District Office), to the Lock and Dam Project Office (located in Fountain City, Wisconsin), to the Lockmaster (one at each site).

The dam and powerhouse at USAF is operated and maintained by Xcel Energy. The powerhouse is attended between 0700 hours and 1530 hours, Monday

through Friday. A powerhouse operator can be contacted by telephone at 612-330-6166. In 1988 the power plant at LSAF was removed and replaced with a non-overflow earthen dam. The earthen dam is owned by Xcel Energy. Brookfield Renewable Power owns the hydropower facility in the auxiliary lock chamber.

1-06. Regulating Agency. Regulation of the intermediate pool at Lower St. Anthony Falls (LSAF) is the responsibility of the Corps of Engineers, St. Paul District according to the Rivers and Harbor Act of 1937. Because of the small volume in the pool, multiple gate changes are required to maintain project. Therefore, site personnel make gate changes as needed. Contact with Water Management is typically only during times of very low flow conditions or very high flow conditions.

When flows are less than the hydropower demand, regulation of the Upper St. Anthony Falls (USAF) pool is the responsibility of Xcel Energy. This is accomplished through regulation of flow at the powerhouse and installation of the flashboard system atop the dam. Flows in excess of the powerhouse capacity are spilled over the dam and are essentially unregulated. An automated control system regulates the upper pool elevation by varying the discharge through the powerhouse. Daily communication with Water Management is not necessary; however, during flood events Water Management will be in contact with USAF to coordinate the opening of the lock chamber to pass flows.

1-07. Vertical Datum. The datum used for the design and construction of the project is MSL 1912. The conversion from MSL 1912 to the current standard of NAVD88 is as follows: MSL 1912 - 0.41 = NAVD88

II – DESCRIPTION OF PROJECT

2-01. Location. Lower St. Anthony Falls (LSAF) Lock and Dam is located on the Mississippi River, 853.4 river miles above the mouth of the Ohio River, and 5.8 river miles above Lock and Dam No. 1. Upper St. Anthony Falls (USAF) Lock and Dam is located on the Mississippi River 0.7 river miles above the lower lock, 854.1 river miles above the mouth of the Ohio River, and 3.4 miles below the upstream limit of the nine-foot channel project at river mile 857.5. Both locks are on the right bank of the river in Minneapolis, Minnesota. The project is bordered by Hennepin County on all sides and is virtually in the center of the metropolis (**Figure 2-1**). The project location is also shown on **Plates 2-1** and **5-1**. The pool upstream of USAF is called the "upper pool", the pool between USAF and LSAF is called the "intermediate pool" and Pool No. 1 downstream of LSAF is called the "lower pool".

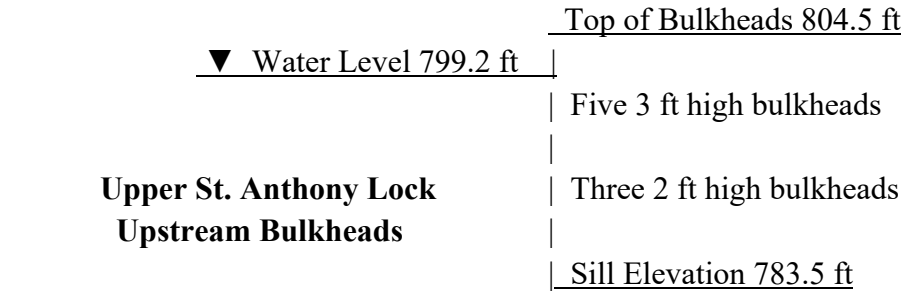


Figure 2-1. Upper and Lower St. Anthony Falls Locks and Dams - 1995

2-02. Purpose. Upper and Lower St. Anthony Falls Locks and Dams are two units within 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 lock and dams were authorized for navigation under the River and Harbors Act of 1930 (PL 71-250). This was expanded to include recreation under the Flood Control Act of 1944 (PL 78-534). In 1937, the Rivers and Harbors Act approved the Minneapolis Upper Harbor Project, which extended the nine-foot channel 4.6 miles upstream of the upper navigation point of Pool No. 1 at river mile 853.0.

The Upper St. Anthony Falls lock was ordered closed on 10 June 2015 to block invasive carp from traveling upriver. The U.S. Army Corps of Engineers maintains the lock in case it is needed for flood control.

2-03. Physical Components. Both Upper and Lower St. Anthony Falls Lock's are 56 feet wide with a clear length of 400 feet. Therefore bulkheads at each site can be shared. In addition, Lock and Dam No. 1's locks are the same dimensions; however, the outlet channel flares out making the downstream bulkheads longer and therefore used strictly at this site. All of Upper and Lower St. Anthony Lock bulkheads as well as Lock and Dam No. 1's upstream bulkheads are 59 feet-9½ inches long. They are commonly referred to as 60-footers. Those at Lock and Dam No. 1 are 2 feet high, whereas those at Upper and Lower St. Anthony are 3 feet high. The 2-foot high bulkheads are red in color and the 3-foot high ones are silver. An inspection of the bulkheads resulted in limiting the 3-foot high bulkheads (silver) to 11 feet of head. The superior construction of the 2-foot high bulkheads (red) allowed them to be certified to a much higher head differential. Therefore the bulkheading procedure calls for a combination of red and silver bulkheads. For example, dewatering of Upper St. Anthony called for the following bulkhead arrangement at the upstream:



There are twenty-two 60-foot bulkheads in total. Most are stored at Lower St. Anthony Falls Lock or near the roadway in between the Upper and Lower Locks. There are nine 2-footers and thirteen 3-footers. The bulkheads not only provide for closure of the locks but also closure of any of the three moveable dam tainter gates at Lower St. Anthony.

2-04. Physical Components of Lower St. Anthony Falls Lock and Dam. Lower St. Anthony Falls Lock and Dam consists of a main lock, an uncompleted auxiliary lock, a moveable dam section, a non-overflow concrete dam, and a non-overflow earthen dam (**Figure 2-2**).



Figure 2-2. Lower St. Anthony Falls Lock and Dam 2020

a. Lock. Lower St. Anthony Falls Lock and Dam has a main and an uncompleted auxiliary lock. They are founded on bedrock. While the main lock is fully functional, the auxiliary lock consists of only an upper gate bay. The upper gates in both the main and auxiliary locks are tainter gates, which can be used when needed to aid in discharging high flows in addition to being used in locking operation. **Figure 2-3** shows the upper tainter gate in the main lock. For the passage of navigation, the upper gate is submerged in the open position. The main and auxiliary lock tainter gates are 56.0 feet wide and have a damming height of 15.2 feet. They can be submerged to the gate sill elevation of 736.3 feet (MSL 1912). Therefore, the top of gate when in the sealed position is elevation 751.5 feet. The lower gate in the main lock consists of two miter gates, each being 32 feet–2 inches wide and 39 feet–8 inches high. A walkway is located atop the lower miter gates. It extends 2.5 feet above the top of miter gates (elevation 752.5 feet) to meet the top of lock walls (elevation 755.0 feet). The lower sill elevation is 712.8 feet.



Figure 2-3. Lower St. Anthony Falls - Main Lock Tainter Gate.

The main lock tainter gates are individually operated by machinery consisting of an electrically operated central driving unit and two chain hoisting units. The electric controls consist of push buttons located in the upper control stand. For locking purposes, there are two gate settings: opened and closed. To monitor the gate position, a wire and pulley system was arranged. A wire attached to the top of the gate passes through a pulley. A weight on the end of the wire sits in front of on an indicator panel. The panel has two marks on it; one for “opened” and one for “closed”.

The main lock is 56 feet wide with a clear length of 400 feet. Filling and emptying of the lock chamber is controlled by tainter valves; one at the upstream (upper) end of the lock and one at the downstream (lower) end. During the filling or emptying process, the upper tainter gate and lower miter gates are closed thus sealing the lock chamber. For a filling operation, the upper tainter valve is opened allowing flow to enter the culvert (**Plate 2-2**, Section D-D). Flow then enters the lock chamber through lateral ports along the lock floor (Section C-C) and the water level in the lock chamber rises until it equals the pool elevation. The upper tainter valve is then closed, the upper tainter gate is opened and the vessel continues on upstream.

The filling operation was modified when it was discovered that when the upper tainter valve is opened completely, a hazardous vortex is created above the filling ports. At maximum head, the vortex is great enough to expose the inlet grate. To avoid this, the filling valve was programmed to open incrementally throughout the filling cycle. Filling time under normal conditions is about twelve minutes. For an emptying operation, the lower tainter valve is opened, thus emptying the lock chamber. Under normal conditions, emptying time is 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 tainter gate remains in the closed position, as do the tainter valves. The lower miter gates are then opened to the recessed position and the upper tainter valve is operated to provide the flushing action. Unfortunately, due to the configuration of laterals at the bottom of the lock, the sediment at the bottom does not flush out well.

Guide walls are located upstream and downstream of the lock to provide a landing for down bound and up bound tows (**Plate 2-2**). The upper guide wall extends 400 feet upstream and the lower guide wall extends 408 feet downstream.

b. Moveable Dam. The moveable dam section extends from the auxiliary lock to the non-overflow closure dam located on the left bank of the main channel (**Figure 2-2**). It is founded on bedrock. The moveable dam consists of three tainter gates, 56.0 feet wide by 20.5 feet high (**Figure 2-4**). The gate sill elevation is 731.0 feet (1912 adjustment); however, the gate seal is at a slightly lower elevation of 728.5 feet. The concrete apron elevation is 710.0 feet, the end sill elevation is 714.0 feet, and the rock and timber crib, downstream of the end sill, is at elevation 712.8 feet. The tainter gates are submergible up to 6 feet below project pool (750.0 feet) to aide in passing of ice or debris.



Figure 2-4. Moveable Dam Tainter Gates and Auxiliary Tainter Gate

As with the lock tainter gates, each moveable dam tainter gate is individually operated by machinery consisting of an electrically operated central driving unit and two chain hoisting units. The electric controls consist of push buttons located in the central control station. The controls are designed to open or close a gate 0.2-foot with each push of the button. The machinery dates back to 1956. Operators verify the gate openings by checking the position indicator with binoculars. The position indicator (**Figure 2-5**) is mounted on the pier and a pointer is mounted on the top of the tainter gate. The indicator is marked in 0.2-foot increments. The travel rate of the tainter gates is approximately one-foot per minute.



Figure 2-5. Moveable Dam Tainter Gate Position Indicators

A service bridge, at elevation 786.94 feet, spans the entire length of the moveable dam, lock chambers, and storage yard and provides for the operation of the crane. The original 50-foot electric locomotive crane, with 25-ton capacity, was replaced in 2002. The new crane has the same 50-foot boom length and 25-ton capacity.

c. Non-overflow Dam. The concrete non-overflow dam is owned by the Corps of Engineers. It is founded on bedrock. It is approximately 230 feet in length and has a top elevation of 755.0 feet (1912 adjustment) with a top width of 5 feet. Northern States Power (now Xcel Energy) used to operate a hydropower plant adjacent to the non-overflow concrete portion of the dam. The non-overflow concrete dam extended upstream in angular fashion and the powerhouse extended downstream at about the same angle, thus forming somewhat of a chevron pointing upstream (**Figure 2-6**). In November 1987 the powerhouse collapsed. It was replaced with non-overflow earthen dam (**Figure 2-2**). The crest elevation of the dam was 751.0 feet. Because it was frequently over topped during the balancing of flows at the moveable dam, it

was raised to elevation 757.0 feet in 1988. The non-overflow earthen dam is owned and maintained by Xcel Energy.

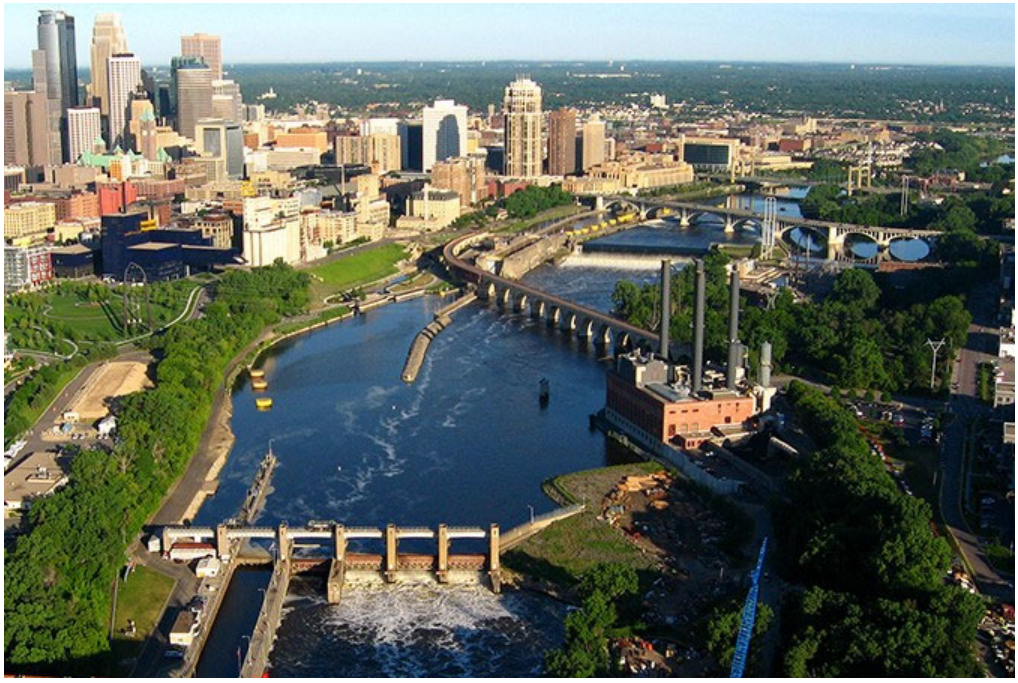


Figure 2-6. Upper and Lower St. Anthony Falls – 2007

d. Hydropower Facility in the Auxiliary Lock Chamber. Brookfield Renewable Power and Nelson Energy own the Hydropower Facility in the Auxiliary Lock Chamber. Sixteen StraflowMatrix combined turbine/generator units are located in the auxiliary lock chamber. These work well in low head flows and pre-existing structures. The hydropower facility averages 63,300 MWh and has a hydraulic capacity of 6,201 cfs. The turbine generators produce 9,176 kW and 12,305 hp at 24 ft of head.

e. Channel Protection. Upstream of the moveable dam the channel is protected by derrick stone. Downstream a concrete apron followed by derrick stone protects the channel (**Plate 2-2**, Section B-B). **Plate 2-5** shows the location of channel sounding transects. The following gives a description of the protection near the moveable dam and the locks.

(1) Moveable Dam. The original scour protection is still in place and no additional rock work has been documented upstream or downstream of the moveable dam. Downstream protection consists of a 3.5-foot section of derrick stone underlain by a 1.5-foot section of riprap. The derrick stone extends 60 feet downstream of the end sill and has a top of rock elevation of 712.8 feet at the upstream end and 711.8 feet at the downstream end (1912 adjustment). Upstream of the dam, the derrick stone section is 2.5-feet thick underlain by alluvial backfill. The derrick stone extends 30 feet upstream of the gate sill and has a top of rock elevation of 726.5 feet.

(2) Locks and Guide Walls. As with the moveable dam, the original scour protection is still in place and no additional rock work has bee been documented. Downstream of the auxiliary lock is a rock and lumber mat crib filled with 3.5 feet of derrick stone with a top elevation of 711.8 feet. Along the riverward side of the riverward wall on the main lock and at the downstream end of the main lock, is a 20-foot wide rock filled timber crib at the same elevation as the rock and lumber mat crib. No scour protection is provided at the upstream end of the lock chambers. Random backfill was placed adjacent to the upper guide wall at an approximate elevation of 729.0 feet.

2-05. Physical Components of Upper St. Anthony Falls Lock and Dam. Upper St. Anthony Falls (USAF) Lock and Dam consists of a single lock and the St. Anthony Falls Hydroelectric Project. Xcel Energy owns the Hydroelectric Project, which includes the horseshoe dam, roll dam, main dam, and the powerhouse. These facilities, along with the University of Minnesota's St. Anthony Falls Laboratory are not a part of the Minneapolis Upper Harbor Project. They are described in **Section 2-06**. The lock and the transition to the dam were the only physical components constructed during the project. The lock is supported on rock foundation.

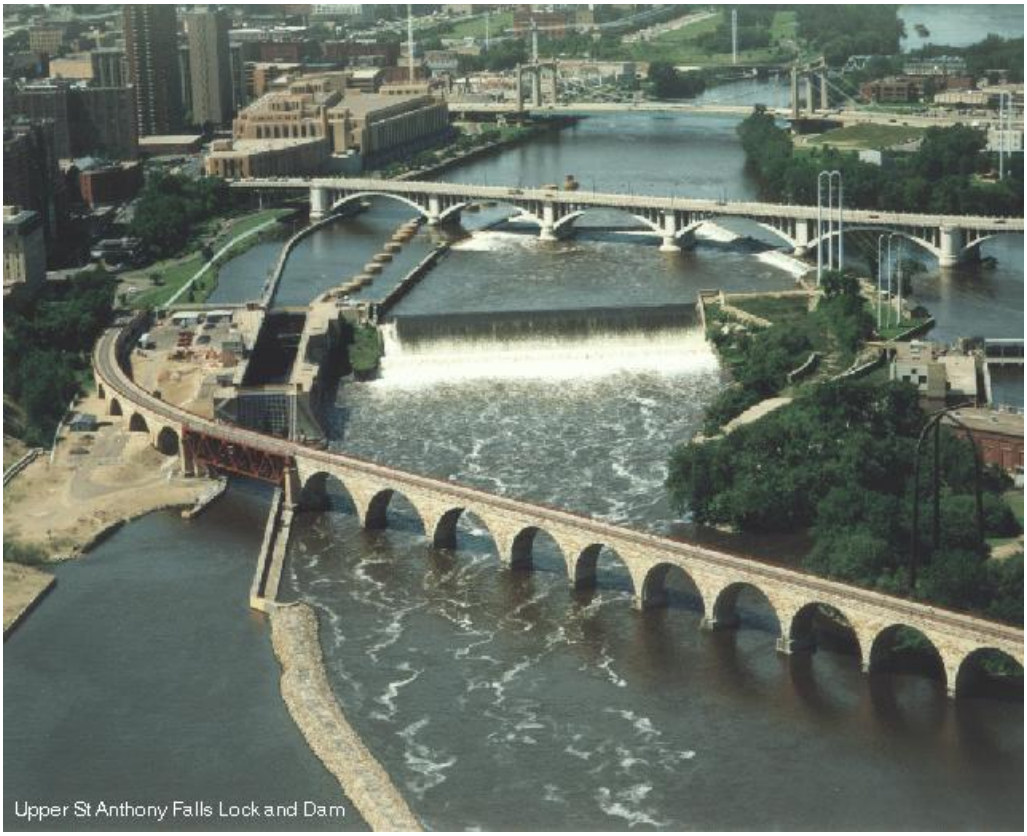


Figure 2-7. Upper St. Anthony Falls Lock and Dam

a. Lock. Upper St. Anthony Falls Lock and Dam has only one lock (**Figure 2-7**). The upper and lower miter gates of the lock are comprised of two leaves each 32 feet–2 inches wide. The upper gates are 20.0 feet high, while the lower gates are 67 feet–$2^3/8$ inches high. The respective sill elevations are 783.5 feet and 736.3 feet (1912 adjustment). A submergible tainter gate is provided inside the lock chamber immediately downstream of the upper miter gate to assist in passing high flows, ice, and debris (**Figure 2-8**). The tainter gate is 56.0 feet wide and has a height of 15.7 feet. It has the same sill elevation as the upper miter gate, 783.5 feet. The upper lock tainter gate is operated by two synchronized electric motors imbedded in the lock walls. It is run by cables connected to the side of the gate. The electric motors are controlled by the upstream miter gate operation building that is located on the upstream end of the lock wall. A walkway is located atop the miter gates. It extends 2.5 feet above the top of miter gates (elevation 803.5 feet) to meet the top of lock walls (elevation 806.0 feet).



Figure 2-8. Upper Lock with Submergible Tainter Gate

The lock is 56 feet wide with a clear length of 400 feet. It is equipped with four floating mooring bits. 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 2-3**). Flow then enters the lock chamber through ports along the lock floor (Section A-A) and the water level in the lock chamber rises until it equals the pool elevation. To empty the lock chamber, the upper tainter valves are closed and lower tainter valves are opened. Under normal conditions, filling and

emptying times are about eight minutes. Periodically, the lock chamber is flushed of sediment and debris. To accomplish this the Upper St. Anthony Falls tainter gate can be exercised to allow debris and sediment to pass. This will effectively flush debris and sedimentation without having to complete a locking cycle.

Guide walls and guard walls are located upstream and downstream of the lock. The guide walls provide a landing for up bound and down bound tows. Tow haulage units are located on each guide wall. The guard walls function to "guard" against a tow going in this direction. Typically guide walls are located on the landward side and guard walls are located on the riverward side. The upper guide wall has a top elevation of 806.0 feet (1912 adjustment) and extends upstream, parallel to the lock chamber, for a distance of 400 feet. To provide protection for the Third Avenue Bridge pier, a training wall extends beyond the guide wall for a distance of 520 feet. Because of the bend in the river, the training wall bends riverward slightly to a point just upstream of the Third Avenue Bridge (**Figure 2-7**). The upper guard wall prevents navigation accidents resulting from outdraft at the dam. To prevent tows from drifting into the horseshoe dam, the guard wall extends from the upstream end of the horseshoe dam, under the Third Avenue Bridge, and downstream to the lock chamber. The guard wall consists of a series of circular sheet pile cells that flare riverward just upstream of the lock and extends beyond the Third Avenue Bridge. **Figure 2-9** shows a boat in the upper approach channel of the lock.



Figure 2-9. Upper St. Anthony Falls Lock - Upper Lock Approach

Upper St. Anthony Falls Lock is unique in that the downstream guide wall is located on the riverward side and the guard wall is located on the landward side. The lower guard wall has an elevation of 760.0 feet and extends downstream, in direct alignment with the lock, for a distance of 160 feet and then makes a slight landward bend and extends for another 100 feet. It essentially "guards" the Stone Arch Bridge pier on the right bank. The lower guide wall has an elevation of 760.0 feet and extends 600 feet downstream of the lock. Because of the alignment of the dam and powerhouse wasteways on the left bank and the skewed position of the Great Northern Railway's arch bridge, flow was directed into the navigation channel causing dangerous cross currents. To eliminate this danger, a 700-foot long training dike was extended from the downstream end of the guard wall to deflect the current away from the navigation channel and towards the lower dam.

b. Transition to Spillway. The lock was cut through the existing portion of the Upper St. Anthony Falls Dam. The lock is located at the old saw mill site on what was formerly known as Upton Island. The transition consists of the old existing structure, which can be seen riverward of the lock (**Figure 2-7**). The transition portion of the dam is 50 feet long with a top elevation of 806.0 feet (1912 adjustment). There is a stop log sluice at the end of the transition. As part of the lock construction, new stop log guides were installed.

c. Channel Protection. The upstream end of the lock chamber and the upper guide wall were founded directly on rock, therefore no rock was placed for scour protection; however, riprap was placed around the base of the guard wall cells. Immediately downstream of the lock chamber, the channel is protected by concrete followed by stone protection. **Plate 2-6** shows the location of channel sounding transects. Scour protection downstream of the lock chamber consists of a two-foot derrick stone section with a top elevation of 731.0 feet (1912 adjustment). The derrick stone extends 260 feet downstream of the lock sill to the end of the landward guard wall. Beyond this, 24-inch riprap extends downstream of the channel for a distance of 150 feet. The rock elevation rises from 731.0 feet to elevation 735.3 feet. Along the riverward lock wall, a two-foot section of derrick stone, varying in width from 25 to 50 feet, was placed. At the riverward guide wall, the derrick stone continues on both sides of the wall. The riverside derrick stone sloped downward with a width of 20 to 25 feet. The landside derrick stone was placed with a top elevation of 735.3 feet and a width of 15 feet. The riverward guide wall protection tied into the down-stream training dike. The training dike was constructed of a stone core with a cover stone on the top and riverward side and 24-inch riprap on the landward side. Additional rock protection has been placed on the dike due to settlement and loss of material over time.

2-06. Related Control Facilities. The Lower Falls Hydroelectric Plant failed in 1987 and was replaced by an earthen dam in 1988 (**2-03. c. Non-Overflow Dam**). In 1903 the steam plant was built on the left bank in the intermediate pool. It is owned, operated, and maintained by the University of Minnesota. The steam plant is flooded by pool elevations above 752.3 feet. Operation of the steam plant has little effect on operations at Lower St. Anthony Falls.

In the upper pool is the St. Anthony Falls Hydroelectric Project. It is owned, operated, and maintained by Xcel Energy. During low flow periods, the project is operated to maintain the upper pool between elevation 799.2 and 798.8 feet. If the pool level drops below elevation 798.6 feet, the power plant is to be sequentially shut down until the normal pool level is restored. If the flashboards atop the horseshoe dam are lost due to ice action during spring breakup or water pressure due to high flows (around pool elevation 801 feet), the horseshoe dam crest (elevation 796.8 feet) becomes the new control level until the flashboards can be replaced. This occurs when the flow subsides to approximately 6,000 cfs. Main features of the project include a horseshoe dam, upper roll dam, main spillway (lower roll dam), and the Hennepin Island Powerhouse.

a. Horseshoe Dam. The horseshoe dam is a gravity dam constructed of concrete, timber, and rock and sits in the middle of the Mississippi River. It extends from the lock on the right bank to the Hennepin Island earthen dam on the left bank (**Figure 2-10**). It is owned and maintained by Xcel Energy. Plan and section views of the horseshoe dam are shown in **Figure 2-11**. Note that Wasteway No. 1 has since been closed to flow.



Figure 2-10. Horseshoe Dam at Upper St. Anthony Falls

Overall, the horseshoe dam is 2,045 feet long (**Figure 2-12**). It was originally comprised of eight sections and two roll dams. Section No. 1 was Wasteway No.1 and no longer exists. Flashboards can be installed on Sections No. 3 through No. 8. The crest of the horseshoe dam at these sections is elevation 796.8 feet (1912 adjustment). The flashboards consist of two rows of tongue and groove 2 by 12's with a total height of approximately 2.0 feet. Therefore, with flashboards in, the crest of the horseshoe dam is elevation 798.8 feet. The length with flashboard section is 1,495 feet. The flashboards can be seen atop the horseshoe dam in **Figure 2-12**. Section No. 2 is part of the upper lock approach (seen in the lower portion of **Figure 2-10**). It is 550 feet long and has a crest elevation of 801.0 feet. The higher elevation was part of the lock construction to provide adequate depths in the lock approach and to eliminate cross-currents in the approach channel.

With flashboards in, the upper pool is maintained at elevation 799.2 feet, as measured at the Corps' pool gage to meet project pool requirements and to optimize powerhouse operations.

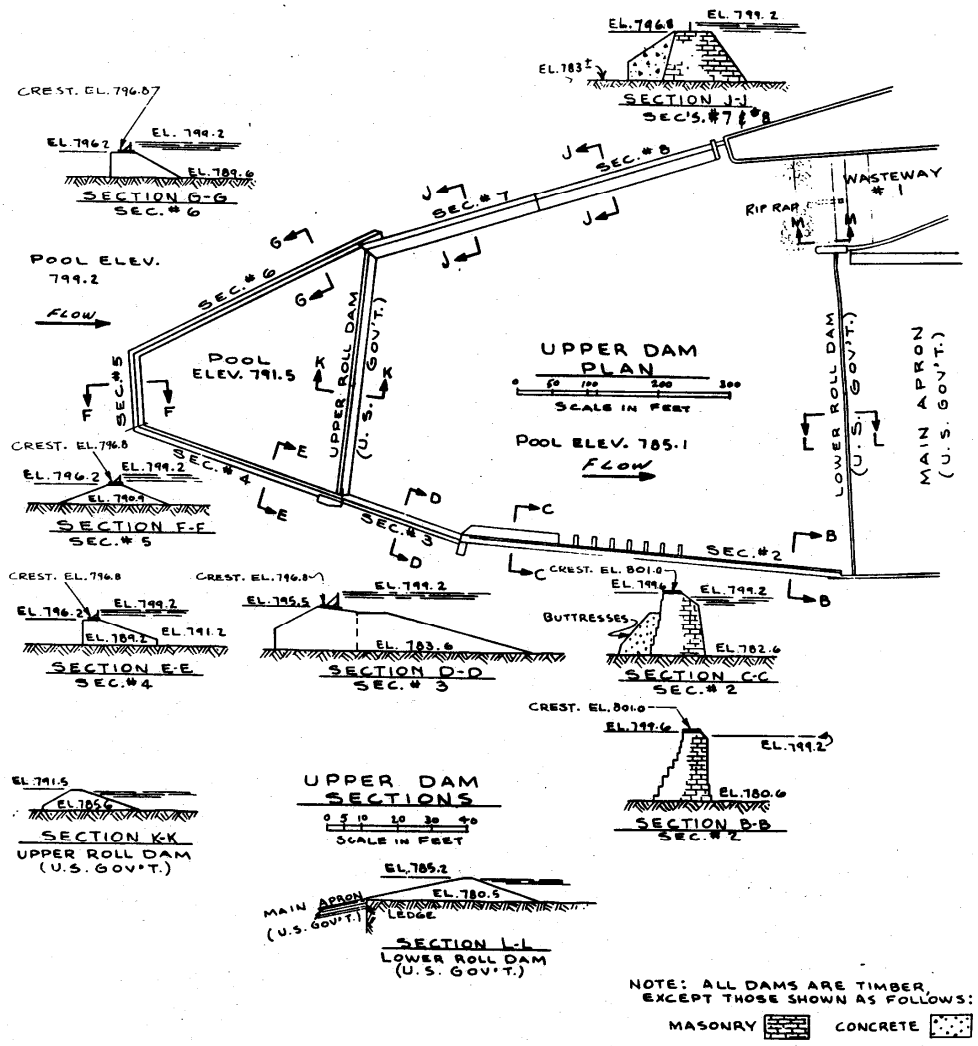


Figure 2-11. Horseshoe Dam – Plan and Sections

b. Upper Roll Dam. The upper roll dam is constructed of rock filled timber cribbing and is located between the main spillway and the horseshoe dam just upstream of the Third Avenue Bridge. The roll dam provides a pool that protects the limestone bedrock from erosion from the plunging of water over the upstream end of the horseshoe dam. It is 5.9 feet high and 340 feet long. It has crest elevation of 791.5 feet. During low water in the summer of 2003, repairs were made to the horseshoe

dam as well as the roll dam. In **Figure 2-12** the roll dam can be seen extending from left to right in the middle of the "horseshoe". The surface of the dam is being rehabilitated with new concrete.



Figure 2-12. Horseshoe and Roll Dam Repairs – Low Water 2003

c. Main Spillway. The main spillway was constructed as the second roll dam of the horseshoe dam. Like the first roll dam, it provides a pool that protects the limestone bedrock from erosion. The spillway is a gravity dam constructed of concrete, timber, and rock (**Figure 2-13**). The spillway length is 425 feet and the crest elevation is at 785.2 feet (1912 adjustment).



Figure 2-13. Main Spillway at Upper St. Anthony Falls

d. Hennepin Island Powerhouse. The Hennepin Island powerhouse is located on the left bank of the river approximately 600 feet downstream of the main spillway. It was constructed in 1908. Xcel Energy owns, maintains, and operates the Hennepin Island powerhouse under Federal Energy Regulatory Commission (FERC) License No. 2056.



Figure 2-14. Xcel Energy -USAF

Figure 2-14 shows the inlet to the power plant in the lower right hand corner of the photo. The power-house has five turbine generators. It is 133 feet long by 92 feet wide with a total height of 43 feet. The hydraulic capacity of the power-house is 4,025 cfs. It has an average annual output of 76,244 MWH.

e. **Hennepin Island Earth Dam.** The Hennepin Island earth dam is located on the left bank between the end of the horseshoe dam spillway and abandoned Wasteways No. 1 and 2. A concrete and limestone training wall is located along the upstream face and acts as a floodwall. The top of wall elevation is 805.1 feet (1912 adjustment).

f. **Wasteways No. 1 and No. 2.** Two wasteways were originally provided at Upper St. Anthony Falls for passing ice and debris. Xcel Energy has since abandoned these. Wasteway No. 1 was located between the main spillway and the Hennepin Island earth dam on the left bank (**Figure 2-10**). A non-overflow earth dam (crest elevation 802.2 feet) with a concrete core wall is located at the upstream end of the channel to prevent flow from the main spillway pool from entering the wasteway. Wasteway No. 2 was located on the left bank between the Hennepin Island earth dam and the University of Minnesota Hydraulics Laboratory. A non-overflow limestone masonry dam (crest elevation 805.0 feet) with reinforced concrete bulkheads and buttresses is located at the upstream end of the channel to prevent flow from the upper pool from entering the wasteway.

2-07. Real Estate Acquisition. In the St. Anthony Falls Pools, the US Government holds 12.46 acres in fee. The city of Minneapolis has furnished the US Government with 2.98 acres of easements in the pools.

2-08. Public Facilities. There are no public facilities at Lower St. Anthony Falls Lock. At Upper St. Anthony Falls Lock there are public restrooms (**Figure 2-15**) and an indoor viewing platform (**Figure 2-16**). There is also a Visitor Center added to the roof of the Central Control Building (**Figure 2-15)** that provides daily tours run by the National Park Service. These tours are provided during seasonal Visitor Center hours. The Visitor Center is named in honor of Morgan J. Tschida, a former Corps of Engineers employee killed in an unfortunate accident at Lower St. Anthony

Falls. Interpretive panels in the Visitor Center providing information on the Corps' efforts to save the Falls and the history of the area. From the observation deck, visitors can take in a panoramic view of St. Anthony Falls, the historic Stone Arch Bridge and the historic milling district.



Figure 2-15. USAF Restrooms and Central Control Station



Figure 2-16. USAF Visitors Center Looking Upstream at Third Ave

In addition to the facilities at the Upper Lock and Dam, there are several other facilities located throughout the upper pool. **Table 2-1** shows a list of the recreational facilities located in the Upper St. Anthony Falls Pool on the Mississippi River.

Table 2-1
Recreation Facilities in the Upper Pool

River Mile	Name	Manager	Parking	Camp Sites	Toilets	Picnic Tables
863.5L	Riverview Heights Park	City of Fridley	20	No	No	No
863.0R	River Park	Brooklyn Park	100	No	Yes	Yes
861.9L	Manomin Park	Anoka County	45	No	No	No
861.0L	Chase Island Park	MN Parks & Rec.	50	No	No	No
860.2R	Brooklyn Park Public Access	Brooklyn Park	10	No	Yes	Yes
859.3L	Riverfront Regional Park	Anoka County	80	No	Yes	Yes
857.8R	North Mississippi Park	Minneapolis	115	No	Yes	Yes
854.8L	Boom Island Park	Minneapolis	120	No	Yes	Yes

III – HISTORY OF PROJECT

3-01. Authorization. The Upper Mississippi River Nine-Foot Channel Project was authorized on 3 July 1930 when the 71st Congress, second session, passed an act that modified the existing six-foot channel project in accordance with the plan for a comprehensive project to procure a channel of nine-foot depth, submitted in House Document No. 290. The nine-foot channel was to be achieved by construction of a system of locks and dams, supplemented by dredging. The upper limit of the nine-foot channel was just downstream of St. Anthony Falls. In 1937, the Rivers and Harbors Act authorized the Upper Minneapolis Harbor Project, which extended the nine-foot navigation channel upstream by 4.6 miles. St. Anthony Falls was to be scaled by two locks. Construction included Lower St. Anthony Falls Lock and Dam and Upper St. Anthony Falls Lock.

3-02. Planning and Design. In 1849, Franklin Steele developed the first dam and millpond at St. Anthony Falls. The dam, built of timber and rock, extended only halfway across the river from the east bank and diverted water and logs to Steele's sawmill. In 1849, Steele registered the land on the east side of St. Anthony Falls as the town site of St. Anthony. In 1856, a dam was started from the west bank and angled upstream to join the original dam. This project resulted in raising the height of the falls to 48 feet and the configuration of the structure gave it the name of horseshoe dam. The dam divided flow into millponds on the east and west sides of the river. The Minneapolis Mill Company, representing west side owners, built a 945-foot canal that drew water from the new millpond to a series of powerhouses, and energy was produced until the mid 1950's. The St. Anthony Company, representing east side owners, relied on shafts and ropes running from water wheels on the dam to supply their mills. Eventually, the Minneapolis Mill Company surpassed the St. Anthony Company in the development of the manufacturing at the falls. **Figure 3-1** shows the progression of the falls upstream starting in 1680 and the location of the horseshoe dam and sawmills in 1876.

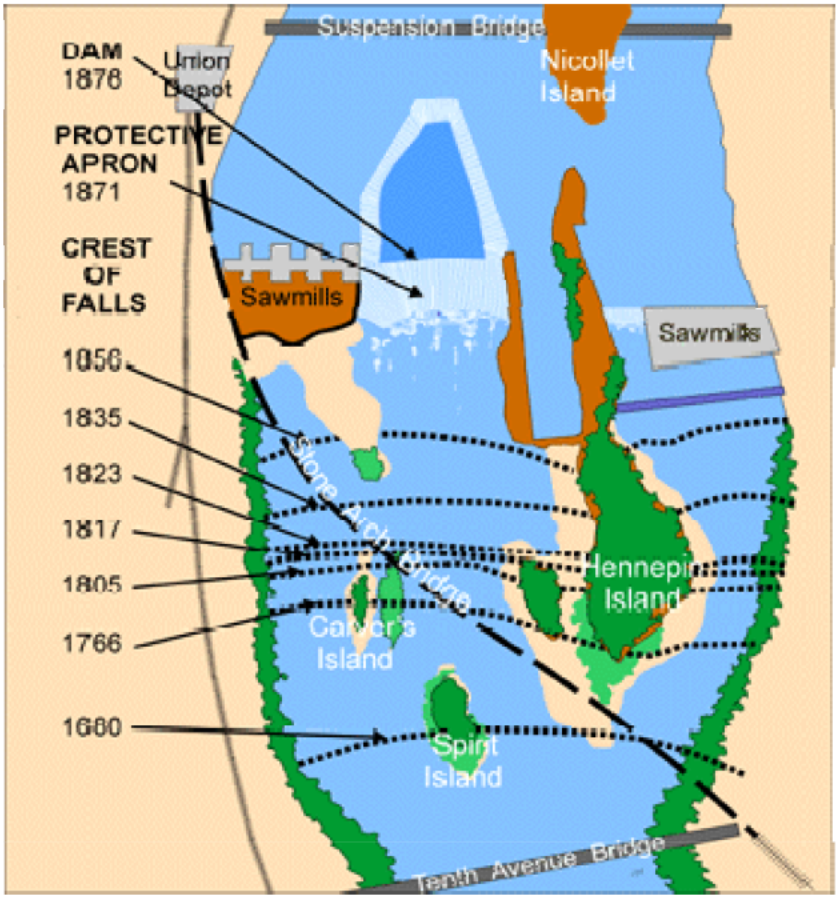


Figure 3-1. Progression of St. Anthony Falls and the Location of Sawmills

An event that occurred in 1869 nearly resulted in disaster for the St. Anthony Falls area. The owners of Nicollet Island, upstream of horseshoe dam, began the construction of a tunnel from Nicollet Island to Hennepin Island, which is below the horseshoe dam, to serve as a tailrace for mills located on Nicollet Island. When the tunnel had nearly reached its upper terminus, the overlying limestone layer collapsed, exposing the soft sandstone beneath. The current rapidly scoured out the 6-foot by 6-foot tunnel, enlarging its width to as much as 90 feet and increasing its depth to over 16 feet. As the roof of the tunnel fell in, Hennepin Island began to sink and the falls was in danger of collapsing. If the tunnel continued to expand, it would have destroyed all the power installations at the falls. A temporary dam was completed by the end of October 1869. Mill owners and citizens debated long-term solutions to repair the tunnel and save the falls.

In August 1870, the Corps of Engineers took over the tunnel repair project from the St. Anthony Company. A dam was constructed between the St. Anthony and Minneapolis millponds that extended from the upper limit of the limestone ledge to the falls. The dam was constructed of timber cribs loaded with stone and was intended to be a permanent wall around the upper breach of the tunnel. Despite these efforts, water continued to leak into the tunnel and in 1873, a flood destroyed a 150-foot wide section of the dam. After continued but unsuccessful efforts to save St. Anthony Falls, the Federal Government approved the construction of a concrete cutoff wall in 1874. The wall was completed in 1876. It extended 40 feet below the limestone ledge into the sandstone and traversed the entire width of the river near the lip of the falls. The project to save the falls also included two roll dams between the horseshoe dam and the falls to maintain a safe water level over the limestone and protecting works below the horseshoe dam. The first roll dam is located in the upper one-third of the horseshoe dam (**Figure 2-11**) and the second roll dam is the main spillway (**Figure 2-10**). These emergency additions continue to protect St. Anthony Falls today.

In 1890, there was no power generation in the vicinity of St. Anthony Falls (**Figure 3-2**). In 1895 the Main Street station, a combination steam-hydro plant, was erected at the east end of the horseshoe dam, and supplied practically all of the electricity for the street lighting system of the city of Minneapolis until 1911 when a fire gutted the station. Rebuilt, the plant is still in use as a substation and one of its three hydroelectric generators continued to produce electricity until the late 1960's. Also in 1895, the Lower Dam was constructed half a mile downstream from the falls. Built of large blocks of granite and limestone, the V-shaped dam impounded water for a 7,000 kilowatt power station, which generated electricity that drove the streetcars of the Twin City Rapid Transit Company. In 1903 that company added another still-standing structure to the St. Anthony waterfront; the Southeast steam generating plant with four steam units, each producing 3,500 kilowatts of electricity (**Figure 2-6**). In 1908 the Hennepin Island hydroelectric plant, the last to be built at the falls, was completed. Its foundations

were cut into the limestone of the riverbed, and penstocks piped water to four 2,250 kilowatt generators.



Figure 3-2. St. Anthony Falls - 1890

Water power at the falls had enabled the city of Minneapolis to become a leader in the flour and lumber industries. However, in the first decades of the 20th century, Minnesota was stripped of its timber, the milling industry shifted eastward, and the electrically operated streetcars were abandoned for motor buses. In 1923 Northern States Power Company (NSP) acquired the two companies that were the original developers of much of the industry in the St. Anthony Falls area, and the power company assumed responsibility for the dam, the falls, and the hydroelectric generators. In the early 1990's, New Century Energies merged with Northern States Power and became Xcel Energy. At present, the Hennepin Island plant is the only producer of electricity in the St. Anthony Falls area.

To plan the extension of the nine-foot channel above St. Anthony Falls, a complete topographical survey was made and a considerable number of borings were taken. A geological investigation of foundations at the locks and dam sites

and at the dredging areas was made. A thorough study of the hydraulic problem was made using a model of the river, depicting the area from the Washington Avenue terminal to the Hennepin Avenue Bridge. This model was constructed to a scale of 1 to 50 at the University of Minnesota's St. Anthony Falls Hydraulic Laboratory, which is located alongside the power plant on Hennepin Island. The following aspects of the project were investigated: hydraulic feasibility, most desirable location of the locks and dam, current conditions in the lock approaches and at three bridges, and backwater caused by the structures. The design of the sills and apron for the Lower Lock and Dam and the details of the filling and emptying systems for both the Upper and Lower Locks were also based on the results of model studies.

3-03. Construction. The total cost of the Minneapolis Upper Harbor Project that included the construction of the Upper and Lower St. Anthony Falls Locks and Lower Dam was approximately $31,749,000. This cost included alterations to several bridges within the pools (**Plate 2-4**). In the lower pool, center pier protection was provided for the Cedar Avenue and lower Northern Pacific Railway bridges. In the intermediate pool, one pier and two arch spans of the Great Northern Railways' historic Stone Arch Bridge were removed and replaced with a steel truss. In the upper pool, guard wall protection was provided at the Hennepin and Third Avenue bridges. The Broadway and Plymouth Avenue bridges were raised to allow the passage of river vessels. The Lowry Avenue Bridge was replaced with a new structure. Steel trusses to provide adequate clearance replaced one pier and two spans of the Great Northern Railway and the Northern Pacific Railway.

Other than bridge alterations, construction of the St. Anthony Falls Project can be divided into five main parts: (a) lower pool, (b) lower lock and dam, (c) intermediate pool, (d) upper lock, and (e) upper pool.

a. **Lower Pool.** While Lock and Dam No. 1 provided a nine-foot navigation channel, it did not extend to Lower St. Anthony Falls. Work in the lower pool consisted of dredging a 400-foot wide channel to a depth of 10 feet below the lowest controlled pool of Dam No. 1, elevation 722.8 feet (normal pool elevation 725.1 feet), from river mile 853.0 to the Lower Lock (river mile 853.4). Work began in 1948 and the dredge plan was completed in 1950.

b. **Lower Lock and Dam.** The original fixed crest lower dam was removed and in its place the lower lock and dam was constructed. The lower lock is a gravity type structure placed on bedrock on the right bank of the river. There is also an uncompleted auxiliary lock that can pass flow. The lower dam has a moveable gate section consisting of three tainter gates. To provide closure for the lower dam, a non-overflow structure placed on bedrock was constructed between the end of the moveable dam and the lower dam power station. The lower dam power station has since been removed and replaced with an earthen non-overflow dam. Construction on the lower lock and dam began in 1950 and was completed in 1956.

c. **Intermediate Pool.** Work on the intermediate pool consisted of dredging an approach channel between the upper and lower locks and the construction of a 700-foot long training wall to eliminate dangerous cross currents in the navigation channel. The intermediate pool was started in 1958 and was completed in 1960.

d. **Upper Lock.** The upper lock is a gravity type structure supported on a rock foundation. It was cut into a portion of the dam on what was known as Upton Island. Alterations to the horseshoe dam included raising section number 2 of the dam to elevation 801.0 feet (1912 adjustment) to provide upstream water depth at the lock and to reduce cross-currents in the upper lock approach. Construction on the upper lock began in 1959 and was completed in 1963.

e. Upper Pool. Work in the upper pool consisted of dredging low areas to provide a 150-foot wide, 9-foot deep navigation channel from the Upper Lock to river mile 857.6. A 500-foot by 1000-foot turning basin is provided at the upper end of the channel. Work on the upper pool started in 1961 and was completed in 1963.

3-04. Related Projects. Upper and Lower St. Anthony Falls Locks and Dams are one part of the 29 locks and dams on the Mississippi River necessary to maintain the nine-foot navigation channel between Minneapolis, Minnesota and St. Louis, Missouri. Thirteen of the 29 locks and dams are located in the St. Paul District. These include Upper and Lower St. Anthony Falls, as well as Lock and Dam Numbers 1 through 10.

3-05. Dam Safety History/Issues.

a. 1973 Modification. A tragic accident occurred at Lower St. Anthony Falls lock in 1973. Morgan J. Tschida, a worker at the lock and dam, was in a small boat on the upstream side of the lock chamber, when the upstream tainter valves were opened to fill the lock chamber. The initial phase of the filling operation causes a vortex to form such that at maximum head, the inlet grate of the filling ports can be seen. The death of the worker resulted in a change in the operating plan. The filling valve is now opened to the one-third point for ten minutes, and then opened completely thus eliminating the deadly vortex. The Visitor Center at Upper St. Anthony Falls was named after Morgan J. Tschida.

b. 1988 Modification. The Lower Dam Hydro Plant located on the left bank of the river at the lower dam (**Figure 2-6**) experienced an undermining failure in November 1987. Northern States Power removed the powerhouse in 1988 and replaced it with a non-overflow earth dam (**Figure 2-2**). The dam extends from the non-overflow concrete dam to the left bank. The downstream side slope is at 1V:10H for 150 feet and then continues at a two percent slope. As

originally constructed, it had a top elevation at about 752.0 feet (1912 adjustment); however, because the dam was frequently overtopped, it was raised to elevation 757.0 feet. All river discharge is now regulated through the moveable dam tainter gates until high flows necessitate the use of the lock tainter gates.

c. 2004 Modification. The normal pool band was previously elevation 750.0 ± 0.5 feet (1912 adjustment). Many gate changes were required to maintain this band and it was quite often violated. The pool level is constrained by Xcel Energy's draft tubes (elevation 748.6 feet) and the University of Minnesota's steam plant (top of wall elevation 752.3 feet). These are the only constraints within the intermediate pool. Therefore, the band was expanded to one-foot such that project pool is 750.0 ± 1.0 foot. It is expected that this will greatly reduce the number of gate movements necessary to maintain project pool. In addition, during flood situations, the pool is now allowed to rise to elevation 751.5 feet in an effort to postpone the opening of the lock tainter gate to pass flow. Gate operations now follow these rules: During normal flows, discharge is to be distributed equally through the three moveable gates. As discharge increases and the top of the pool band (elevation 751.0 feet) can no longer be held, the auxiliary lock tainter gate is to be opened and flow is to be distributed evenly across these four gates. When the three movable gates and the auxiliary tainter gate are all raised above the water, the pool is allowed to rise to elevation 751.5 feet. When the pool rises above elevation 751.5 feet, the lock tainter gate is to be opened and a pool band of 750.0 ± 1.0 foot is to be maintained.

d. Highway 35W Bridge Collapse. On 1 August 2007 at 1800-hours, the Interstate 35W Bridge collapsed during rush hour. Water Management requested an emergency deviation to lower the Intermediate Pool from 750.00 ft to 731.00 ft over a 12 hour time frame. Lowering the pool elevation was necessary to aid in dive recovery efforts.

3-06. Principal Regulation Problems.

a. Upper Lock Tainter Gate. To increase depths and reduce cross currents in the lock approach, a portion of the horseshoe dam was raised. This removed some of the flow capacity of the dam. The lock tainter gate was introduced to the design plan to replace the lost flow capacity. The plan called for the tainter gate to be opened when discharge in the river exceeded 40,000 cfs and the discretion of Water Management depending on forecasts. This discharge coincides with the closure of the lock to navigation, hence its selection. The use of the tainter gate during flood events introduces rock and debris into the lock chamber that results in deterioration of the lock floor and laterals as well as increases the possibility of damage to the miter gates. The design plan also called for the tainter gate to be used for skimming ice and floating debris from the upper approach as well as providing an emergency backup if the upper miter gates were damaged and could not be closed.

Historically, the gate has been used four times in the past to help pass flood flows in 1965, 1969, 1997 and most recently in 2001 (**Figure 3-3**). So far it has not been used to skim ice or debris as most ice and debris passes over the spillway. The minimal use, continued maintenance, and damage to the lock chamber caused by rock and debris has called into question the need for maintaining the existence of the upper lock tainter gate. Although not used very often, the continued maintenance and/or rehabilitation of the upper lock tainter gate is necessary to provide a means of helping discharge flood waters during extreme events. The loss of spillway capacity at the horseshoe dam as a result of the construction of the lock as well as the loss of discharge capacity of Wasteways No. 1 and 2 require that the lock be used to discharge a portion of the river flow during extreme flood events. Results of hydraulic modeling indicate for the FEMA 100-year flood event (total river discharge = 100,000 cfs), the base flood elevation would increase from 804.34 feet to 805.25 feet (MSL 1912) at Upper St. Anthony Falls, a difference of 0.9 feet.



Figure 3-3. Flow Beneath the Upper Lock Tainter Gate - 2001 Flood

Another reason for maintaining the tainter gate is for its use as an emergency backup gate in the event the upper miter gates fail. This is particularly important because of the intake structure for the City of Minneapolis water supply is located upstream of St. Anthony Falls. Loss of pool resulting from a gate failure could lower the water surface elevation below the water intake.

The crown elevation of the intake structure is 796.75 feet in MSL 1912 datum. Gage zero is elevation 710.75 feet MSL 1912 datum.

b. Higher Pool Elevations. The current operating plan at Lower St. Anthony Falls allows for a normal pool elevation of 750.0 ± 1.0 foot (1912 adjustment). The cement and wood surfaces of the back dock behind the upper guide wall have an elevation of 750.8 feet. Therefore, these surfaces may become intermittently wet causing the surfaces to become slippery. Should a high pool occur during the winter, icing of the surfaces may become a problem.

When flows are sufficient that the three movable gates and the auxiliary lock tainter gate are all raised above the water surface, the pool is allowed to rise to elevation 751.5 feet. This is the top elevation of the main lock tainter gate. Therefore, there is a possibility of wind blowing water over the top of the gate. While navigation with the pool at this elevation is unlikely, it should be pointed out that at a pool elevation 751.5 feet, there is only 30 feet – 5 inches of clearance at the entrance of the bridge span.

c. Frazil Ice. In 1951 frazil ice became a problem. Opening of the auxiliary gate to pass ice is now part of the standard operating procedure when frazil ice becomes a problem (see section **7-03b**). Fortunately it was discovered to be a problem before the lock system was complete. Above normal precipitation during the later part of October and early November had resulted in flow of about 19,000 cfs on 19 November. By 22 November the flow had decreased to 15,000 cfs and some surface ice was present in Pool No. 1. During the next few days below freezing temperatures (low -6ºF to high 24ºF) caused the formation of frazil ice, which anchored to the surface ice and created a solid barrier in much of the reach of the river above Lake Street Bridge. Ice extended to the river bottom in places and was up to 24 feet in depth. Temperatures remained below freezing until the morning of 28 November at which time the temperature rose to a high of 38ºF. At about noon, an ice jam

above St. Anthony Falls broke loose and released a wave into Pool No. 1. This resulted in high river stages from Upper St. Anthony Falls to Lock and Dam No. 1. On 25 November, Northern States Power transferred all possible steam plant loads from generating stations in St. Paul to the Riverside Station above St. Anthony Falls in an attempt to raise the water temperature above the ice jam. The City of Minneapolis diverted sewage flows into the river above the falls for the same reason. Outflows were reduced at the Headwater Reservoirs. While all this certainly had some impact, it was felt that the warm weather on 28 November was the major contributor to the reduction of the ice jam. As a result of ice completely inundating the lower lock's cofferdam, which was being constructed, the tailwater at St. Anthony Falls rose to a total of 25 feet above normal. Damages occurred at the University of Minnesota steam plant, the hydraulics laboratory, and at the Minneapolis Barge Terminal. It was determined there were five prerequisites for the formation of frazil ice: 1. High flows. 2. Water temperature at or below 35 ^{o}F. 3. Open river (i.e. no ice cover). 4. Sudden drop in temperature to 5 ^{o}F or lower to super chill the water. 5. Aeration of flow.

In 1971, the potential for a frazil ice problem was greater than that of 1951. Flows were nearly double that of 1951, which could cause considerably more frazil ice, provided that a sudden drop in temperature occurred while the river was still wide open. On 29 November 1971, Water Management was advised that the intermediate pool was icing up badly. Considerable amounts of slush ice and pan ice were passing over the horseshoe dam and were piling up in the intermediate pool. While the tainter gates of the moveable dam were submerged five feet, slush ice had jammed into the pool and no ice was passing through the gates. At 1100-hours that day, the tainter gate of the auxiliary lock was raised clear of the water surface. Slowly portions of the ice broke off and passed through the auxiliary gate. While ice problems continued to persist, ice continued to pass through the auxiliary gate. By 3 December,

running ice began to dissipate and the hydropower plat at USAF was at full capacity.

d. Floating Ice and Debris. When floating ice or debris becomes a problem at Upper St. Anthony Lock, it can be locked through if necessary. First the lock is filled and the upper miter gates are opened. Ice is then drawn into the lock chamber by cracking open the downstream tainter valves. The lock chamber is sealed, the lower tainter valves are opened and the lock chamber is drained. The lower miter gates are opened and the ice is coaxed out of the chamber by opening the upstream tainter valves. At Lower St. Anthony, ice and debris is typically passed over a submerged tainter gate in the moveable dam; however, if necessary, the lock can be used in similar fashion as the upper lock.

e. Outdraft. An outdraft problem exists at both the Upper and Lower St. Anthony Falls Locks for down-bound as well as up-bound tows. Signs are located at the end of the upper and lower guide walls to warn of outdraft when flows are above 20,000 cfs. The signs are circular, about three feet in diameter, and are orange in color. They are permanently mounted on a hinge, thereby allowing them to be swung out into view when necessary. An orange light is tuned on to draw attention when the signs are put into service.

f. Zebra Mussels. Xcel Energy's FERC license was issued on 8 March 2004. Article 406 of the license requires Xcel Energy to file a plan with the FERC Commission to manage the spread of zebra mussels at St. Anthony Falls Project to protect water quality in the Mississippi River. The plan is to include consideration of the timing of hot water releases to avoid potential effects on fisheries during periods when water temperatures may be high. Also, Xcel Energy is to ensure, prior to the disposal of any removed pipes or strainers, that all attached zebra mussels are dead. The plan is to be prepared in consultation with the Minnesota Department of Natural Resources and the US Fish and Wildlife Service.

Presently, infestations of zebra mussels are not having significant impacts on operations at the St. Anthony Falls Locks. Dewatering of Lower St. Anthony's Lock in 2002-2003 and Upper St. Anthony's Lock in 2004-2005 showed only a handful of Zebra Mussels at each site.

Zebra Mussels however, are present at all St. Paul District locks and dams. It is possible that they may foul the gage wells, concrete surfaces, and untreated metal surfaces such as the lock miter gates. Masses of dead zebra mussels could accumulate in the gate recesses, hindering operation. The St. Paul District developed a "Zebra Mussel Response Plan" in November 1997. The following tables show the possible problems and the recommended control techniques.

Table 3-1
Zebra Mussel Control Techniques

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

Table 3-2 Proposed Zebra Mussel Control Techniques for Locks and Dams		
Component	**Potential Problem**	**Method**
Lock Walls	Heavy encrustations can be expected. Structural damage limited to abrasion during cleaning.	A,D
Gages	Occlusion of the pipe leading from the well to the river. Encrustation of level markings.	A,B,C,D
Thermometers	Encrustations could reduce reliability of readings.	A
Miter Gates	Increased corrosion of metal surface, paint deterioration, and unbalanced loading.	A,D
Bulkhead Slots	Accumulation along the sealing surfaces.	A,D
Lock Culverts	Reduced flow area and increased roughness could cause increased emptying and filling times.	A,D
Roller Gates	Increased gate weight and corrosion.	A,D
Side Seals	Accelerated deterioration of seals.	A,D,C,E
Tracks, Chains, Cables	Accumulation could prevent movement of roller gates. Metal and paint deterioration.	A,D

3-07. Modification to Regulations

a. Lower St. Anthony Falls Hydropower Project. Brookfield Renewable Electric and Nelson Energy installed hydropower within the auxiliary lock chamber at LSAF. StraflowMatrix combined turbine/generator units were installed and work well in low head conditions. This replaced the NSP power house that had a foundation failure in 1987. The I-35W Bridge collapsed during preparation, causing a project delay of approximately two years. There were construction delays due to equipment availability and performance. The hydropower facility started commercial operation on 7

December 2011. Operation was adapted to meet hydropower demands and maintain the primary purpose of the project.

b. Upper St. Anthony Falls Lock Closure. On 10 June 2015, The Upper St. Anthony Falls Lock closed. The lock was used to transport barges carrying material upstream. The Water Resources Reform and Development Act of 2014 called for the lock's closing due to continued decline of commercial barge traffic. In addition, St. Anthony falls provides a barrier to prevent invasive species from migrating upstream. The U.S. Army Corps of Engineers continues to maintain the lock for flood control. As a direct result modification to the operation of the main flood gate within the lock chamber had to be adapted to meet project maintenance requirements.

c. Expanded Hydropower operations. In 2019 Brookfield Energy, the operator of the hydropower facility within the auxiliary lock chamber of Lower St. Anthony Falls, requested to expand the operating limit of their facility. Before this expansion hydropower production was halted when flow conditions rose above 32,000 cfs. This threshold was expanded to 38,000 cfs in 2021 and adopted into the regulation plan. The current operation plan for Lower St. Anthony Falls is outlined in **7-4 b.**

IV – WATERSHED CHARACTERISTICS

4-01. General Characteristics. The intermediate pool at St. Anthony Falls has a total surface area of 50 acres at project pool elevation of 750.0 feet (1912 adjustment). The upper pool has a total surface area of 358 acres at project pool elevation 799.2 feet. The upstream limit of Nine-Foot Channel Project is at river mile 857.6. The Coon Rapids Dam at river mile 866.2 requires a portage to continue navigation. The drainage area above St. Anthony Falls Pools totals 19,680 square miles. There are no major tributaries that flow into the St. Anthony Falls pools.

4-02. Topography. Topography for the St. Anthony Fall's pools watershed consists of a large amount of paved surface area. Heavy rainfall events can make a substantial increase in short term flows and flash flood scenarios. There are three major storm sewer inlets above Upper St. Anthony and two between Upper and Lower St. Anthony including Bassett Creek.

4-03. Geology and Soils. St. Anthony Falls was formed by the jutting edge of a hard layer of limestone, 10 to 13 feet in thickness, overlying a bed of soft sandstone. In prehistoric time, the falls was located near the junction of the Mississippi and Minnesota Rivers, about eight miles downstream from its present site. Through the years, as sections of the protecting limestone layer broke off, the falls gradually receded (**Figure 3-1**). If this natural process had continued upstream another 300 yards, the upper end of the limestone shelf would have been reached and the falls would have disappeared. Twelve miles upstream of the falls is the next major change in water surface elevation at the Coon Rapids Dam. For more information on the topography of the Upper Mississippi River basin, see the Master Water Control Manual for the Locks and Dams.

4-04. Sediment. Routine dredging of sediment is part of the nine-foot navigation plan. There are several sites in the upper pool that have required 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 4-1** gives a summary of dredging in the upper pool and in the lower lock approach at St. Anthony Falls (Pool No. 1) since 1970. After the closure of the upper lock at SAF MVP dredging funds were diverted to higher priority reaches of the navigation channel. Since 2014 no additional dredging activities have taken place within the SAF pools.

Table 4-1
Summary of Dredging Activity – 1970 through 2014

Cut Name	River Mile	Avg. Vol. Per Year	Avg. Vol. Per Job	Freq. of Dredging	Last Year Dredged
Minneapolis Turning Basin	856.8-857.6	13,626	29,029	47 %	2012
Above Lowry Ave Bridge	856.4-856.8	18,229	33,082	55 %	2014
Below Lowry Ave Bridge	856.0-856.4	181	8,871	2 %	1992
Broadway Ave Bridge	855.3-856.1	3,706	13,451	28 %	2011
Above Plymouth Ave Bridge	854.8-855.3	5,501	21562	26 %	2011
Lower Approach LSAF	853.3-853.4	161	830	19 %	2014

4-05. Climate. The National Weather Service maintains temperature and precipitation records for Lower St. Anthony Falls Lock and Dam. Temperature and precipitation data shown in **Tables 4-2** and **4-3** were taken from National Oceanic and Atmospheric Administration's Online Weather Data for Minneapolis-St. Paul area.

Table 4-2
30-Year Normal Monthly Temperature - ºF (1991 to 2020)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
16.2	20.6	33.3	47.1	59.5	69.7	74.3	71.8	63.5	49.5	34.8	22.0	46.9

Table 4-3
30-Year Normal Monthly Precipitation – Inches (1991 to 2020)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
0.89	0.87	1.68	2.91	3.91	4.58	4.06	4.34	3.02	2.58	1.61	1.17	31.62

Pan evaporation data was collected at Lock and Dam No. 6, but stopped after 1997. Pool evaporation was estimated by assuming a pan coefficient of 0.7.

Table 4-4
Pan and Pool Monthly Evaporation in Inches (Lock and Dam No. 6)

	Apr	May	Jun	Jul	Aug	Sep	Oct	Period of Record
Pan Evaporation	0.26	3.35	3.92	5.15	4.66	2.88	0.65	(1983 – 1997)
Pool Evaporation	0.18	2.35	2.74	3.61	3.26	2.02	0.46	(1983 – 1997)

While wind may not have any significant impact on the intermediate pool, it definitely impacts pool levels at USAF. 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". While it is recognized that this phenomenon occurs, it is not accounted for in the regulation of the upper or intermediate pool. As for the intermediate pool, the short fetch length limits any wind setup. In the upper pool, trigger elevations are not adjusted for wind. During low flows, Xcel Energy is to maintain project pool of 799.2 feet (1912

adjustment) regardless of wind influence. During moderate to high flows, wind influence is of no importance to regulation.

4-06. Storms and Floods. The steep bluffs and high bank lines minimize damages in the upper pool during high flows. After construction of the Lower Lock and Dam (1956) and the Upper Lock (1963), the first significant flood event occurred in the spring of 1965. **Table 4-5** gives a summary of peak elevations and discharges followed by a brief description of some of the larger events. The Corps, in cooperation with the US Geological Survey, has a Data Collection Platform (DCP) at Anoka, Minnesota (ANKM5), river mile 864.8.

Table 4-5
Summary of Peak Stages/Elevations and Discharges

Anoka, MN (ANKM5)			**St. Anthony Falls Locks and Dams**				
Date	Stage ft	Elev. ft (NAVD88)	Date	Upper Pool ft (1912)	Intermediate Pool ft (1912)	Lower Tailwater ft (1912)	Discharge cfs
17-Apr-1965	**19.53**	**824.27**	**17-Apr-1965**	**803.43**	**751.42**	**739.02**	**91,000**
14-Apr-1969	16.84	821.58	14-Apr-1969	802.50	750.40	737.46	72,000
9-Apr-1997	16.44	821.18	10-Apr-1997	803.20	750.30	737.90	69,000
15-Apr-2001	15.77	820.51	16-Apr-2001	802.55	750.56	736.95	65,800
31-Mar-2019	13.15	817.89	31-Mar-2019	802.36	750.36	734.50	51,800
23-Jun-2014	12.72	817.46	23-Jun-2014	799.9	750.12	733.92	49,000
06-Apr 2020	11.87	816.59	06-Apr-2020	801.78	750.02	733.58	44,600
27-Apr-2018	10.40	815.14	27-Apr-2018	801.82	750.06	731.15	36,000

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 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 the following stages with normal precipitation and a snowmelt of more than three days:

Table 4-6
USACE Forecast for April – May 1965

Station	River	Flood Stage	Forecast	Spring 1952
Aitkin, MN	Mississippi	12.0 ft	13.0 ft	14.7 ft
Ft. Ripley, MN	Mississippi	10.0 ft	12.0 ft	12.2 ft
Minneapolis, MN	Mississippi	16.0 ft	16.0 ft	19.5 ft
Rockford, MN	Crow	10.0 ft	16.5 ft	16.2 ft
St. Francis, MN	Rum	8.0 ft	12.0 ft	11.0 ft

The forecast cautioned that if rainfall of one inch should occur before or during the crest, the resulting peak stages would be near the 1952 level. The St. Paul District began preparations for the flood emergency. At the Upper Lock and Dam, the non-overflow section of the dam and the upstream earth fill were sandbagged. At the Lower Lock and Dam, sandbags were placed to protect the esplanade. Almost four inches of rain fell in the first two weeks of April. The National Weather Service revised the forecast as follows:

Table 4-7
NWS Forecast for April – May 1965

Station	River	Flood Stage	Forecast	Spring 1952
Aitkin, MN	Mississippi	12.0 ft	14.5 ft	14.7 ft
Ft. Ripley, MN	Mississippi	10.0 ft	15.0 ft	12.2 ft
Minneapolis, MN	Mississippi	16.0 ft	21.0 ft	19.5 ft
Rockford, MN	Crow	10.0 ft	18.0 ft	16.2 ft
St. Francis, MN	Rum	8.0 ft	13.0 ft	11.0 ft

The rapid increase of inflow began on the 7th of April when the discharge rose from 5,000 cfs on this date to a peak of 91,000 cfs on the 17th of April. On the 12th of April, it became necessary to open the lock tainter gates at Upper and Lower St. Anthony to aid in discharging the flood flows, thereby halting all navigation until the 3rd of May. By April 15th, all tainter gates at the Lower

Lock and Dam had been raised to the maximum openings, and no reduction in those settings were possible until the 21st of April for the gates at the dam, the 22nd of April for the auxiliary lock gate, and the 23rd of April for the main lock gate. The upper pool at St. Anthony Falls crested on the 17th of April at elevation 803.43 feet (1912 adjustment) with a peak flow of 91,000 cfs. At peak flow, it was estimated that 12,000 cfs passed through the upper lock. The intermediate pool crested on the 17th of April at elevation 751.42 feet, and the tailwater crested at elevation 739.02 feet (1912 adjustment). Although the peak flow was 30 percent greater than the design flood, there was no damage to the project. The Mississippi River near Anoka (ANKM5) peaked on the 17th of April at elevation 824.27 feet (NAVD 88), 2.0 feet higher than the 1952 flood.

Both the Sauk River and Elk River reached the highest discharge in recorded history. The Sauk River at St. Cloud peaked with a discharge of 9,100 cfs and the Elk River near Big Lake peaked at 7,300 cfs. Severe flooding occurred along the Crow River from Cosmos, Minnesota on the South Fork to the confluence with the North Fork and along the entire main stem. At Hutchinson, Minnesota, the South Fork Crow River crested on the 11th of April, 4.0 feet above flood stage and 1.3 feet higher than the 1952 flood. At Watertown, Minnesota, the South Fork Crow River crested on the 13th of April, 4.5 feet above flood stage and 3.5 feet higher than the 1952 flood. At Delano, Minnesota, the South Fork Crow River crested on the 13th of April at 10.4 feet above flood stage, 3.0 feet higher than the 1952 flood. At Rockford, Minnesota, the main stem of the Crow River crested on the 16th of April at 9.3 feet above flood stage, 3.0 feet higher than the 1952 flood. The peak discharge was 22,400 cfs. Flooding in the Rum River was caused mainly by the melting of deep snow cover combined with over an inch of rainfall. Flow in the Rum River at St. Francis increased from 500 cfs on the 11th of April to a peak discharge of 10,100 cfs on the 20th of April. The maximum stage at St. Francis exceeded the flood stage by 3.6 feet.

b. April 1969. The flood of 1969 can be attributed primarily to an exceptionally heavy blanket of snow, which accumulated during December 1968 through February 1969. Very intense flooding occurred on the Crow River. Throughout most of the basin, the second highest flood of record occurred. At Rockford the peak discharge was 15,100 cfs as compared to 22,400 cfs in 1965. On the Rum River, the peak discharge of 10,100 cfs at St. Francis was the same as the flood of 1965. The combined influence of these tributaries plus the significant floods in the main stem above St. Cloud caused the Mississippi River to exceed the 50-year flood downstream of Anoka. At the gaging station downstream of Anoka, a discharge of 72,500 cfs was recorded. Minneapolis was fortunate in that there is little low-lying area along the river's bank, and as a consequence, the city never suffered severe flood losses. The peak pool elevation occurred on 15 April at elevation 733.02 feet (1912 adjustment) and a discharge of 72,000 cfs.

c. 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 the river would reach elevation of 839.21 feet (NAVD88) at Anoka wastewater treatment plant (AKAM5). On the 9th of April it crested at elevation 840.5 feet, 2.5 feet above flood stage. Also on the 9th of April, the Mississippi River near Anoka (ANKM5) crested at elevation 821.18 feet (NAVD88). The Mississippi River at the Minneapolis Water Works located at river mile 858.6 crested on 11 April at a stage of 17.1 (flood stage 16.0 feet). The upper pool at St. Anthony Falls crested on the 10th of April at elevation 803.20 feet (1912 adjustment). Peak discharge was 69,000 cfs. The intermediate pool at St. Anthony Falls crested at elevation 750.30 feet and the tailwater crested at elevation 737.90 feet (1912 adjustment). Both the Upper and Lower Locks were out of operation for 15 days from the 4th to the 19th of April.

d. April 2001. The National Weather Service's 2001 Spring Snowmelt Flood Outlook predicted minor to moderate flooding for St. Anthony Falls. 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 high flood stages in both the upper and intermediate pools and St. Anthony Falls. On the 11th of April at 0945-hours, Upper St. Anthony Falls' lock was opened to pass flow. This was followed by Lower St. Anthony Falls' when on the 12th of April the lock was opened to pass flow. On the 15th of April, the stage at Anoka (ANKM5) peaked at 15.77 feet (elevation 820.51 NAVD88) with a discharge of 65,600 cfs. On the 15th of April, the upper pool at St. Anthony Falls peaked at elevation 802.55 feet (1912 adjustment) with a discharge of 65,800 cfs. The intermediate pool at St. Anthony Falls crested at elevation 750.56 feet and the tailwater crested at elevation 736.95 feet. Due to additional rainfall, a second, lower crest occurred between the 27th and 29th of April, resulting in a peak of 802.17 feet at the upper pool, 750.62 feet at the intermediate pool, and 737.77 feet at the lower dam tailwater. The lower lock's gate was closed to flow on 3 May. The upper lock followed the next day. The Coast Guard closed the river to navigation from the 9th of April to the 9th of May. The Upper and Lower Locks did not reopen to navigation until the 11th of May.

4-07. Runoff Characteristics. The US Geological Survey, in cooperation with the Corps of Engineers, maintains a continuous record of stage and discharge for the gage located near Anoka (ANKM5). While discharge is computed at Lower St. Anthony Falls, the Brooklyn Park gage provides a much longer period of record. The mean annual discharge at the gage near Anoka is 8,306 cfs, based on a period of record from 1990 to 2020. The following table shows the monthly average discharges.

Table 4-8 Monthly Average Flow at USGS Gage No. 05288500 Mississippi River at Hwy 610 in Brooklyn Park, MN (Years 1990 to 2020)											
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
5,060	4,640	7,020	16,800	15,800	11,900	10,200	6,390	5,790	7,310	8,420	6,340

A maximum discharge of 91,000 cfs occurred on 17 April 1965 (**Table 4-5**). The lowest discharge recorded at Anoka (ANKM5) during navigation season was 529 cfs on 29 August 1976. It should be pointed out that this was due in part to regulation at the Coon Rapids Dam. A discharge-frequency curve for the Mississippi River near Anoka is shown on **Figure 8-1**.

Construction of the lock and dam greatly influenced stage-duration curves throughout the pool. Based on a period of record from 1988 to 2018, the following three elevation-duration tables were developed: (1) Lower St. Anthony Falls' tailwater (2) Intermediate Pool, and (3) Upper Pool. The tables indicate the percent of time the water surface is at or above the indicated elevation (1912 adjustment).

Table 4-9
Elevation-Duration, St. Anthony Falls Intermediate Pool
Percent of Time at or Above Indicated Elevation (Years 1990 to 2020)

Percent	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0.1	750.77	750.91	750.96	751.01	751	750.92	750.86	751.03	750.86	751.02	751.06	750.99
0.2	750.64	750.84	750.86	750.91	750.89	750.81	750.83	750.9	750.85	750.9	750.9	750.77
0.5	750.52	750.77	750.76	750.72	750.78	750.78	750.8	750.82	750.79	750.8	750.75	750.64
1	750.5	750.61	750.69	750.7	750.67	750.68	750.73	750.77	750.73	750.72	750.69	750.59
2	750.44	750.5	750.61	750.65	750.59	750.62	750.66	750.7	750.65	750.65	750.61	750.51
5	750.26	750.37	750.52	750.54	750.5	750.52	750.55	750.56	750.53	750.58	750.5	750.45
10	750.08	750.24	750.48	750.5	750.49	750.5	750.5	750.5	750.5	750.5	750.49	750.28
15	750	750.1	750.4	750.4	750.41	750.44	750.43	750.44	750.46	750.48	750.4	750.17
20	749.89	750	750.33	750.33	750.33	750.36	750.36	750.38	750.39	750.41	750.35	750.06
30	749.61	749.75	750.24	750.25	750.24	750.26	750.25	750.29	750.3	750.32	750.25	749.84
40	749.5	749.55	750.13	750.17	750.17	750.2	750.17	750.2	750.23	750.25	750.17	749.6
50	749.4	749.43	750.02	750.08	750.08	750.12	750.09	750.13	750.15	750.16	750.05	749.47
60	749.31	749.31	749.9	750	750	750.02	750	750.03	750.07	750.06	750	749.34
70	749.25	749.21	749.72	749.94	749.95	750	749.95	749.98	750	750	749.88	749.25
80	749.15	749.12	749.43	749.85	749.84	749.89	749.85	749.85	749.9	749.9	749.74	749.15
85	749.1	749.06	749.28	749.75	749.77	749.84	749.77	749.78	749.84	749.83	749.6	749.09
90	749	749	749.12	749.65	749.71	749.75	749.71	749.72	749.76	749.75	749.4	749
95	748.92	748.91	749	749.52	749.61	749.62	749.62	749.58	749.68	749.6	749.15	748.92
98	748.85	748.81	748.88	749.37	749.49	749.50	749.5	749.42	749.55	749.29	748.97	748.58
99	748.8	748.74	748.8	749.24	749.36	749.47	749.43	749.36	749.49	748.91	748.91	748.13
99.5	748.77	742.9	748.72	749.06	749.3	749.44	749.36	749.12	749.44	742.31	748.58	745.09
99.8	748.4	737	740.27	747.67	749.2	749.2	749.25	748.29	748.09	737.8	746.02	745
99.9	747.62	747.76	738.04	748.83	749.10	748.93	749.32	747.46	749.31	748.55	743.46	744.91

Table 4-10
Elevation-Duration, Lower St. Anthony Falls Tailwater
Percent of Time at or Above Indicated Elevation (Years 1990 to 2020)

Percent	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0.1	737.43	728.55	734.32	737.14	737.33	734.44	732.31	728.68	728.24	731.24	740.12	734.69
0.2	729.63	728.28	734.15	736.97	735.49	734.08	731.71	728.64	729.15	731.89	735.75	733.05
0.5	728.33	728.06	733.55	736.78	733.67	733.72	731.11	728.47	729.03	731.8	731.83	731.28
1	728.22	727.58	732.22	736.57	732.86	733.33	730.74	728.24	728.57	731.61	730.1	730.21
2	727.95	727.39	731.01	735.7	732.52	732.51	730.5	727.9	727.81	730.93	728.68	729.19
5	727.11	726.9	729.39	733.08	731.53	731.56	729.86	727.4	727.28	728.81	727.85	727.77
10	726.38	726.31	727.77	731.58	730.39	729.7	728.71	726.99	726.94	727.73	727.09	726.88
15	726.15	726.02	727.27	730.48	729.79	728.67	728.29	726.75	726.7	727.13	726.82	726.47
20	726	725.86	726.97	729.46	729.42	728.21	727.78	726.56	726.52	726.8	726.65	726.31
30	725.73	725.67	726.48	728.53	728.5	727.63	727.09	726.23	726.2	726.43	726.43	726.02
40	725.59	725.56	726.13	727.88	727.74	727.11	726.71	725.88	725.95	726.02	726.23	725.76
50	725.44	725.42	725.83	727.37	727.25	726.65	726.31	725.67	725.62	725.77	725.99	725.58
60	725.23	725.26	725.64	726.99	726.91	726.38	726	725.47	725.44	725.58	725.72	725.4
70	724.96	724.95	725.47	726.67	726.62	726.13	725.74	725.22	725.18	725.33	725.56	725.22
80	724.54	724.25	725.22	726.18	726.3	725.8	725.32	724.95	724.94	725.01	725.3	724.99
85	724.13	723.91	725.02	725.97	726.1	725.55	725.05	724.75	724.78	724.86	725.18	724.87
90	723.58	723.37	724.46	725.73	725.81	725.30	724.81	724.54	724.53	724.69	725.0	724.68
95	723.03	723.03	723.33	725.48	725.56	724.76	724.50	723.72	724.07	724.37	724.80	724.36
98	722.8	722.81	722.87	724.74	725.15	723.98	724.11	722.84	723.25	723.38	724.55	723.82
99	722.69	722.65	722.76	724.16	724.77	723.66	723.92	722.14	723.07	723.1	724.15	723.36
99.5	722.61	722.51	722.6	723.56	724.49	723.57	723.69	721.38	722.9	722.49	723.72	723.03
99.8	722.53	722.39	722.48	721.94	724.26	723.24	723.62	721	722.84	722.29	723.5	722.84
99.9	722.51	722.28	722.3	720.49	724.08	722	722.83	720.59	722.81	722.09	722.35	722.3

Table 4-11
Elevation-Duration, St. Anthony Falls Upper Pool
Percent of Time at or Above Indicated Elevation (Years 1990 to 2020)

Percent	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0.1	801.61	801.08	802.54	802.95	802.28	802.50	803.82	801.80	801.12	801.73	801.32	802.60
0.2	800.17	800.78	802.31	803.00	802.27	802.34	802.00	800.59	800.84	801.63	800.61	800.13
0.5	799.83	800.53	802.06	802.80	802.26	802.23	801.94	800.55	800.69	801.55	800.49	800.10
1	799.62	799.91	801.84	802.45	802.21	802.14	801.80	800.49	800.59	801.29	800.44	800.04
2	799.53	799.55	801.42	802.20	802.10	801.89	801.65	800.32	800.36	801.08	800.36	799.90
5	799.46	799.41	800.90	801.85	801.72	801.56	801.30	800.17	800.16	800.72	800.24	799.78
10	799.39	799.33	800.42	801.52	801.42	801.18	800.55	800.00	799.92	800.44	800.10	799.65
15	799.34	799.27	800.04	801.29	801.07	800.92	800.32	799.77	799.76	800.17	800.00	799.57
20	799.28	799.19	799.87	801.15	800.90	800.78	800.18	799.44	799.58	799.98	799.90	799.48
30	799.12	799.07	799.52	800.92	800.67	800.39	799.94	799.19	799.33	799.75	799.76	799.35
40	799.05	798.93	799.35	800.62	800.43	799.99	799.63	799.04	799.17	799.58	799.61	799.22
50	798.96	798.84	799.18	800.40	800.18	799.66	799.40	798.95	799.02	799.41	799.48	799.13
60	798.78	798.71	798.97	800.03	799.87	799.29	799.17	798.82	798.92	799.23	799.30	798.96
70	798.68	798.57	798.80	799.75	799.59	799.06	798.90	798.61	798.82	799.01	799.13	798.83
80	798.51	798.44	798.61	799.22	799.24	798.74	798.62	798.32	798.64	798.86	798.93	798.62
85	798.42	798.36	798.48	799.04	799.03	798.57	798.43	798.19	798.42	798.78	798.84	798.53
90	798.20	798.24	798.36	798.72	798.69	798.43	798.32	798.00	797.98	798.63	798.73	798.39
95	797.66	797.49	798.09	798.46	798.46	798.07	797.84	797.66	797.42	797.86	797.85	797.73
98	797.40	797.31	797.62	798.14	798.22	797.67	797.29	797.36	797.29	797.39	797.43	797.43
99	797.36	797.28	797.36	798.05	798.04	797.59	797.25	797.22	797.23	797.32	797.39	797.36
99.5	797.33	797.27	797.34	797.93	797.99	797.54	797.23	797.10	797.21	797.29	797.36	797.31
99.8	793.55	797.24	797.29	797.87	797.89	797.40	797.16	794.03	794.53	796.94	797.27	797.25
99.9	797.29	797.26	797.51	797.68	798.02	798.14	797.90	797.02	797.11	796.82	797.63	797.13

4-08. Water Quality. The Minnesota Pollution Control Agency (MPCA) and the Metropolitan Council Environmental Services Division (MCES) monitor water quality in the Upper Mississippi River. The MPCA periodically reports to Congress under Section 305(b) of the Clean Water Act. Their *Assessment of Stream Water Quality* was a part of the report in 2002. The assessment included a reach of the Mississippi River that extended from the Coon Rapids Dam (river mile 866.2) downstream to Upper St. Anthony Falls (river mile 854.0). Aquatic life, swimming, oxygen depletion, turbidity, non-ionized ammonia, bacteria were "fully supported" indicating that was not a significant problem in these areas. Total phosphorous, nitrite/nitrate, oxygen demand (BOD), and suspended solids were "fully supported but threatened" indicating a concern for these factors.

The St. Paul District does not collect water quality information for the Upper or Intermediate Pools of St. Anthony Falls Locks and Dams; however, the US Geological Survey (USGS) maintained a Water Quality Station at the Anoka gage site intermittently. For more information on this go to **Section 5-02. Water Quality Stations**.

4-09. Channel and Floodway Characteristics. The top of the lower lock sill at Upper St. Anthony Falls (USAF) is elevation 736.3 feet (1912 adjustment) and the top of the upper lock sill at Lower St. Anthony Falls (LSAF) is elevation 736.3 feet. Therefore, there is no drop in sill elevation along the intermediate pool, which has a length of 0.7 miles. The top of the lower lock sill at LSAF is elevation 712.8 feet and the top of the upper lock sill at Lock and Dam No. 1 is elevation 709.7 feet. Therefore, there is a 3.1-foot drop in sill elevation along the lower pool, which has a length of 5.8 miles as measured along the navigation channel. The navigation channel is 400 feet in width in the approach to the lower dam. In the intermediate and upper pools, the navigation channel is approximately 150 feet in width. There is a 500-foot by 100-foot turning basin at end of the nine-foot channel at river mile 857.6. The line of navigation is shown on **Plate 2-8.**

4-10. Upstream Structures. Upper St. Anthony Falls Lock is the most upstream structure in the St. Paul District Nine-Foot Navigation Project on the Mississippi River. Coon Rapids Dam is located 12 miles upstream of Upper St. Anthony Falls at River Mile 866.1. The drainage area above the dam is approximately 19,100 square miles. The dam is part of the Coon Rapids Dam Regional Park, which is operated by Hennepin Parks for recreational purposes. The 1,000-foot long dam spans the Mississippi River between the cities of Brooklyn Park and Anoka.

4-11. Downstream Structures. Lock and Dam No. 1 is located 5.8 miles downstream of Lower St. Anthony Falls Lock and Dam. The drainage area above Lock 1 is 19,684 square miles. The lock and Dam system continues downstream to Lock and Dam No. 27 in St. Louis, Missouri; however, St. Paul District terminates with Lock No. 10.

4-12. Economic Data. Both the intermediate pool and upper pool lie completely within Hennepin County in Minnesota. Based on the US Census Bureau, county populations have increased.

Table 4-12
County and City Populations Near St. Anthony Falls Pools

	2010	2019	Difference	Change
County				
Hennepin, MN	1,152,385	1,265,843	113,458	9.8%
City				
Minneapolis, MN	382,578	429,606	47,028	12.3%

The following table gives a break down of the employment by industry. The data were taken from the US Census Bureau's 2012 Industry Report.

Table 4-13
Employment by Industry (2012 Economic Census)

Industry	Hennepin County
Manufacturing	72,307
Wholesale Trade	36,257
Retail Trade	74,958
Real Estate, Rental, Leasing	17,614
Professional, Scientific, Tech Services	74,416
Admin & Support, Waste Management	79,747
Education Services	5,005
Health Care & Social Services	128,451
Arts, Entertainment & Recreation	12,947
Accommodations & Food Services	66,296
Other Services	22,081
Total	590,079

V - DATA COLLECTION AND COMMUNICATION NETWORKS

5-01. Hydrometeorological Stations.

a. Facilities. The Corps of Engineers is required to maintain pool and tailwater elevations at all lock and dam projects. Lower St. Anthony Falls (LSAF) pool and tailwater gages are located in concrete gage houses on the upper and lower guide walls (**Figures 5-1** and **5-2**). The gages are stilling wells that feed their information back to the Central Control Station (CCS) where it is recorded on a PAV-C Strip Chart (**Figure 5-4**). Because the intermediate pool is so short, LSAF's pool gage serves as the tailwater gage for Upper St. Anthony Falls (USAF). At USAF, both Xcel Energy and the Corps of Engineers have pool gages. The Corps' gage is a stilling well located beneath a trap door in the guide wall (**Figure 5-3**). Like LSAF, information is sent back to the CCS where it is recorded on a PAV-C Strip Chart (**Figures 5-4** and **5-5**). Xcel Energy's pool gage is also a stilling well. It is located at their Riverside Power Plant (river mile 857.0). All the gages have a staff gage in the well to verify the gage reading.



Figure 5-1. Lower Lock and Dam Pool Gage.



Figure 5-2. Lower Lock and Dam Tailwater Gage.

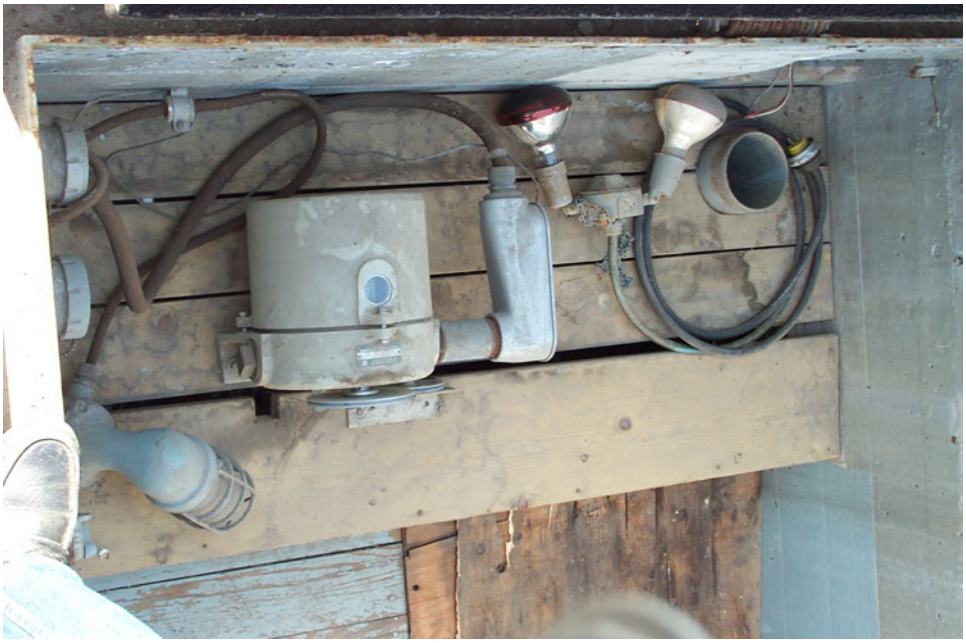


Figure 5-3. Upper Lock and Dam Pool Gage.



Figure 5-4. LSAF Lock and Dam Stevens PAV-C Strip Charts.



Figure 5-5. USAF Lock and Dam Stevens PAV-C Strip Chart.

Site personnel at LSAF compute the discharge based on gate settings and the pool elevation. When a gate or gates are raised above the water surface, the tailwater rating curve is used. As an additional source of discharge data, the Corps has entered into a cooperative agreement with the US Geological Survey (USGS) to maintain the Highway 610 gage (formerly known as the Anoka Gage) (**Figure 5-6**). While the gage is 10.7 miles upstream of USAF (**Plate 5-1**), there are no major tributaries between the gage and the dam; therefore, the discharges are often very close in agreement. The stage at the Highway 610 gage (formerly known as the Anoka Gage) is determined by a float, attached to a tape that sits in a stilling well. The site is a Data Collection Platform (DCP). It has a DAA H-522+DCP data recorder with GOES Telemetry. The GOES Telemetry provides hourly stage information to Water Management through communication with a satellite system. There is a manually operated electronic tape gage (ETG) inside the gage house that is used to verify the gage elevation. **Exhibit B** contains the USGS rating table for the Highway 610 Gage (formerly known as the Anoka Gage).



Figure 5-6. Highway 610 Gage over Mississippi River.

All equipment at the highway 610 gage site, except the ETG, is owned by the Corps of Engineers. The equipment is maintained by the USGS through a cooperative agreement.

Additional gages at the locks and dams include a portable water temperature sensor reading in degrees Fahrenheit at the upper lock and an anemometer on the roof of the lower lock's Central Control Station. Site personnel are responsible for the maintenance of this equipment. A standard eight-inch precipitation gage is located at the lower lock for obtaining the 24-hour precipitation (**Figure 5-7**). The lower lock is equipped with a measuring rod for snow depth and a snow tube and scale for determining snow-water content. Site personnel maintain the precipitation gage and snow measuring equipment. Water Management is responsible for providing any replacement equipment. The National Weather Service (NWS) has an air temperature sensor installed at LSAF. Data types and equipment are listed in **Table 5-1**.



Figure 5-7. Air Temperature Gage House and Precipitation Gage

Table 5-1 Hydrometeorological Stations			
Location	**Data Type**	**Equipment**	**Notes**
Highway 610 over Mississippi River (formerly known as the Anoka Gage)	Stage Water Quality	OTT RLS non-contact radar DAA H-522+DCP GOES Telemetry No Modem Wire Weight Gage Radar Sensing	Gage Zero: 807.74 (NAVD88) NWS ID: ANKM5 Co-Op Gage WQ Data ended in 2002
Xcel Energy Riverside Plant Pool Gage	Water Surface Elevation	Water Surface Meter Stilling Well Staff Gage	Owned by Xcel Energy. Located 3 miles upstream of USAF.
Upper Lock & Dam Upper Guide wall	Upper Pool Elevation	Waterlog 522 Recorder Stilling Well Staff Gage	Continuous Strip Chart record of pool elevations.
Lower Lock & Dam Upper Guide wall	Intermediate Pool Elevation	Stevens PAV-C Recorder Stilling Well Staff Gage	Continuous Strip Chart record of pool elevations.
Lower Lock & Dam Lower Guide wall	Lower Tailwater Elevation	Stevens PAV-C Recorder Stilling Well Staff Gage	Continuous Strip Chart record of TW elevations.
Lower Lock & Dam	Snow Depth & Water Content	Snow Rod , Snow Tube, Scale	Maintained by site personnel. Water Management provides replacement.
Lower Lock & Dam CCS Roof	Wind Speed & Direction	Anemometer	Maintained by site personnel.
Lower Lock & Dam Near Lock House	Precipitation	Standard 8-inch Rain Gage	Water Management provides replacement.

b. Reporting. Personnel at Upper and Lower St. Anthony Falls maintain a daily log book as do all other lock and dam sites. All of the hydrologic data recorded in the log book, as well as additional hydrologic information, is transferred to Water Management via a remote computer terminal through "secure CRT". Water Management archives the data electronically into individual files. The data is also manipulated into an electronic "daily log sheet for St. Anthony Falls Locks and Dams". It is available from the Water Management website at http://www.mvp-wc.usace.army.mil/ or at the national access to water website here http://water.usace.army.mil/a2w/f?p=100:1:1. **Table 5-2** lists the data, the

data intervals, and the start time for each data set. All 0800-hour data is actually collected at 0600-hours. Max-min air temperature is taken at 1900-hours.

Table 5-2
Data Collection at Upper and Lower St. Anthony Falls

Data Type	USAF	LSAF	Interval	Start
Xcel Energy Pool		x	15 minutes	0400
Pool Elevation	x	x	15 minutes	0400
Water Temperature	x		daily	0800
Air Temperature	x	x	8 hours	0800
Gate Settings		x	4 hours	0800
Computed Discharge		x	15 minutes	0800
Anoka Stage/Discharge		x	15 minutes	0400
Precipitation		x	daily	0800

During the winter months, once a week the lower lock reports percent of ice coverage over the intermediate pool, snow depth, and snow-water content to Water Management. The measurements are taken every Sunday and are made available on the Water Management web site on an annual basis.

The Stevens PAV-C strip charts are kept in a secure location. The hard copies remain at the District Office until they have been microfilmed at which time they are then stored off site. The microfilm data remains at the District Office.

c. Maintenance. All the gage equipment associated with the operation of Upper and Lower St. Anthony Falls Locks and Dams is owned by the Corps of Engineers, with the exception of Xcel Energy's pool gage. The Water Management Gage Crew maintains all gage equipment at the dam. The US Geological Survey maintains the Highway 610 gage (formerly known as the Anoka Gage) under a cooperative agreement with the St. Paul District. The Water Management Gage Crew provides emergency backup. Dam personnel maintain the Stevens PAV-C strip chart recorders with the Gage Crew used as a backup. The anemometer, water temperature thermometer, and standard precipitation gage are maintained by site personnel; however should the precipitation gage become damaged, Water Management would mail a new

one to the site. The National Weather Service maintains the air temperature sensor at the lower lock. Repair of the snow survey equipment is the responsibility of the Water Management Gage Crew.

5-02. Water Quality Stations. There are no Corps operated water quality stations in the upper or intermediate pools at St. Anthony Falls; however, the US Geological Survey (USGS) did have a Campbell CR 10 water quality sensor at the Anoka gage site. The CR 10 was installed in May 1996 and was removed in July 2003. Water temperature and specific conductance was recorded. In previous years, observers took these measurements, along with other water quality data. Data recorded included dissolved oxygen, ph, conductance, air and water temperature, and dissolved organic carbon. The period of record was for water years 1963-67, 1975-98, and 2001. Maximum observed water temperature was 31.0ºC on 25, 26 August 1976, 19 July 1977, and 13 July 1995. The minimum of coarse was 0.0ºC on many days each winter. Maximum specific conductance was 646 µs/cm on 22 June 1996 and the minimum was 128 µs/cm on 17, 18 November 1996. A more complete description of the period of record and data collected can be obtained from the USGS *Water Resource Data, Minnesota* manual for the given water year of interest.

5-03. Sediment Stations. No suspended sediment data has been collected in the upper or intermediate pools at St. Anthony Falls; however, the US Geological Survey (USGS) collected sediment samples downstream of the Anoka gage from August 1975 to September 1996. Samples collected prior to 1 October 1978, were taken at the Lowry Avenue Bridge. After that, samples were collected at the Camden Avenue Bridge, 7.0 miles downstream of the Anoka gage. The maximum daily mean was 222 mg/l on 20 March 1995. The minimum daily mean was 1 mg/l on several days in 1978, 1980, 1981, and 1983.

5-04. Recording Hydrologic Data. All hydrologic data received by Water Management from the dam sites are compiled and archived using Hydraulic Engineering Center's Data Storage System (HEC-DSS). Each data set is accessible from the Water Management web site at http://www.mvp-wc.usace.army.mil/ or at the national access to water website here http://water.usace.army.mil/a2w/f?p=100:1:1. In 2001, log sheets were generated from the lock and dam data stored in DSS files. Log sheets were back generated to August 1998. Water Management also maintains DSS files of hourly stage/elevation data for the gage located at Highway 610 gage (formerly known as the Anoka Gage) beginning 1 January 1998. The US Geological Survey (USGS) maintains a discharge gage on Highway 610 over the Mississippi River (formerly known as the Anoka gage) (ANKM5). The data are archived in the USGS WATSTORE data base in Reston, Virginia and are available from the annual publication of the USGS Water-Data Report, *Water Resources Data, Minnesota*. https://waterdata.usgs.gov/nwis/si shows the electronically available data from the US Geological Survey web site.

Table 5-3
Electronically Stored Hydrologic Data Records

Data Type	Taken	Start of Record
Upper Pool Elevation	15 minutes	01 Jan 1964
Xcel Pool Elevation	15 minutes	01 Jan 1988
Intermediate Pool Elevation	15 minutes	25 Jul 1950
Lower Pool Elevation	15 minutes	25 Jul 1950
LSAF Discharge	15 minutes	01 Jan 1990
USAF Discharge	15 minutes	18 Mar 1998
LSAF Precipitation	daily	11 Jul 1988
LSAF Air Temperature	8 hours	18 Aug 1998
LSAF Max-Min Temp	daily	18 Aug 1998
USAF Water Temperature	daily	31 Oct 1998
LSAF Wind Speed/Direction	15 minutes	17 Aug 1998

5-05. Communication Network. The communication network consists of computer terminal, *T1* line, telephone, pager, facsimile, voice modem, satellite, and the US Postal Service. Computer communication is done via e-mail, and the "secure CRT" which allows remote access to the Water Management network. When the computer is down, the transfer of data is by facsimile or telephone. During non-duty hours on weekends and holidays, dam personnel can contact the river regulator by calling the cellular telephone number (651-260-5786). The gage site on the Mississippi River at Highway 610 sends hourly stage/elevation data via satellite to Water Management. This information is made available to the dam site from the Water Management web site; http://www.mvp-wc.usace.army.mil/ or at the national access to water website here http://water.usace.army.mil/a2w/f?p=100:1:1. Discharge information at Highway 610 can be obtained from the US Geological Survey web site. A *T1* line ensures communication between Water Management and the Mississippi River Valley Division Office (MVD) in Vicksburg, Mississippi. Bulk items like Stevens PAV-C strip charts are kept in a secure location.

5-06. Communication with Project.

a. Regulating Office with Project Office. Lock staff at Lower St. Anthony Falls transfer data to Water Management though out the day via remote computer. If there is a need to report additional information, lock staff at either site use the telephone. The e-mail system is available as backup. Should the dam site have computer problems, such that the transfer of data is not possible then communication can be achieved using the Lockmaster's government cellular phones. The Water Management river manager can then enter the information into the Regulation Program and Information Management (IM) will be notified of the computer problem.

b. **Between Project Office and Xcel Energy.** Xcel Energy Riverside Plant personnel contact the lower lock site daily at midnight everyday to report the 4-hour pool elevations for the previous day. Communication with the plant is via telephone at 612-330-6166.

c. **Between Project Office and Others.** The general public has access to river level and discharge data by visiting Water Management's web site at http://www.mvp-wc.usace.army.mil/ or at the national access to water website here http://water.usace.army.mil/a2w/f?p=100:1:1. From here the public can access current water surface elevations for the Mississippi River as well as the daily log sheets for the locks and dams. Notifications of severe weather or impending unusual conditions are handled through local law enforcement, civil defense authorities, and the National Weather Service.

5-07. Project Reporting Instructions. The project staff reports hydrologic and climatic conditions to Water Management via computer terminal and by telephone on as needed basis. Any problems with machinery that operate the gates are to be reported to Water Management Section and Construction-Operations Division.

5-08. Warnings. In the event of a gate failure, communications must be established as quickly as possible with the Water Management Section and the Construction-Operations Division. Notification should be given to the Ford Powerhouse, Lock and Dam No. 1, and Lower Saint Anthony Falls, if a failure occurs at the upper dam. The installation of any bulkheads at the Lower Dam must be coordinated with Water Management. Contact numbers available in the Water Management Assistance and Significant Contacts table provided in the introduction section of this manual.

VI – HYDROLOGIC FORECASTS

6-01. General. The Corps has no gates at Upper St. Anthony Falls to operate other than the tainter gate in lock chamber. This gate is only opened to pass flow for high discharge events (>40,000 cfs at Lower Saint Anthony). While 40,000 cfs is the design point to begin discharge through the upper lock chamber, opening of the lock chamber may be postponed dependant upon the river forecast. Water Management analyzes the National Weather Service forecast and the Corps of Engineers forecast for St. Anthony Falls and, based on these forecasts, directs the opening of the lock chamber. Inspections of the lock chamber have indicated severe damage occurs with the passing of flow through the lock chamber. Rocks can become trapped on the lock floor. The heavy turbulence gyrates the rock around thus forming a gouge in the lock floor. Therefore, should the forecast indicate that discharge will not exceed 52,000 cfs and will only be above 40,000 cfs for a short period of time, Water Management will not call for opening the lock chamber.

At the lower lock for flows below 6,200 cfs all flow will be directed though the hydropower. During this low flow the hydropower will regulate the pool to maintain the pool between elevations 749.0 feet and 751.0 feet. Between flows of 6,201 cfs and 36,000 cfs, gates 1 through 3 will be used to regulate and the hydropower will be at full capacity. The project pool elevation of 750.0 feet (1912 adjustment) will be targeted; however, the pool will be allowed to fluctuate between elevations 749.0 feet and 751.0 feet. When flow exceeds 36,000 cfs, the hydropower turbines are pulled the auxiliary gate draft tubes are to be opened. As flow continues to increase, these four gates are opened in an effort to maintain a maximum pool elevation of 751.0 feet. When all the gates are raised clear of the water, the pool is allowed to climb to elevation 751.5 feet. When the pool exceeds this elevation, the main lock gate is to be opened. At this time discharge will be around 60,000 cfs. The remaining four gates are to be placed back into the water and the flow is to be balanced across the five gates.

The lower St. Anthony Falls lock go out of operation to small pleasure craft when the Mississippi River reaches a discharge of 30,000 cfs. When the river reaches 40,000 cfs, the locks typically go out of operation to all watercraft. The forecasted inflow hydrograph is used to alert the towing industry and the public when lock closure is expected. In addition to forecasting lock closures, the inflow hydrograph is important for forecasting when the lock will come back into service. The St. Paul District developed an unsteady-flow model of the Mississippi River for forecasting river stages and discharge. The unsteady-flow model is part of the Corps Water Management System (CWMS). The same model is used in all flow conditions including flood, drought or conservation purposes. However, The National Weather Service remains the official river forecaster for public purposes.

a. Role of the Corps. The St. Paul District produces internal forecasts. The National Weather Service (NWS) is the official public river forecaster. The NWS forecasts river stages for designated sites along the Mississippi River. The two nearest forecast sites to St. Anthony Falls are the Minneapolis gage at the water treatment plant and the gage at the Highway 610 in Brooklyn Park (AKAM5). The NWS forecast typically is only a five-day forecast with a projected crest height and date. Any discharge information would have to be obtained by contacting the NWS directly. The St. Paul District developed what is called the Corps Water Management System (CWMS) for internal purposes. It utilizes HEC products including RAS and HMS to produce forecasts upon request. The CWMS model also can be used to simulate deviations or "what if" scenarios.

b. Roles of Other Agencies. The National Weather Service (NWS) provides the District forecasted stage hydrographs of the major tributaries to the Mississippi River by 0830-hours daily and a second forecast by 1100-hours daily. The NWS forecast sites nearest St. Anthony Falls are at the Minneapolis water treatment plant and the Highway 610 in Brooklyn Park (AKAM5). The USGS is responsible for the maintenance and repair of the Highway 610 in Brooklyn Park (AKAM5).

6-02. Flood Condition Forecasts.

a. Requirements. Flow and stage data is required to provide the boundary conditions that drive the Corps Water Management System (CWMS) model. Observed stages are updated daily. The model is dependent upon forecasted tributary inflows from the headwaters which can be generated by Water Management. Computed forecast hydrographs can be computed using CWMS within twenty minutes of run time; which does not include data collection or calibration time. The model requires 6 hour increment time series for input and can create output in any time step but usually defaults to 12 hour time steps.

b. Methods. St. Paul District uses the Corps Water Management System (CWMS) to forecast flood conditions at Upper and Lower St. Anthony Falls. The model begins with observed data at Highway 610 in Brooklyn Park (AKAM5), Minnesota and extends downstream to Lock and Dam 10 in Guttenberg, Iowa. The system utilizes HEC-RAS, which is an unsteady flow computer program. HEC-RAS was modified to simulate navigation dams according to built-in "Nav-Dam" rules. As an alternative the National Weather Service (NWS) forecast can also be utilized which typically include the 24-hour but can include up to 7 days of quantitative precipitation forecast (QPF). Forecasts beyond five to seven days are very approximate due to unknowns such as forecasted rainfall. Forecast for the locks and dams are made available to the public via the official government river forecasters the National Weather Service (NWS) https://water.weather.gov/ahps/ . A long term forecast is available to Corps personnel by request to Water Management.

6-03. Conservation Purpose Forecasts.

a. Requirements. See section 6-02 a. The model requirements are the same.

b. **Methods.** The lock and dam system operates as "run of the river". That is whatever flow enters the pool is passed on as outflow. The project pool elevation is maintained provided there is sufficient inflow to meet withdrawal needs and pool evaporation. There is no conservation purpose forecast model other than the Corps Water Management System (CWMS) previously discussed.

6-04. Long-Range Forecasts.

a. Requirements. See section 6-02 a. The model requirements are the same.

b. Methods. The Corps Water Management System (CWMS) is used for making long-range forecasts. The model forecasts elevation and discharge for the locks and dams and control points 28-days out. However, as previously noted, the 28-day tributary inflow provided by the National Weather Service typically only includes the 24-hour quantitative precipitation forecast (QPF). Therefore, judgment is required when looking at long-range forecasts.

6-05. Drought Forecast.

a. Requirements. See section 6-02 a. The model requirements are the same.

b. Methods. The lock and dam system operates as "run of the river". That is what ever flow enters the pool is passed on as outflow. During low flow, the project pool elevation is maintained provided there is sufficient inflow to meet withdrawal needs and pool evaporation. There is no drought forecasting model other than the Corps Water Management System (CWMS) 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 the St. Anthony Falls Pools, without inducing higher stages during flood events. Project pool for Upper St. Anthony Falls Lock and Dam is elevation 799.2 feet (1912 adjustment). This assumes the flashboards are up. When the flashboards are down, the pool is not allowed to be lower than the dam crest (elevation 796.8 feet). Project pool for the intermediate pool is elevation 750.0 feet. Maintaining project pool elevations during periods of low flows ensures a minimum channel depth of nine feet; however, periodic dredging is required.

7-02. Constraints.

a. Pool Levels. The intermediate pool is maintained as near as possible to elevation 750.0 feet (1912 adjustment) at the dam. This is "project pool" for Lower St. Anthony Falls Lock and Dam. The intermediate pool is constrained to be no lower than Xcel Energy's draft tubes (elevation 748.6 feet) and no higher than the University of Minnesota's steam plant (top of wall elevation 752.3 feet). During normal operations, the pool is held between elevations 749.0 feet and 751.0 feet. An alarm sounds at elevations 749.2 feet and 750.8 feet to alert lock personnel that an immediate gate change is required. When the auxiliary gate is in use, the pool is not to exceed elevation 751.5 feet. When the main lock is opened to pass flood flows, the pool is again constrained to be between elevations 749.0 feet and 751.0 feet.

At Upper St. Anthony Falls (USAF), when the flashboards are up, "project pool" or "normal pool" is elevation 799.2 feet as measured at the Corps' pool gage. Flow is controlled through the powerhouse such that during low flow, the upper pool is maintained between elevation 799.2 feet and 798.8 feet. The flashboards are automatically removed due to ice action during spring break up or water pressure during high flows (i.e. ~ elevation 801.0 feet). When the flashboards are down, project pool is the elevation of the spillway crest 796.8

feet. The pool is not to fall below this elevation. If it does, turbines within the powerhouse are to be shut down sequentially until the normal operation level is restored. When the discharge subsides to less than 6,000 cfs, the flashboards are installed and normal control levels are restored. **Exhibit C** is a letter from Northern States Power in 1970 clarifying operation of the hydropower plant.

b. Open River Conditions. "Open river conditions" exist at Lower St. Anthony Falls when all the gates, including the auxiliary and main lock gates, are raised above the water surface. This happened in the flood of 1965, but only for a brief period. The drawdown at the gated spillways gave the appearance that less flow was passing through the openings; therefore, the moveable gates were placed back into the water thus raising the water surface at the gates. It was assumed the moveable gates passed more flow. What actually happened was a redistribution of flow at a slightly higher head. When the gates were placed in the water, flows through the gates were reduced producing a higher head. The higher head then forced more water through the auxiliary and main lock gates. This was the standard operating procedure until now.

c. Closure of the Lock to Navigation. The lock at Upper St. Anthony Falls was closed to navigation in 2015. The lock at lower St. Anthony Falls closes to navigation for small pleasure craft when the discharge reaches 30,000 cfs and all river traffic when discharge reaches 40,000 cfs. A tow may be allowed to pass through lower St. Anthony Falls lock when the discharge is above 40,000 cfs, but only when it is coordinated through Operations Division.

As winter approaches, the lock remains open as long as towboats and barges can travel. The lock is also closed when ice is too thick to permit tow traffic. Water temperatures are monitored to predict lock closure. In early March the ice becomes thin enough for some tow traffic and the lock is opened. The following table shows some of the recent history of opening and closing dates for Upper and Lower St. Anthony Falls Locks and Dams.

Table 7-1 Spring Opening and Fall Closing Dates					
Year	Opening Date	Closing Date	**Year**	Opening Date	Closing Date
1990	08 Mar	26 Nov	**2006**	20 Mar	30 Nov
1991	22 Mar	25 Nov	**2007**	24 Mar	29 Nov
1992	11 Mar	24 Nov	**2008**	25 Mar	05 Dec
1993	25 Mar	24 Nov	**2009**	20 Mar	04 Dec
1994	29 Mar	24 Nov	**2010**	05 Apr	28 Nov
1995	21 Mar	22 Nov	**2011**	19 Mar	03 Dec
1996	03 Apr	21 Nov	**2012**	12 Mar	07 Dec
1997	26 Mar	21 Nov	**2013**	18 Apr	03 Dec
1998	03 Mar	27 Nov	**2014**	02 Apr	11 Nov
1999	23 Mar	27 Nov	**2015**	29 Mar	10 Dec
2000	20 Mar	04 Dec	**2016**	13 Mar	11 Dec
2001	20 Mar	19 Dec	**2017**	04 Mar	10 Dec
2002	20 Mar	25 Nov	**2018**	18 Mar	03 Dec
2003	01 Apr	22 Nov	**2019**	24 Apr	08 Dec
2004	18 Mar	05 Dec	**2020**	16 Mar	10 Dec
2005	20 Mar	02 Dec	**2021**	15 Mar	28 Nov

*Only LSAF 2016 -Pres

7-03. Overall Plan for Water Control.

a. General Plan. The primary purpose of Upper and Lower St. Anthony Falls Locks and Dams is to maintain a minimum depth of nine feet throughout the navigation channel without inducing higher stages during flood events. The secondary purpose at both sites is power generation.

The top of flashboard elevation is 798.8 feet. Therefore, while project pool elevation is 799.2 feet, the normal operating band is elevation 799.0 ± 0.2 feet. High flow or debris will knock the flashboards down. To meet absolute minimum depth requirements, the upper pool must not be lower than the dam crest elevation of 796.8 feet (1912 adjustment). The flashboards are to be reinstalled as soon as possible. For this to happen, discharge must fall below 6,000 cfs. When the flashboards are being installed, the pool must be dropped below the dam crest; however, it is not to go below elevation 796.4 feet. The installation typically takes two to four days depending on how much debris is on the spillway. Given that the Xcel plant can pass around 4,000 cfs

historically the tainter valves were used to pass around 2,000 cfs additionally to facilitate the drawdown to 796.4 feet. However, now that the lock at Upper St. Anthony Falls is not utilized since 2015 the tainter valves are no longer operable. Thus it will be necessary to use the tainter gate within the lock chamber to pass the additional 2,000 cfs for the duration of the flash board installation process.

The intermediate pool is maintained at the project pool elevation of 750.0 feet. Because of the small storage capacity, the elevation is quickly affected by lockages at lower St Anthony Falls and power generation changes at the upper dam. Frequent tainter gate changes are required to maintain project pool. The actual pool elevation during normal operations is allowed to vary from 749.0 to 751.0 feet. When flow is high enough to require use of the auxiliary tainter gate to pass flow, the pool is allowed to rise to elevation 751.5 feet in an attempt to prevent the opening of the main lock. Once the main lock is opened, the pool is maintained between elevations 749.0 feet and 751.0 feet.

b. Computed Discharge. Discharges are computed at the lower dam. With the gates in the water, the theoretical discharge per gate would be $Q=CA(2gH)^{1/2}$, where Q is discharge, C is the orifice coefficient, A is the flow area, and H is the head. While head can be calculated, the orifice coefficient C can vary with the degree of submergence. The US Geological Survey (USGS) took discharge measurements at the dam under various head conditions. From this data set, they developed a discharge rating curve based on head for a one-foot gate opening. Submergence was addressed in the head calculation. For free flow conditions, when the tailwater depth is less than the conjugate depth;

Head = Pool Elevation – Gate Seal Elevation – ½ the Gate Opening

When the tailwater depth is greater than the conjugate depth, flow is "drowned" by the high tailwater. To eliminate the need for calculating conjugate depths, submergence was assumed to begin when the tailwater was

above the gate seal. The degree of submergence was accounted for by introducing the tailwater (TW) elevation into the determination of head;

Head = Pool Elev. – 0.5 (Gate Seal Elev. + Gate Opening + TW Elev.)

As flow increases, the gates are opened farther and farther such that the tailwater would never be above the top of the gate opening, unless there was a gate malfunction. Should this happen, the gate would be considered fully submerged and head would be represented by,

Head = Pool Elevation – Tailwater Elevation

With these three flow conditions defined, head can be determined for the dam gates (seal elevation 728.5 feet) and lock gates (seal elevation 735.3 feet). The rating curve presented in the 1975 *St. Anthony Falls Reservoir Regulation Manual* was translated into a tabularized format and is presented in **Plate 7-2**. From this table, the discharge per foot of opening for each gate can be determined. The following summarizes the procedural steps used to compute total discharge at Lower St. Anthony Falls (LSAF).

Discharge for Dam Gates (1, 2, or 3) and Lock Gates (main and auxiliary)

	Dam Gates	Lock Gates
Top of Sill Elevation:	731.0 feet	736.3 feet
Gate Seal Elevation:	728.5 feet	735.3 feet

1. a. *Head for when tailwater is below dam gate seal*.
   Head = Pool Elevation - Gate Seal Elevation - ½ Gate Opening
   b. *Head for when tailwater is above dam gate seal.*
   Head = Pool Elev – 0.5 (Gate Seal Elev + Gate Opening + TW Elev)
   c. *Head for when tailwater is above dam gate opening.*
   Head = Pool Elevation – Tailwater Elevation
2. Enter **Table 7-2** with the head value and get Discharge per Foot Opening.
3. (Discharge per Foot) (Gate Opening in feet) = Total Gate Discharge
4. Sum the total gate discharges for Total Dam Discharge.

The following are sample calculations for the movable dam at LSAF. The computed discharge for 0800-hours is shown with the 0800-hour US Geological Survey's (USGS) published discharge for Anoka (11 miles upstream). There are always minor discrepancies between the two discharges. Some of this can be explained through local inflow, travel time, or shifts in the Anoka rating curve. Also, during the winter months ice can influence the Anoka gage. To investigate how well these two values compare, the 24-hour average of computed discharges was plotted with the USGS published discharge for the years 1999 through 2002. Included with the plots were the computed discharges at Lock and Dam No .1. The plots are presented in **Exhibit D**.

Sample Calculation:

Pool Elevation: 749.48 ft Tailwater Elevation: 727.77 ft

	Gate Opening	Head feet	Discharge per foot	Discharge	Anoka Discharge
Hydropower	NA	18.58	NA	6,200 cfs	
Gate No. 1	4.8 ft	18.58[1]	1535 cfs	5,308 cfs	
Gate No. 2	4.8 ft	18.58	1535 cfs	5,308 cfs	
Gate No. 3	4.7 ft	18.63	1538 cfs	5,209 cfs	
Aux Lock	Not in Use				
Main Lock	Not in Use				
Total Discharge:				22,025 cfs	21,360 cfs

[1]Head = (749.48 – 728.5 – 2.4) = 18.58 ft

Sample Calculation:

Pool Elevation: 749.50 ft Tailwater Elevation: 730.18 ft

	Gate Opening	Head feet	Discharge per foot	Discharge	Anoka Discharge
Hydropower	NA	16.81	NA	0 cfs	
Gate No. 1	6.5 ft	16.81[1]	1429 cfs	8,843 cfs	
Gate No. 2	6.5 ft	16.96	1438 cfs	8,918 cfs	
Gate No. 3	6.5 ft	16.96	1438 cfs	8,918 cfs	
Aux Lock	Open	12.95[2]	NA	9,372 cfs	
Main Lock	Not in Use				
Total Discharge:				36,051 cfs	36,025 cfs

[1]Head = 749.50 – 0.5 (728.5 + 730.18 + 6.7) = 16.81 ft
[2]Head = (749.50 – 735.3 – 1.25) = 12.95 ft

Sample Calculation:

Pool Elevation: 750.34 ft Tailwater Elevation: 735.55 ft

	Gate Opening	Head feet	Discharge per foot	Gate Discharge	Anoka Discharge
Hydropower	NA	13.73	NA	0 cfs	
Gate No. 1	10.0 ft	13.73[1]	1213 cfs	12,130 cfs	
Gate No. 2	10.0 ft	13.73	1213 cfs	12,130 cfs	
Gate No. 3	9.8 ft	13.42	1220 cfs	11,956 cfs	
Aux Lock	Open	10.71[2]	NA	10,500 cfs	
Main Lock	12.5 ft	10.61[3]	840 cfs	10,500 cfs	
Total Discharge:				57,216 cfs	58,090 cfs

[1]Head = 750.34 – 0.5 (728.5 + 735.55 + 10.0) = 13.32 ft
[2]Head = 750.34 – 0.5 (735.3 + 735.55 + 12.5) = 8.67 ft
[3]Head = 750.34 – 0.5 (735.3 + 735.55 + 12.5) =

At discharges below 6,200 cfs all discharge is through the hydropower who will report computed discharges to the lock staff.

At high discharges when one or more of the gates are out of the water, discharge can be obtained from the tailwater rating curve (**Plate 7-1**).

c. Regulation Procedure. The upper pool is only regulated when inflow is very low or very high. When flow is above 40,000 cfs, Water Management directs the opening of the lock chamber to pass flow. When inflow is equal to or less than the hydropower water demand, regulation is conducted by Xcel Energy under FERC License No. 2056. When the flashboards are up, the upper pool is to be maintained between elevation 799.2 and 798.8 feet (1912 adjustment) as measured at the Corps' pool gage. Xcel Energy operates its turbines by computer program. The program monitors Xcel Energy's pool gage, which is located at the Riverside Power Plant, three miles upstream of St. Anthony Falls. When the pool falls below the trigger elevation, one of the turbines is taken off line. If the pool falls to the trigger elevation again, another unit is taken off line and so on. As the pool rises, units are brought back into operation. Because Xcel Energy's pool gage is upstream of the Corps' gage, it reads higher. Therefore, the trigger elevation has been adjusted upward to correspond to the Corps' gage thereby accounting for the gage differential.

If the flashboards are lost due to ice action during spring break up or water pressure due to high flows (~ elevation 801.0 feet), the pool is not to be lower than the dam crest (elevation 796.8 feet), except when replacing the flash-boards. The flashboards are to be replaced when the discharge falls below 6,000 cfs. This operation typically takes two days. The pool is lowered below the spillway crest to make replacement possible. During this time, the crest is not to fall below elevation 796.4 feet.

Lower St. Anthony Falls Lock personnel regulate the intermediate pool. Project pool is elevation 750.0 feet. Prior to June 2015 lockage at Upper St. Anthony had a significant impact on the intermediate pool level. Therefore, the pool is allowed to vary from elevation 749.0 to 750.5 feet. Gate operation is presented in detail in the next section.

d. Winter Regulation. If necessary, ice and debris can be passed through the lock chamber at Upper St. Anthony Falls. In preparation, the lower miter gates are closed and the lock is filled. The upper miter gates are opened and the lower tainter valves are opened a bit to draw the ice/debris into the chamber. The lock is then sealed and the lower tainter valves are opened to drain the lock. The lower miter gates are opened and then the upper tainter valves are opened to flush the lock chamber. At Lower St. Anthony Falls, the three tainter gates on the moveable dam can be submerged up to six feet below the project pool elevation. Any one or more of these gates can be submerged as necessary to pass ice and debris. The auxiliary and main lock tainter gates can be submerged to the gate sill elevation, but they are rarely used to pass ice or debris. A rating table for submerged tainter gates is shown in **Plate 7-3**. Head is equal to the difference between the intermediate pool elevation and the top of submerged gate elevation.

Unlike the other Upper Mississippi River Locks and Dams, during the winter, the tainter valves in the lock walls of Upper and Lower St. Anthony Falls are kept closed. Experience has shown that excessive sediment builds up in the

lock chambers over the winter making it difficult to open the lower miter gates. Therefore, the upper gates are closed and the lower miter gates are left in the open position.

Starting with the end of navigation season, the pool at Lower St. Anthony will be lowered approximately one foot to prevent ice building up on the dam tainter gate arms and pier house walls. In the past, ice had to be manually chipped away requiring hours of dangerous labor. The lower pool level prevents the ice buildup. The pool is to be maintained between elevation 749.50 feet and 748.60 feet (1912 adjustment) until ice conditions are no longer prevalent.

7-04. Standing Instructions to St. Anthony Falls Staff.

a. Data Collection. Both Upper and Lower St. Anthony Falls maintain a logbook that includes most of the daily operational information. Lower St. Anthony Falls (LSAF) does project data entry for both sites via a remote computer. The data entry interval varies from once a day to every four hours. Four-hour data includes elevations for the Xcel Energy (NSP) pool gage, the Corps' upper pool gage, the intermediate pool, the lower tailwater, and the discharge. Four-hour data begins at 0400-hours. Xcel Energy calls LSAF every day at midnight with that day's pool elevations. Upper St. Anthony Falls (USAF) reports their pool elevations to LSAF every four hours. Eight-hour data includes gate settings, discharge per gate, total discharge, air temperature, and wind speed and direction. Eight-hour data begins at 0800-hours. Daily data includes precipitation (0800-hours), water temperature (0800-hours), and maximum-minimum air temperature (1600-hours). All 0800-hour data are collected at 0600-hours. Maximum-minimum air temperature is taken at 1900-hours.

During the winter months, data also include percent of ice coverage over the intermediate pool, ice thickness, snow depth, and snow-water equivalent. These data are collected once a week on Sundays at the lower lock and dam.

b. Gate Operation at Lower St. Anthony Falls. Gate operation is to follow a sequential order. For flows below 6,200 cfs all flow will be directed through the hydropower. During this low flow the hydropower will regulate the pool to maintain the pool between elevations 749.0 feet and 751.0 feet. Between flows of 6,201 cfs and 38,000 cfs, gates 1 through 3 will be used to regulate and the hydropower will be at full capacity. Flow is to be balanced across these three gates with no gate differential greater than one-foot. The project pool elevation of 750.0 feet (1912 adjustment) will be targeted; however, the pool will be allowed to fluctuate between elevations 749.0 feet and 751.0 feet. When flow exceeds 38,000 cfs, the hydropower turbines are pulled, and the auxiliary gate draft tubes are to be opened. Flow is to be balanced across these four gates. As flow continues to increase, these four gates are opened in an effort to maintain a maximum pool elevation of 751.0 feet. When all the gates are raised clear of the water, and the pool is allowed to climb to elevation 751.5 feet after which the main lock gate is to be opened. At this time discharge will be around 60,000 cfs. The remaining four gates are to be placed back into the water and the flow is to be balanced across the five gates. The pool is to be maintained between elevation 749.0 and 751.0 feet. If discharge continues to increase, all gates are raised until they are all clear of the water. The following table gives guidance for the operation of the gates at LSAF.

Table 7-2
Gate Operation at Lower St. Anthony Falls

Discharge (cfs)	Pool Elevation (feet)	Hydro-power	Gates in Operation			Comments
			Gates 1, 2, 3	Aux Lock	Main Lock	
< 6,200	> 749.0 < 751.0	X				All flow routed through the hydropower.
> 6,200 < 38,000	> 749.0 < 751.0	X	X			Spread flow across the dam. Maximum gate differential is one-foot.
> 38,000 < 60,000	> 749.0 < 751.5		X	X		Balance flow through the four gates until they are all raised clear of the water.
> 60,000	> 749.0 < 751.0		X	X	X	Return gates to the water and open as necessary until all gates are raised clear of the water.

c. Gate Operation at Upper St. Anthony Falls. Water Control will direct the opening of the lock tainter gate to flow during high water events. Because of damage to the lock chamber when passing flow, opening of the lock chamber may be delayed depending on the forecasted inflow hydrograph. The operating plan calls for opening the gate when the discharge exceeds 40,000 cfs; however, if the forecast indicates inflow will only exceed 40,000 cfs for a brief period of time, the lock chamber may remain closed. If inflow is forecasted to be over 52,000 cfs, it is very likely that Water Control will direct opening of the gate.

Due to the closure of USAF lock in 2015 there is no longer an opportunity for sedimentation and debris to be flushed using the normal lock cycle (See section **2-05.a**). It is important for the operation of the USAF tainter gate that sedimentation and debris is clear from the upstream end of the lock. As an alternative the USAF tainter gate can be operated for less than an hour at the discretion of the Lock Master and with coordination of the LSAF and the Xcel energy power plant.

d. Installation of the Flashboards. If ice/debris or high flow conditions caused the flashboards to come down, Xcel Energy is to replace them as soon as possible. This occurs when the discharge falls below 6,000 cfs. Xcel Energy will coordinate this activity with Water Control. Upper St. Anthony Falls Lock personnel are to closely monitor pool levels during the flashboard installation. While the target pool elevation is 796.6 feet (1912 adjustment), the pool is not to fall below 796.4 feet. Given that the Xcel plant can pass around 4,000 cfs, historically the tainter valves were used to pass around 2,000 cfs additionally to facilitate the drawdown to 796.4 feet. Now that the lock at Upper St. Anthony Falls is not utilized since 2015 the tainter valves are no longer operable. Thus it will be necessary to use the tainter gate within the lock chamber to pass the additional 2,000 cfs for the duration of the flash board installation process.

e. **Maintenance of the Horseshoe Dam.** It is understood that Xcel Energy must perform maintenance on the horseshoe dam. It will be necessary for Xcel Energy to lower the pool below the dam crest. River flows must be below 6,000 cfs to allow for a pool lowering. When work is required, Xcel Energy is to coordinate with Water Management (651-290-5786) ten days prior to the lowering of the pool. This will give the Corps time to coordinate with the towing industry, other agencies, and interested parties. Pool elevations needed to complete the work, as well as a time schedule, must be coordinated with Water Control. Upper St. Anthony Falls Lock personnel are to closely monitor pool levels during this time to ensure that the pool does not fall below agreed upon levels.

f. **Maintenance of the Intermediate pool.** Maintenance activities in the intermediate pool to include; hydropower inspections, dam safety inspections, and flood control works inspections will be required on a periodic basis. This maintenance requires a drawdown of the intermediate pool of 13 feet to elevation 737.0 feet (MSL 1912). Inspections of this kind will only commence outside of the navigation season as to not interrupt the primary purpose of the SAF structures. In order to reduce negative impacts, the full drawdown is to last 5 to 7 days and the pool is to return to normal operating elevations after 10 days from the start of the drawdown.

   This maintenance drawdown must occur gradually in order to comply with Geotechnical Branch guidance. The rate of pool change must be about 4 ft/day or less when the pool is outside the normal operating band.

   Water Management will coordinate internally with Operations Division, Regional Planning and Environmental Branch, Engineering and Construction Division, and the Public Affairs Office. External coordination will take place with Xcel Energy, Brookfield Renewable, the University of Minnesota, Minneapolis Fire, Hennepin Water Patrol, and the City of Minneapolis.

g. Low Flow Conditions. When discharge falls to approximately 2,500 cfs measured at Highway 610 near Anoka, the time to fill the lock chamber will be doubled to prevent generators at the power plant from tripping out. If flows are below 2,000 cfs hydropower plants are to ramp their changes in flow such that there is no more than a 10 percent change in flow over a two-hour period. During extreme low-flow events, Lower St. Anthony Falls Lock personnel are to monitor changes in outflow by Xcel Energy. If calculations show Xcel Energy has violated the rule, they are to contact Water Control as soon as possible. During low discharges commercial navigation will be locked through as needed. When discharges are below 1,000 cfs, recreational craft will be locked through on the hour.

h. Contact With Water Management. Normal duty hours for Water Management are 0600 to 1430-hours during the week, and 0600 to 1000-hours on weekends and holidays. **Table 7-3** lists Water Management personnel with river regulation responsibilities. If contact with Water Management is necessary, follow the list sequentially until you get an answer. If lock personnel have any questions for Water Management, they are to contact the river regulator on duty via the telephone number reported on daily orders. During computer outages, information can be delivered via cell phone.



7-05. Flood Risk Management. Upper Saint Anthony Falls Lock and Dam has a single gate to be operated in a flood event. Although the gate is operated during a flood event, it cannot retain water and thus does not provide any flood control benefits. The gate only serves to protect the Upper Saint Anthony Falls Lock and Dam from overtopping. See Section 7-04.c for more details on how the lock tainter gate is operated.

Lower St. Anthony Falls Lock and Dam has no flood control benefits. Lower St. Anthony Falls has an extremely small pool and cannot retain water for flood control benefits.

7-06. Recreation. The major recreation features for Upper and Lower St. Anthony Falls Locks and Dams are fishing and boating. No operational changes shall be made to explicitly benefit recreation. Navigation is the primary mission of the Saint Anthony falls structures. Any benefits to recreation are a byproduct of the primary mission.

7-07. Water Quality. The Corps of Engineers does not perform any water quality analysis in the St. Anthony Falls Pools; however, the Minnesota Pollution Control Agency (MPCA) and the Metropolitan Council Environmental Services Division (MCES) periodically monitor water quality between St. Anthony Falls and the Coon Rapids Dam. For more information, see **Section 4-07. Water Quality**.

7-08. Fish and Wildlife. The only deliberate operational change made to influence Fish and wildlife was the congressional directive to close the lock at Upper Saint Anthony Falls. This was done to deter invasive fish passage through the lock chamber. Any future deviation from the approved water control plan outlined in this document must be done at the discretion of the Environmental Branch within the St. Paul District. This is done with the goal of reducing the environmental impact of the project as much as possible while still maintaining the operational mission.

7-09. Water Supply. Minneapolis Water Works (MWW) provides water to the City of Minneapolis, Minnesota. MWW obtains all of their drinking water directly from the Mississippi River in Columbia Heights at approximately river mile 859.5. This is just above of the upstream limit of the nine-foot channel project. The crown of the water intake forebay is at elevation 796.3 feet (NGVD 1929) or elevation 796.75 feet (1912 adjustment). The lower pool limit for Upper St. Anthony Falls is elevation 796.8 feet (1912 adjustment). Because of the water intake, the pool is not to be lower than elevation 796.4 feet when the flashboards are being installed. St. Paul Regional Water Services (SPRWS) provides water to the City of St. Paul. SPRWS obtains nearly 70 percent of their drinking water directly from the Mississippi River located near river mile 863, which is above the upstream limit of the nine-foot channel project. No intake problems have been reported during low pool periods.

7-10. Hydroelectric Power. In 1903 the steam plant was constructed in the intermediate pool (**Figure 2-7**). Operation of the steam plant has little to do with the operations of the locks; however, it is important to note that the top of wall elevation at the steam plant is elevation 752.3 feet (1912 adjustment) and the maximum allowable intermediate pool elevation is 751.5 feet.

The Upper St. Anthony Falls powerhouse has five turbine-generator units. Unit numbers 1 through 4 are Francis horizontal turbines rated at 3,200 hp, under 48 feet of head, connected to a generator rated at 2,750 kVA. Unit number 5 is a Kaplan single vertical shaft turbine rated at 3,500 hp, under 48 feet of head, connected to a vertical generator rated at 3,125 kVA. Total installed capacity is 12.4 MW and maximum hydraulic capacity of 4,025 cfs. Total gross energy generated by the facility in the 2018 water year was approximately 90 million kWh. Brookfield Renewable Electric and Nelson Energy were granted FERC approval and started generation in 2011. The power plant consists of a StraflowMatrix turbine concept located in the lower part of the downstream section of the auxiliary lock. A bulkhead wall is constructed at the downstream end of the existing wall and a crane and framework over the auxiliary chamber.

An Obermeyer gate is located on the crest of the concrete section. The Matrix turbine operation (all 16 units) can be hoisted out of the auxiliary lock to an elevation above the adjacent piers. This allows for use of the auxiliary lock to discharge flood flows.

7-11. Navigation. The primary purpose of Upper and Lower St. Anthony Falls Locks and Dams is to provide navigation. The upper and lower locks are both 56 feet wide and 400 feet long. In a single lockage, this will accommodate a towboat (about the same length as a barge) and two barges (typically 35 ft by 195 ft). Filling and emptying time for the upper lock under normal conditions is eight minutes. Filling time for the lower lock under normal conditions is twelve minutes and emptying time is eight minutes. Lockage time depends on the experience of the deck hands breaking and making couplings, number of loaded and empty barges, wind speed and direction, and flow conditions. On average, a lockage takes 40 minutes at the upper lock and 30 minutes at the lower lock.

7-12. Drought Contingency Plans. Operation of the dam is run of the river. Therefore, rate of release change is nature driven. While not desirable, outflows may be reduced to zero to maintain navigation. A discharge of 2,000 cfs as measured at Anoka triggers the "drought watch" phase described in the Minnesota Department of Natural Resource's *Drought Response Plan*. In 1996, the *System-Wide Low-Flow Management Plan* was developed to address ramping rates at hydropower plants (**Exhibit E**). Xcel Energy is signatory to this document. Hydropower operations have the potential to cause large percentage changes in river flow. Hydropower plants are to ramp their changes in flow such that there is no more than a 10 percent change in flow over a two-hour period. During extreme low-flow events, Lower St. Anthony Falls Lock personnel are to monitor changes in outflow by Xcel Energy. If calculations show Xcel Energy has violated the rule, they are to contact Water Control as soon as possible. When the discharge at Anoka falls to 554 cfs, this triggers an automatic request to the

Governor related to water deficiencies. This discharge was based on the following:

Minneapolis Water Supply	125 cfs
St. Paul Water Supply	50 cfs
St. Cloud Water Supply	20 cfs
Brooklyn Center Water Supply	7 cfs
Xcel Energy Cooling Water	2 cfs
USAF Corps Lockages (1/hr)	350 cfs
Total	554 cfs

7-13. Emergency Action Plans. The Emergency Action Plan is a stand-alone document entitled *Emergency Plan for the Locks and Dams at St. Anthony Falls, Minneapolis, Minnesota*, March 1987. 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 Upper and Lower St. Anthony Falls Locks and Dams include structural damage, sabotage, extreme storm, excess seepage, and failure due to scouring.

Xcel Energy (formerly NSP) has created an *Emergency Action Subplan* for the St. Anthony Falls Hydroelectric Project. The subplan specifies notifications and other actions to be taken upon discovery of a pre-emergency or emergency condition at the project. The subplan is performed and coordinated with the Corps of Engineers' Emergency Action Plan for Saint Anthony Falls.

Other emergency situations not addressed in the Emergency Action Plan are barge incidents and chemical spills. Should a barge go into the dam at Lower St. Anthony Falls, Water Management is to be notified as soon as possible. Most likely, the manipulation of gates will be necessary to accommodate removal of the barge. All gate movements are to be coordinated with Water Management to reduce the potential for erosion of the channel bottom downstream of the dam. In the event of a chemical spill resulting from a barge incident or other disaster, the Lockmaster is to immediately notify the National Response Center. The telephone number is on the Emergency Notification Chart at the site. The Lockmaster is also to notify Water Management (651-290-5786) and the

Emergency Operations Center (EOC) at 651-290-5220. Water Management will coordinate with the lock site as well as Emergency Management and Environmental Branch.

There are no required flood protective measures for Upper and Lower St. Anthony Falls Locks and Dams. Structural components of both projects are located at elevations that are not threatened during high flood flows. During extremely high flows, as in the 1965 flood, sandbags can be placed to protect structures at risk.

A dam break analysis for Saint Anthony Falls was conducted as part of the 1987 *Emergency Plan for the Locks and Dams at St. Anthony Falls*. A dam failure analysis was done for the Standard Project Flood (SPF) and a normal pool failure. For the SPF failure, the discharge downstream increased from 157,000 cfs to 214,000 cfs. Because of the relatively low storage volume behind the dams the "with failure" hydrograph returned to the "without failure" hydrograph in about half an hour. The spike in flow was rapidly attenuated downstream. It was reduced to 180,000 cfs about a mile downstream and to about 171,000 cfs at Lock and Dam No. 1. The stage increase was approximately two feet at the Lower St. Anthony Falls to about one foot at Lock and Dam No. 1. For the normal pool failure, flow went from 7,500 cfs to 43,000 cfs. The stage increase was about 7.7 feet just below St. Anthony Falls, 3.0 feet at Lock and Dam No. 1, and 1.3 feet at the confluence of the Minnesota River.

7-14. Other. At Lower St. Anthony, ice or debris is typically passed by submerging a tainter gate on the moveable dam. While the main and auxiliary lock tainter gates can be submerged, they are rarely used for this purpose. At Upper St. Anthony, most ice and debris passes over the dam.

7-15. Deviation from Normal Regulation. Project pool elevations were established in 1937 when the Rivers and Harbors Act authorized the Upper Minneapolis Harbor Project. Xcel Energy maintains project pool for Upper St. Anthony as set forth in **Exhibit C**. Deviations are permitted for replacement of the flashboards and for repairs to the horseshoe dam when the target elevation is 796.6 feet is needed. The lowest allowed pool level is elevation 796.4 feet. A request for deviation should be submitted to Water Control verbally at 651-290-5786 two weeks prior to the desired start date.

The intermediate pool is very small and may occasionally drift outside of approved limits. Because these deviations are unplanned and are only temporary, they do not require notification to the Mississippi Valley Division (MVD) office, provided actions are being taken to correct the deviation. MVD must be notified when a deviation outside the normal operating limits is intentional and for a prolonged period of time. Planned deviations must first be coordinated with the District's Environmental Branch. Once the plan is coordinated within the District, it will be submitted to Division Water Management for approval. Minor deviations may be approved verbally whereas major deviations will require approval by Division Commander. All deviation requests should describe cause and effect. MVD will decide if the deviation is major or minor. The District Commander or Chief of Engineering Division may deviate from the approved plan in an emergency situation. The District is to inform MVD as soon as possible with a written confirmation of the deviation and description of the cause.

7-16. Rate of Release Change. The only guidelines for rate of release change apply when the measured discharge at Anoka drops below 2,000 cfs. Hydropower plants are to ramp their changes in flow such that there is no more than a 10 percent change in flow over a two-hour period. Other than this, there are no guidelines for rate of release change. Operation of the upper and lower dams 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 the Upper and Lower St. Anthony Falls Locks and Dams is to maintain a nine-foot depth in the navigation channel of the intermediate and upper pools. St. Anthony Falls Locks and Dams are just one piece of the lock and dam system that provides navigation as described in the Master Water Control Manual for the Locks and Dams. However on June 2015, due to the Water Resources Reform and Development Act of 2014, Upper St. Anthony Falls Lock and Dam was ordered non navigable. Both Upper and Lower St. Anthony Falls aid in hydro-electric generation.

8-02. Flood Risk Management. The locks and dams provide no flood control benefits. They were constructed strictly for navigation and hydroelectric purposes. The upper and lower dams operate on a run-of-river principal.

a. Spillway Design Flood (SDF). The Spillway at Upper St. Anthony Falls has a capacity of 48,000 cfs. As flows increase flow must be passed through the hydropower bays for an additional 4,000 cfs as well as the flood control gate within the lock chamber when flows are over 52,000 cfs. The design flood used was recorded in 1881 with a measured discharge of 73,500 cfs.
b. Other Floods. The Standard Project Flood (SPF) for both upper and lower St. Anthony Falls Lock and Dams utilized is 157,000 cfs. The Probable Maximum Flood (PMF) for both upper and lower St. Anthony Falls Lock and Dams utilized is 286,000 cfs. The Minimum Flow of record for both upper and lower St. Anthony Falls Lock and Dams utilized is 462 cfs recorded 1934.

8-03. Recreation. The project is not regulated for recreation purposes; however, it does provide recreational benefits. The three recreation qualities associated with the St. Anthony Falls Pools are fishing, bird watching, and boating. The St. Anthony Falls Locks and Dams **still** provides a benefit to recreational boating while the towing industries operations are slowed due to the non-navigable of Upper St.

Anthony Falls Lock and Dam. The more stable water surface provides a more suitable environment for docks and marinas. There were over 2,000 recreation boat lockages through the St. Anthony Falls locks in the year 2000.

Table 8-1 and **8-2** show a comparison of recreational to towboat lockages at Upper and Lower St. Anthony Falls Locks.

Table 8-1
Commercial & Recreational Lockages at Lower St. Anthony Falls Lock

Year	Towboats & Barges	Recreation Boaters	Other Lockages	Total Lockages	Percent Recreation
2008	1,000	920	36	1,956	47%
2009	772	1,104	84	1,960	56%
2010	813	1,155	35	2,003	58%
2011	837	865	66	1,768	49%
2012	607	742	21	1,370	54%
2013	1,365	470	7	1,842	26%
2014	1,009	552	24	1,585	35%
2015	899	405	8	1,312	31%
2016	626	250	2	878	28%
2017	622	209	0	831	25%
2018	721	85	0	806	11%
2019	471	57	0	523	11%
2020	98	67	0	165	40%

Table 8-2
Commercial & Recreational Lockages at Upper St. Anthony Falls Lock
***Lockage is no longer conducted at this site**

Year	Towboats & Barges	Recreation Boaters	Other Lockages	Total Lockages	Percent Recreation
2008	1,610	786	40	2,436	32%
2009	1,356	1,005	42	2,403	42%
2010	1,471	1,113	34	2,618	43%
2011	1,487	846	59	2,392	35%
2012	594	745	17	1,356	55%
2013	581	549	6	1,136	48%
2014	535	657	15	1,207	54%
2015	206	252	8	466	54%
2016	NA	NA	NA	NA	NA

8-04. Water Quality. The project is not regulated for water quality purposes. No benefits to water quality can be attributed to Upper or Lower Saint Anthony Falls.

8-05. Fish and Wildlife. Water Management activities have immediate as well as long term effects on fish and wildlife resources. Because there are no gates regulating water flow at Upper St. Anthony Falls and the Intermediate Pool is so small, operation of the locks and dams has less influence on fish and wildlife than operation of other Nine-Foot Navigation Project locks and dams. Upper and Lower St. Anthony Falls Locks and Dams are located in the 72-mile long Mississippi National River and Recreation Area, a unit of the National Park System. St. Paul Parks and the Minneapolis Park and Recreation Board own the shoreline and river bluffs for several miles upstream and downstream of the project. These riparian properties are part of the Mississippi Gorge Regional Park and are managed for recreation and resource preservation in cooperation with the National Park Service. The river reach here in this major metropolitan region represents a significant corridor of open space and habitat for both aquatic and terrestrial plants and animals. The corridor provides an important north-south wildlife corridor. A mixed species heron rookery, bald eagle breeding territories, and peregrine falcon breeding territories are present in Pool No. 1. Forty-seven bird species breed in the corridor and additional 100 bird species are known to occur in this corridor during migration. The Upper St. Anthony Falls locks have allowed fish to circumnavigate the Falls which historically served as a faunal barrier to their upstream dispersal. Mussels in their larval stage require fish as hosts and have also circumnavigated the Falls. As a result, species of fish and mussels have expanded their range into the Upper Pool from the lower reaches. Now an effective barrier exists at the Coon Rapids Dam. Albeit small, the Intermediate Pool supports a variety of fish and mussel species. In 1987, when the powerhouse at Lower St. Anthony Falls collapsed and the pool was lowered, many mussels were observed stranded (D. Wilcox, USACE, pers. comm.). No aquatic federally endangered species occur in the vicinity. Every Periodic Inspection the intermediate pool may be drawn down (see section **7-04f**).

Cumulative effects of the project maintenance would be minor. Aquatic macroinvertebrates exposed to the elements during drawdowns will likely be killed. Many of these macroinvertebrates are able to quickly recolonize. Some longer lived species, such as particular mussel species, take more time to recover. A drawdown every periodic inspection may prevent significant mussel colonization. However, due to the highly degraded habitat and the low abundance of specimens found in the area, it is unlikely that significant mussel colonization would occur in this area.

8-06. Water Supply. Minneapolis Water Works (MWW) provides water to the City of Minneapolis, Minnesota. MWW obtains all of their drinking water directly from the Mississippi River in Columbia Heights at approximately river mile 859.5. This is just above the upstream limit of the nine-foot channel project. No intake problems have been reported during low pool periods. Also as a side effect of the navigation mission the dams create steadier pools which can have beneficial effects on water supply users.

8-07. Hydroelectric Power. Xcel Energy owns and operates a run-of-river hydroelectric project at Upper St. Anthony Falls under FERC License No. 2056. The Xcel energy plant in the upper pool was in existence before the lock was built, so the power generation is not an effect of the project. The Hennepin Island Powerhouse is operated 24 hours a day, 7 days a week via automated controls. The project is designed to generate the maximum amount of power for the available head and discharge. The power generated by the project is utilized by surrounding cities. The average annual plant factor for the period 1991-1996 was 75.8 percent. Average annual gross energy production for the period 1988 to 1996 was 76,244 megawatt-hours. Total power plant capacity is approximately 12 MW. Lower Saint Anthony Falls power plant is a partnership of Brookfield Renewable Power and Nelson Energy under FERC License No. 12451. Lower Saint Anthony Falls project operates to produce approximately 63,300 MWh per year. The turbine generator technology utilizes low head environments by

working well in the existing structures and providing economic development revitalization of older dams in renewable hydroelectric generation.

8-08. Navigation. The Upper Minneapolis Harbor Project, which extended the Nine-Foot Navigation Channel by 4.6 miles and included the construction of Lower St. Anthony Falls Lock and Dam and Upper St. Anthony Falls Lock, was authorized in the Rivers and Harbors Act of 1937. Ultimately, the economic benefits overrode all other concerns. After completion of the project, river traffic increased from 2,400,000 tons in 1939 to the peak of 68,400,000 in 1976. Since that time Upper St. Anthony Falls barge traffic has declined drastically to the point that in 10 June 2015, The Upper St. Anthony Falls Lock closed. The Water Resources Reform and Development Act of 2014 called for the lock's closing due to continued decline of commercial barge traffic. **Table 8-3** and **8-4** show the recent history of tonnage commodities at Lower and Upper St. Anthony Falls Locks and Dams, respectively. The impact of Upper St. Anthony Falls Lock and Dam being non navigable is shown in the later years. As a result navigational benefits of both Upper and Lower St. Anthony Falls Lock and Dam are currently and are projected to be next to nothing. There is an ongoing disposition study being conducted concerning the public benefit and continued federal ownership of these projects as they are no longer fulfilling their primary purpose.

8-09. Drought Contingency Plan. There is no Drought Contingency Plan. Operation of the dam is basically run of the river. Therefore, rate of release change is nature driven. While not desirable, outflows may be reduced to zero to maintain navigation.

8-10. Flood Emergency Action Plans. Both lower and upper Saint Anthony falls have no flood control benefits. During flood events the dams are designed to pass as much inflow as possible to prevent inducing additional flooding upstream. Upper Saint Anthony Falls has a flood gate that is opened when flows reach 52,000 cfs

but the gate only serves to protect the Upper Saint Anthony Falls Lock and Dam from overtopping.

Lower Saint Anthony Falls has an extremely small pool and cannot retain water for flood control benefits. In the event of a flood all gates are pulled in accordance with **Table 7-4.**

During a flood emergency contact will be kept with E.O.C. (651-290-6166) as well as Water Management (651-290-5786).

8-11. Frequencies. St. Paul District developed a discharge-frequency relationship in 1989 for the Mississippi River near Anoka, Minnesota (ANKM5). It is presented in **Figure 8-1**. The Anoka gage is located upstream of Upper St. Anthony Falls Lock and Dam at Hwy 610 in Brooklyn Park, MN. The frequency curve is derived from regionalized statistics for the mean and standard deviation, based on drainage area relationships at this location.

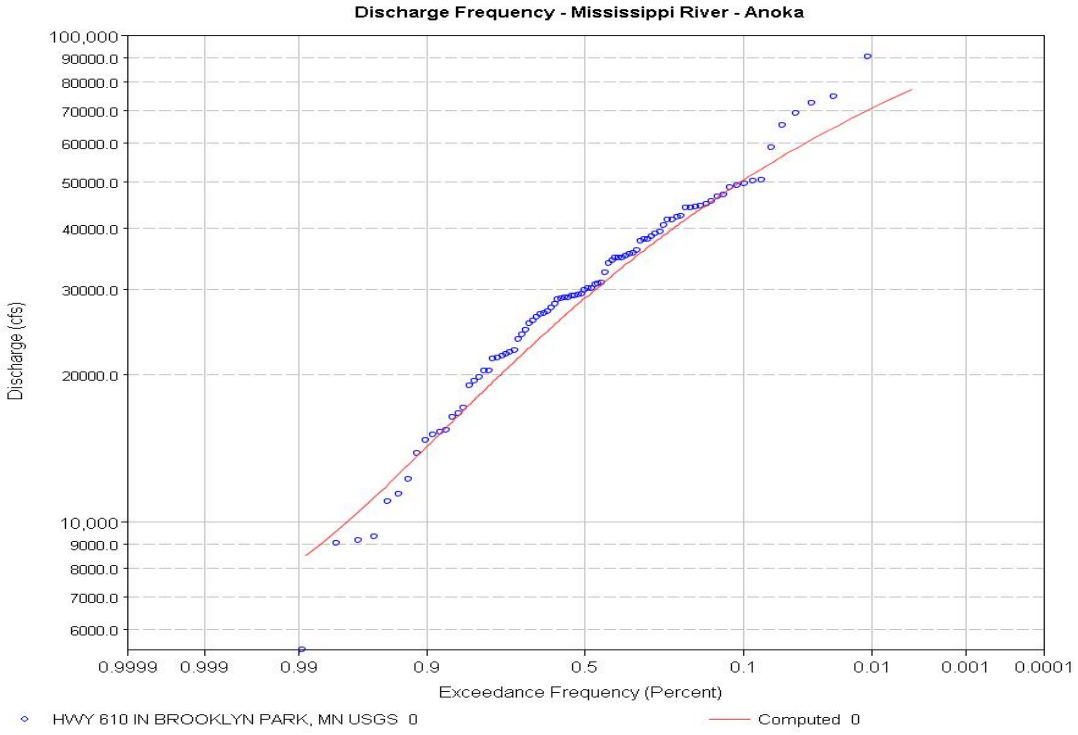


Figure 8-1. Discharge Frequency – Mississippi River Hwy 610 in Brooklyn Park, MN (1931-2020)

The upper horseshoe dam was constructed in 1856 and the upper lock was completed in September 1963. Construction of the lower dam was completed in November 1956, but operation of the lower dam did not begin until November 1958. **Figure 8-2** shows a history of the upper pool elevation. Note that the difference between the high elevation (~ 803 feet) and the low elevation (~ 797 feet) is only six feet. The lowest recorded pool elevation was 796.42 feet during the repairs to the horseshoe dam in August 2003. **Figure 8-3** shows a history of the intermediate pool. The greatest drawdown occurred in November 1987 when the pool was drawn down to elevation 735.50 feet for five days.

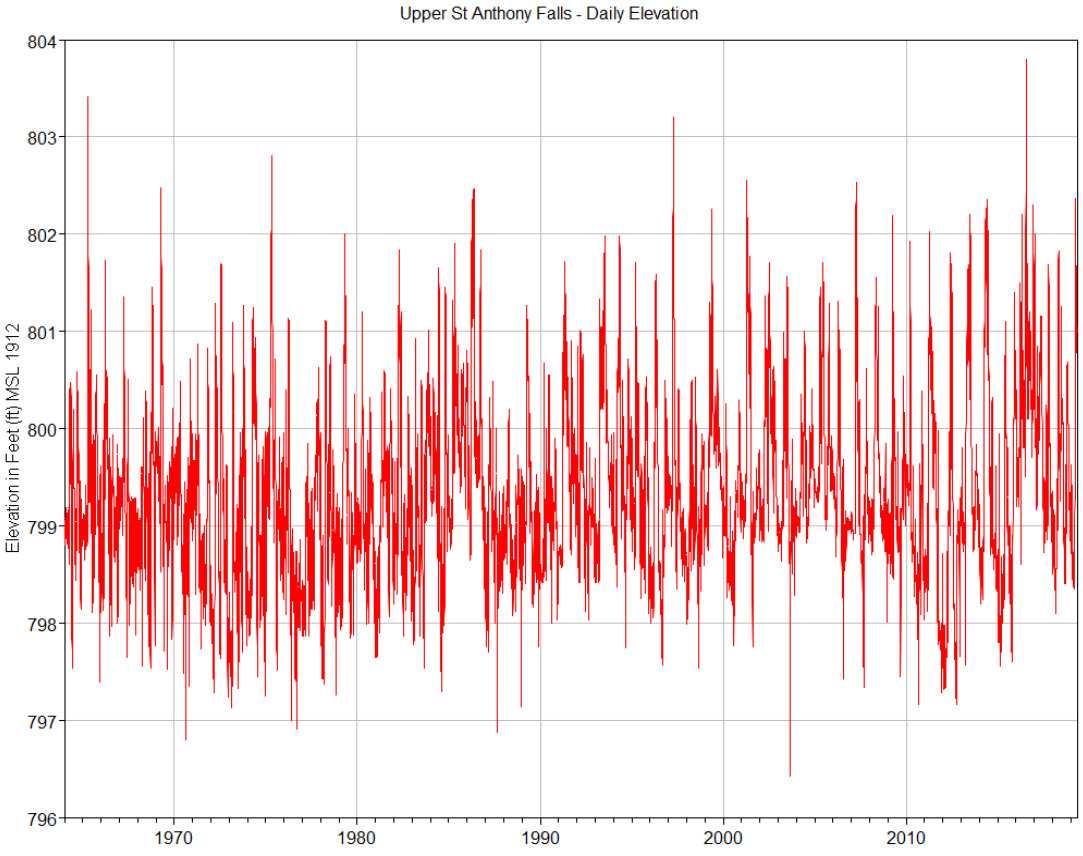


Figure 8-2. History of Upper Pool Elevation

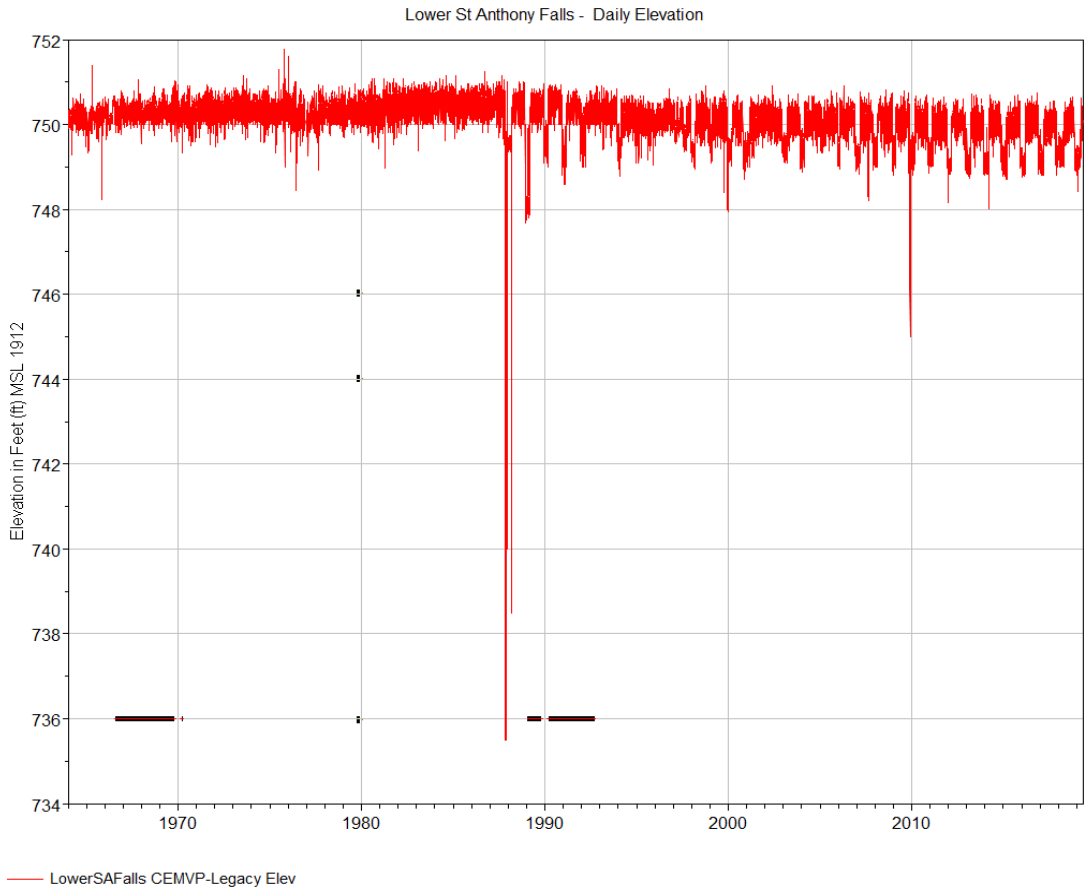


Figure 8-3. History of Intermediate Pool Elevation

8-12. Other Studies.

a. Example of regulation. A recent improvement for this location was an increase in forecasting ability due to the development of the Corps Water Management System (CWMS). This made it possible to create long range forecasted outflows for lower Saint Anthony Falls.

b. Channel and Floodway Improvement. Due to the closure of Upper Saint Anthony Falls Lock in 2015 this section of the river is a very low priority. Thus, as a result no channel improvements have been made since the last manual.

c. Miscellaneous Studies. In 2018 a flow frequency study was completed covering this area of interest. There was not a significant change from the previous flow frequency analysis. This study is cited in chapter one of this manual.

Table 8-3
Lower St. Anthony Falls Lock and Dam Tonnage – Commodities

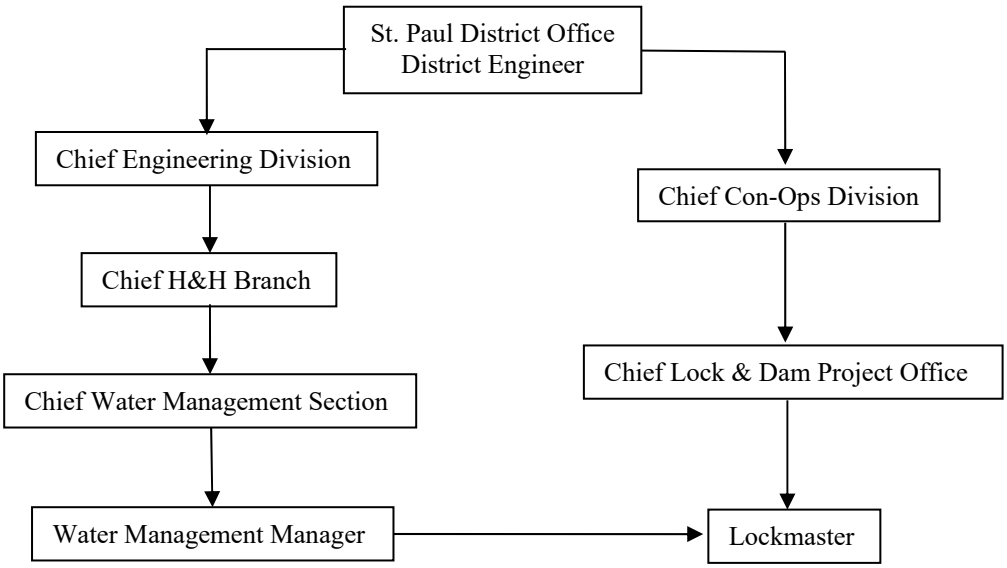
Year	Coal	Petrol Product	Chemical Products	Crude Material	Manu Goods	Farm Products	Equip Mach	Misc Product	Total Tonnage
2000	123,052	0	144,000	1,110,480	370,600	478,500	8,135	2,500	2,237,267
2001	86,350	0	172,500	1,089,401	220,750	238,500	6,987	0	1,814,488
2002	113,400	0	192,000	1,185,500	290,500	257,500	2,940	0	2,041,840
2003	123,100	0	352,500	1,191,500	96,000	165,000	5,702	10	1,933,812
2004	96,000	0	40,500	1,079,892	250,500	12,500	925	3,000	1,483,312
2005	99,000	0	13,500	999,000	27,700	12,000	2,396	4,500	1,158,096
2006	105,100	0	3,000	1,163,400	38,100	0	6,000	0	1,316,210
2007	87,000	0	3,000	867,000	25,500	0	9,143	1,500	993,963
2008	110,100	0	18,000	778,000	12,000	0	9,500	1,500	929,600
2009	87,000	0	45,000	538,380	7,575	0	14,515	4,000	696,470
2010	104,260	1,500	60,000	474,000	21,000	0	2,150	1,500	664,410
2011	89,600	9	53,800	586,400	24,000	0	5,344	0	759,153
2012	0	0	43,500	687,400	64,500	0	21,382	0	816,782
2013	12,050	0	45,000	697,500	58,500	0	8,100	0	821,150
2014	0	0	15,000	643,950	49,500	1,500	6,407	0	716,357
2015	0	0	1,500	279,000	12,000	0	3,735	0	296,235
2016	0	0	0	0	0	0	0	0	0
2017	0	0	0	0	0	0	6,000	0	0
2018	0	0	0	0	0	0	0	0	0
2019	0	0	0	0	0	0	0	0	0
2020	0	0	0	0	0	0	0	0	0

Table 8-4 Upper St. Anthony Falls Lock and Dam Tonnage – Commodities *Lockage is no longer conducted at this site									
Year	Coal	Petrol Product	Chemical Products	Crude Material	Manu Goods	Farm Products	Equip Mach	Misc Product	Total Tonnage
2000	123,052	0	141,000	1,111,500	369,600	483,200	7,712	2,500	2,238,564
2001	87,850	0	166,500	1,089,700	232,500	240,000	9,825	0	1,826,375
2002	112,350	0	193,500	1,186,500	290,000	256,250	4,100	0	2,042,700
2003	121,700	0	358,500	1,191,000	100,500	166,500	3,347	1,200	1,942,747
2004	96,000	0	40,500	1,073,392	264,000	15,500	5,147	0	1,494,539
2005	99,000	0	13,500	1,003,100	29,000	0	5,400	4,000	1,154,000
2006	106,600	0	3,000	1,147,600	39,670	0	18,900	0	1,315,770
2007	87,000	0	3,000	873,000	25,500	0	8,770	1,500	998,770
2008	107,100	0	18,000	789,000	15,000	0	11,700	1,500	942,300
2009	85,500	0	45,000	525,900	6,000	0	20,070	4,000	686,470
2010	106,125	1,500	57,000	474,500	19,500	1,500	3,810	0	663,935
2011	88,100	8	52,400	595,500	21,000	0	7,843	0	764,851
2012	0	0	45,000	690,400	58,500	0	21,290	0	815,190
2013	12,050	0	45,000	696,000	60,000	0	8,100	0	821,150
2014	0	0	15,000	646,550	46,500	1,500	2,409	0	711,959
2015	0	0	0	279,000	13,500	0	6,400	0	298,900
NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

IX – WATER CONTROL MANAGEMENT

9-01. Responsibilities and Organization.

a. Corps of Engineers. The Corps of Engineers is the owner, operator, and regulator for the Upper Lock and Lower Lock and Dam at St. Anthony Falls. Lock personnel at Lower St. Anthony Falls are responsible for the day-to-day regulation of the intermediate pool. Construction and Operations Division is responsible for operation and maintenance of the upper and lower locks as well as the lower dam. Note that Corps responsibilities end at the concrete non-overflow dam. Xcel Energy is responsible for the earthen dam that ties the structure to the left bank. The following shows the working relationship for the locks and dams within the St. Paul District.



b. Other Federal Agencies. During high water, the National Weather Service (NWS) forecasts stage heights for Minneapolis, at the water plant (MSPM5), and Highway 610 gage (formerly known as the Anoka gage) (AKAM5). Water Management provides the NWS with the daily output from the Mississippi Basin Modeling System to aid them in making their forecast. The US Geological Survey (USGS) maintains a gage site at Highway 610 (ANKM5), which is not to be confused with the NWS Anoka site (AKAM5). Daily stage and discharge values for the Highway 610 gage (formerly known as the Anoka gage) (ANKM5) can be obtained from "Agency Links",

"Federal Agencies", "USGS", "Minnesota current stream flow conditions" on the Water Management web site at **http://www.mvp-wc.usace.army.mil/** or at the national access to water website here **http://water.usace.army.mil/a2w/f?p=100:1:1.**

Upper and Lower St. Anthony Falls Locks and Dams are located in the 72-mile long Mississippi National River and Recreation Area, a unit of the National Park System.

c. **Local Agencies.** St. Paul Parks and the Minneapolis Park and Recreation Board own the shoreline and river bluffs for several miles upstream and downstream of the project. These riparian properties are part of the Mississippi Gorge Regional Park and are managed for recreation and resource preservation in cooperation with the National Park Service.

d. **Private Agencies.** At Upper St. Anthony Falls, Xcel Energy owns, operates, and maintains the St. Anthony Falls Hydroelectric Project. This includes the horseshoe dam, powerhouse, and other related facilities. Xcel Energy has direct day-to-day responsibility for maintaining the upper pool when flows are less than powerhouse capacity. They are also responsible for operating and maintaining the flashboard system that is mounted atop the horseshoe dam. At Lower St. Anthony Falls, Xcel Energy owns and maintains the non-overflow earthen dam that extends from the Corps' concrete non-overflow dam to the left bank. Brookfield Renewable Power and Nelson Energy are responsible for the hydropower facility in the auxiliary lock chamber.

9-02. Interagency Coordination.

a. **Local Press and Corps Bulletins.** Information concerning regulation of the St. Anthony Falls Locks and Dams is provided by the St. Paul District's Public Affairs Office (PAO) to the local news media in response to their requests. PAO coordinates with Construction and Operations Division and Water Management Section 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 with 14-day forecasted stage hydrographs of the Mississippi River tributaries daily by 0830-hours. The forecast includes the 24-hour quantitative precipitation forecast (QPF). These hydrographs and gridded precipitation data is input to the Corps Water Management Software (CWMS).

c. US Geological Survey. To maintain the vast network of stream gages for operation of the locks and dams in the St. Paul District would be a costly undertaking. Because of the existing infrastructure of the US Geological Survey (USGS), the St. Paul District enters into a cooperative agreement each year with the USGS to maintain many of the gages on the Mississippi River and its tributaries. As for the St. Anthony Falls Pools, this includes the Highway 610 at Mississippi River (formerly known as the Anoka Gage) (ANKM5). With the exception of the electronic tape gage (ETG), St. Paul District owns all the gage equipment. The USGS publishes the daily discharges for Highway 610 (formerly known as the Anoka Gage) annually as part of their *Water Resources Data – Minnesota*. Daily data can be obtained from the USGS web site at https://waterdata.usgs.gov/nwis/si.

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, Departments of Natural Resources of Minnesota, Iowa and Wisconsin, Departments of Transportation of Minnesota and Wisconsin, and representatives of the commercial navigation industry.

9-03. Interagency Agreements. There is an agreement with the National Park Service conducting tours within the visitor's center of Upper Saint Anthony Falls. The park service also maintains the bathroom facility and visitor center for recreational pedestrian visitors.

9-04. Commissions, River Authorities, Compacts and Committees. Bassett Creek Watershed Commission is responsible for the maintenance of the outlet of Bassett Creek with in the intermediate pool. This maintenance of the intermediate pool outlined within chapter **7-03** of this manual. This agreement is outlined in the Bassett Creek Operation and Maintenance manual.

9-05. Non-Federal hydropower. Xcel Energy owns and operates a run-of-river hydroelectric project at Upper St. Anthony Falls under FERC License No. 2056. Lower Saint Anthony Falls power plant is a partnership of Brookfield Renewable Power and Nelson Energy under FERC License No. 12451. The manner of operation of these two hydropower facilities are outlined in chapter **7-03 a.** of this manual.

9-06. Reports. Standardized reports created concerning or utilizing data form Upper and Lower Saint Anthony falls are outlined in Table **9-1** below:

Table 9-1
Standard Reports

Report	Frequency	Purpose
Situation Report	Bi-weekly	A brief upward reporting document. Designed to give a quick summary of the current state of hydrologic conditions within the St. Paul District.
Post Flood Report	Created by request	A report created to document a significant flooding event as well as the events leading up to it.

Exhibit A

PERTINENT DATA – LOWER LOCK AND DAM

Location: Lower St. Anthony Falls Lock and Dam is located on the Mississippi River, 853.4 river miles above the mouth of the Ohio River and 5.8 river miles above Lock and Dam No. 1. The lock is on the right bank of the river in Minneapolis, Minnesota at approximate latitude 44° 58' 43" N and longitude 93° 14' 45" W.

Drainage Area: 19,680 square miles

Datum: MSL 1912 adjustment
MSL 1912 - 0.41 = NAVD88

Moveable Dam:

Tainter Gates (3 Gates):	56 ft wide by 20.5 ft high
Tainter Gate Sill:	Elevation 731.0 feet
Tainter Gate Seal:	Elevation 728.5 feet

Auxiliary Lock (uncompleted):

Tainter Gate Only:	56 feet by 15.5 feet
Tainter Gate Sill:	Elevation 736.3 feet
Tainter Gate Seal:	Elevation 735.3 feet

Closure Dams:

Type:	Non-Overflow Concrete	Non-Overflow Earthen
Owner:	Corps of Engineers	Xcel Energy
Length:	230 feet	
Crest:	Elevation 755.0 feet	Elevation 757.0 feet
Top Width:	5 feet	

Lock:

Main Lock Chamber:	56 feet by 400 feet
Top of Lock Walls:	Elevation 755.0 feet
Top of Upper Gate Sill:	Elevation 736.3 feet
Depth on Upper Gate Sill:	13.70 feet (U.P. 750.0 feet)
Top of Lower Gate Sill:	Elevation 712.8 feet
Depth on Lower Gate Sill:	12.30 feet (L.P. 725.1 feet)
Lock Floor:	Elevation 711.8 feet
Height of Upper Tainter Gate:	15.2 feet
Height of Lower Miter Gates	39.7 feet

Pool:

Normal (Project) Intermediate Pool	Elevation 750.0 feet
Normal (Project) Lower Pool	Elevation 725.1 feet (flashboards in)
Pool Area (at Project Pool)	50 acres
Primary Control Point	Pool Gage

Notes:

1. Tainter gates at the moveable dam are submergible to 6 feet below Normal Pool (750.0 feet).
2. Tainter gates at the main and auxiliary lock are submergible to the gate sill elevation of 736.3 feet.

PERTINENT DATA – UPPER LOCK AND DAM

Location: Upper St. Anthony Falls Lock and Dam is located on the Mississippi River 0.7 river miles above Lower St. Anthony Falls Lock and Dam at 854.1 river miles above the mouth of the Ohio River and 3.4 miles below the upstream limit of the nine-foot channel project at river mile 857.5. The lock is on the right bank of the river in Minneapolis, Minnesota at approximate latitude 44° 58' 51" N and longitude 93° 15' 26" W.

Drainage Area: 19,680 square miles

Datum: MSL 1912 adjustment
MSL 1912 - 0.41 = NAVD88

Lock:

Lock Chamber Dimensions	56 feet by 400 feet
Top of Lock Walls	Elevation 806.0 feet
Top of Upper Gate Sill	Elevation 783.5 feet
Top of Lower Gate Sill	Elevation 736.3 feet
Lock Floor	Elevation 735.3 feet
Height of Upper Miter Gates	20.0 feet
Height of Upper Tainter Gate	15.7 feet
Height of Lower Miter Gates	67.2 feet

Pool:

Normal (Project) Upper Pool	Elevation 799.2 feet (flashboards in) Elevation 796.8 feet (flashboards out)
Normal (Project) Intermediate Pool	Elevation 750.0 feet
Pool Area (at Project Pool)	358 acres
Control Point	Upper Pool Gage

Horseshoe Dam:

Owner:	Xcel Energy
Type:	Gravity dam – concrete, timber, and rock
Overall Length:	2,045 feet
Length With Flashboards:	1,495 feet (Sections 3 through 8)
Length of Lock Approach:	550 feet (Section 2)
Crest Elevations:	
Sections 3 though 8:	798.8 feet with flashboards raised 796.8 feet with flashboards lowered
Section 2:	801.0 feet (lock approach)
Roll Dam:	
Type	Rock filled timber cribbing
Length	340 feet
Crest Elevation	791.5 feet
Main Spillway:	
Type	Gravity dam – concrete, timber, and rock
Length	425 feet
Crest Elevation	785.2 feet

Note: 1. The tainter gate in the upper lock chamber is maintained in the submerged position except during large flood events that require discharge through the lock.
2. Since 2015 the Upper St. Anthony Falls Lock and Dam was closed to navigation.

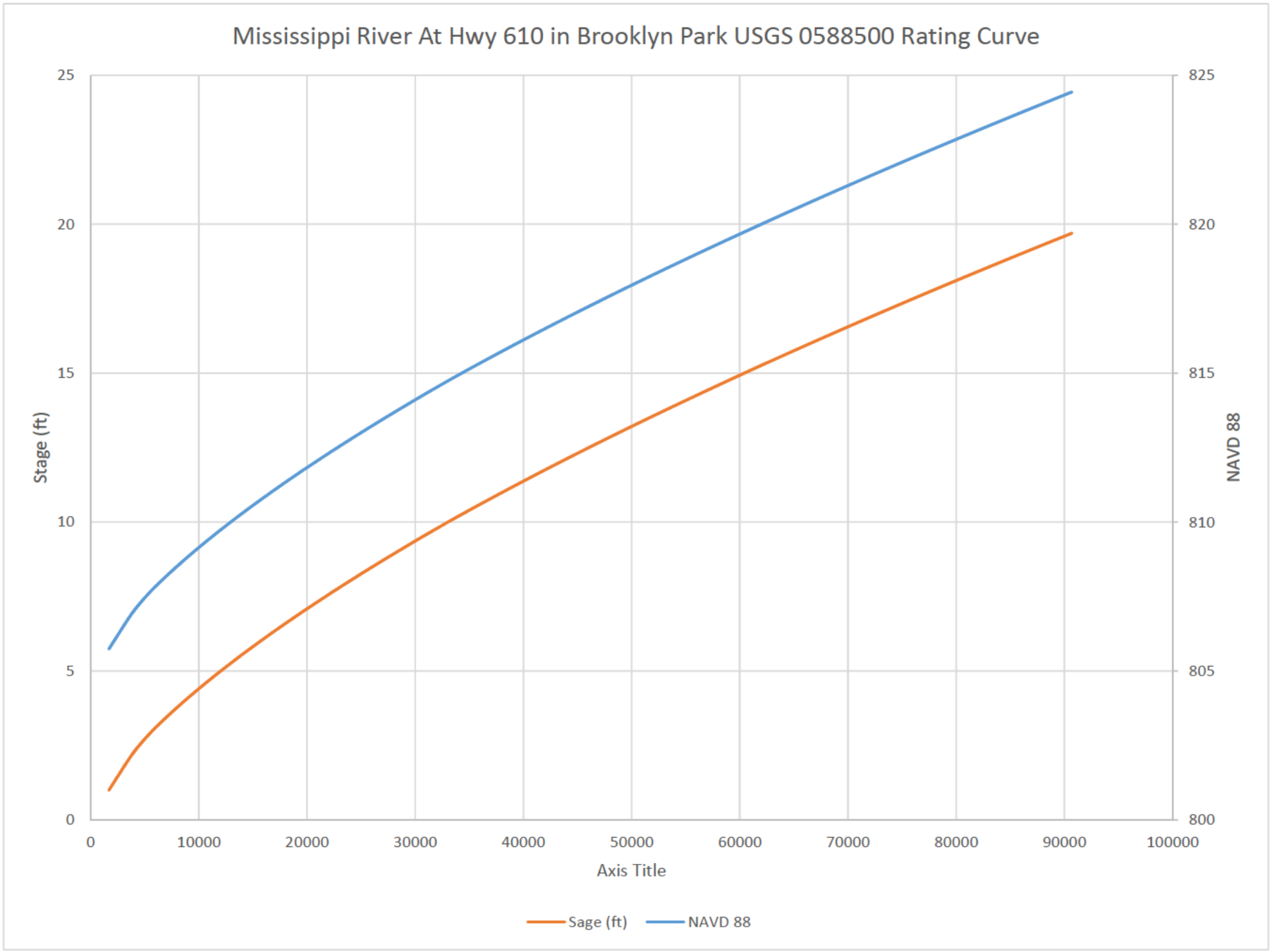

Mississippi River At Hwy 610 in Brooklyn Park USGS 0588500 Rating Curve
25
20
15
10
5
0
Stage (ft)
825
820
815
810
805
800
NAVD 88
0
10000
20000
30000
40000
50000
60000
70000
80000
90000
100000
Axis Title
Sage (ft)
NAVD 88

Exhibit B

EXHIBIT C

NSP

NORTHERN STATES POWER COMPANY

MINNEAPOLIS, MINNESOTA 55401

October 13, 1970

Colonel Charles I. McGinnis
District Engineer
U.S. Post Office and Custom House
180 E. Kellogg Blvd.
St. Paul, Minnesota 55101

Dear Colonel:

This letter concerns the plant control automation project at our Hennepin Island and Lower Dam Hydro Plants on the Mississippi River at Minneapolis. We have been in contact with Mr. Harich, Chief of the Regulating and Reservoir Section of the Corp of Engineers, and Mr. Platte, Lockmaster at the St. Anthony Locks, concerning the project. This letter will summarize some of our discussions for your information and possible dissemination to the St. Anthony Locks.

At present, the two plants are remote controlled from the Main Street substation. The automation project, to be completed in October of this year will remove the remote control. After automation, the new control will regulate the reservoir levels and therby the power output. Basically the control will accomplish what the remote control does now, but we will have a more efficient operation. This letter will cover the basic philosophy of the control and give the tentative operating limits at each plant.

Hennepin Island Hydro Plant

This control will sense the reservoir level above the St. Anthony Falls dam and will control the Hennepin Island Plant discharge to keep the reservoir level within our present operating limits. The upper reservoir limit is set at about elevation 799.2 and the lower limit is set at about 799.0. When either limit is reached, the control will adjust the plant's discharge to bring the reservoir level back into the control range. When in normal operation, we expect the level to slowly swing between the control limits over period of several hours. Only occasionally would the level stay constant within the control limits. If the water level should drop below elevation 798.6, then the control will shut down all units until the level is restored. If the level should rise to 799.5 then the control will

alarm. If the reservoir level should reach either alarm point the controls will send a remote alarm to our Riverside Steam Plant switchboard. Riverside will also receive the additional alarms listed below but will not have any controls for the plant. When a level alarm is received, the Riverside operator will dispatch an operator to make the necessary corrections after first checking with the locks on water levels.

At the lower river flows, the plant will automatically increase the generated power for daily system peak load periods and then restore the pond level during the off peak hours by cutting back on the generated output. Our peak load periods vary with the season and, as is our present practice, we will usually have the reservoir level restored by the next morning.

The Hennepin Island Alarms and tentative alarm settings sent to Riverside are as follows:

Alarm	Elevation
High reservoir level	799.5
Low reservoir level	798.6
All available machines at Full gate	Above 4500 cfs river flow
Electrical Lockout	Generator Electrical Fault
Control Malfunction	Loss of control voltages or air supplies
Plant Trip	Electrical fault or high trash buildup on racks
High trash rack differential	Trash buildup on racks causing units to run back

Summary of The Tentative Control Settings and elevations at Hennepin Island

Elevation	Point
799.5	Remote Alarm high level
799.2	Upper control limit
799.0	Lower control limit

Elevation	Point
798.6	Rapid runback of units and remote alarm
798.5	Peaking stop point
796.8	Dam Crest

When the dam flashboards are lost the dam crest will become the control level until a flow of about 6000 cfs is reached. At this time the control levels will be changed. After about 6000 cfs the St. Anthony crew will replace the flashboards as soon as possible and then we will again control at the normal levels.

Lower Dam

Because of the small reservoir at the Lower Dam Plant, the control is faster and should respond much faster than the present remote control. The control will attempt to keep the Lower reservoir within our normal operating limits below elevation 750.3. Because of the rapid pond oscillations caused by lockages and discharges from Hennepin Island the limits will often be exceeded. However, any time the level exceeds either the high or the low band limit the control will respond at a faster rate until the level is restored. Whenever the flows are above about 5500 cfs the lower locks will control the level with the dam tainter gates. At the request of Mr. Platte we have installed light indication equipment mounted on the river side of the plant. This light indication will tell the locks how many units are running and, when all available units are at full gate. Amber colored lights blink continuously when all available units are at full gate and signal the lower locks that they are to control the water level.

The Riverside Switchboard will also have the same alarms from Lower Dam as Hennepin Island.

Above river flows of 5500 cfs the locks will have control of the reservoir and to prevent the Lower Dam unit's control from working against the lock control our controls will lock out until a low water elevation of 749.0 is reached. At this point the Lower Dam plant control will again regulate the pond. The lower locks will be able to tell when our plant takes over control because they know the river flow conditions and the light indication will stop blinking.

As agreed with Mr. Harich, the Lower Locks will continue to seal the gates at elevation 750.5 At flows up to about 20,000 cfs Mr. Harich thought the locks could control the pond level about elevation 750.5 At higher flows the surcharge from the dam starts to flood out the ' University Hydraulic Laboratory. When this happens, Mr. Harich thought the Locks would control at a lower level to help the Hydraulics Laboratory. At this time we will change our control limits to correspond to the newer level the locks will use. We have summarized the tentative control settings and elevations below.

Elevation	Function
751	High pond alarm
750.5	Gate seal and gate control level
750.4	Fast lower control point
750.3	Upper control level of the normal control band
750.0	Lower control level of the normal control band
749.5	Fast raise pond control point
749.0	Remote alarm and take over control point after the locks has control.

The main concern in the design of this control was to protect navigation from extreme low levels at each reservoir. However, if some emergency should arise we ask that the locks take over control and manipulate the pond in whatever way they can and then notify Northern States Power Company. If any navigation is in danger in the lower pool they can even discharge water into the lower pool by filling and emptying the upper locks. The locks should not worry about our plants during emergency conditions because the plants are fully protected.

Our plants will be attended during weekdays 0800 to 1600 hours. During this time, we ask the locks to contact the St. Anthony Office at 330-5847, or if no answer contact any one at the Hennepin Island Plant 330-6166 or Lower Dam Plant 330-6093. For help when unattended, the locks should call the Riverside Switchboard. The Riverside number is 330-5990 or 789-3124.

During high flow periods, we will usually have a maintenance man at the plants around the clock for handling the river trash. Our maintenance men will know how to take emergency action in the unlikely event of a low pool at either plant and can be reached at any of the above plant numbers if on duty.

Yours very truly,

L. O. Mayer, P.E.
Manager of Power Production

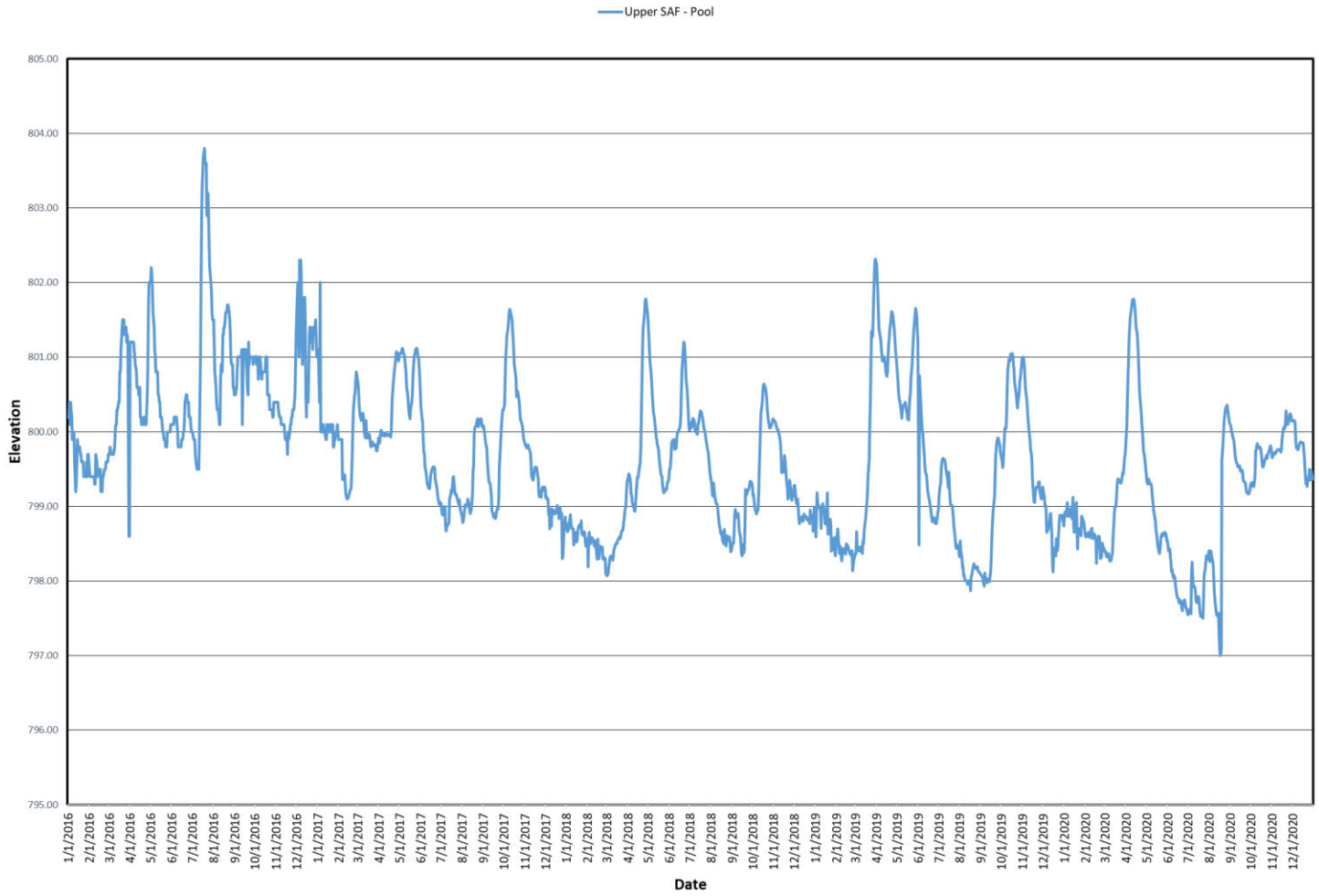
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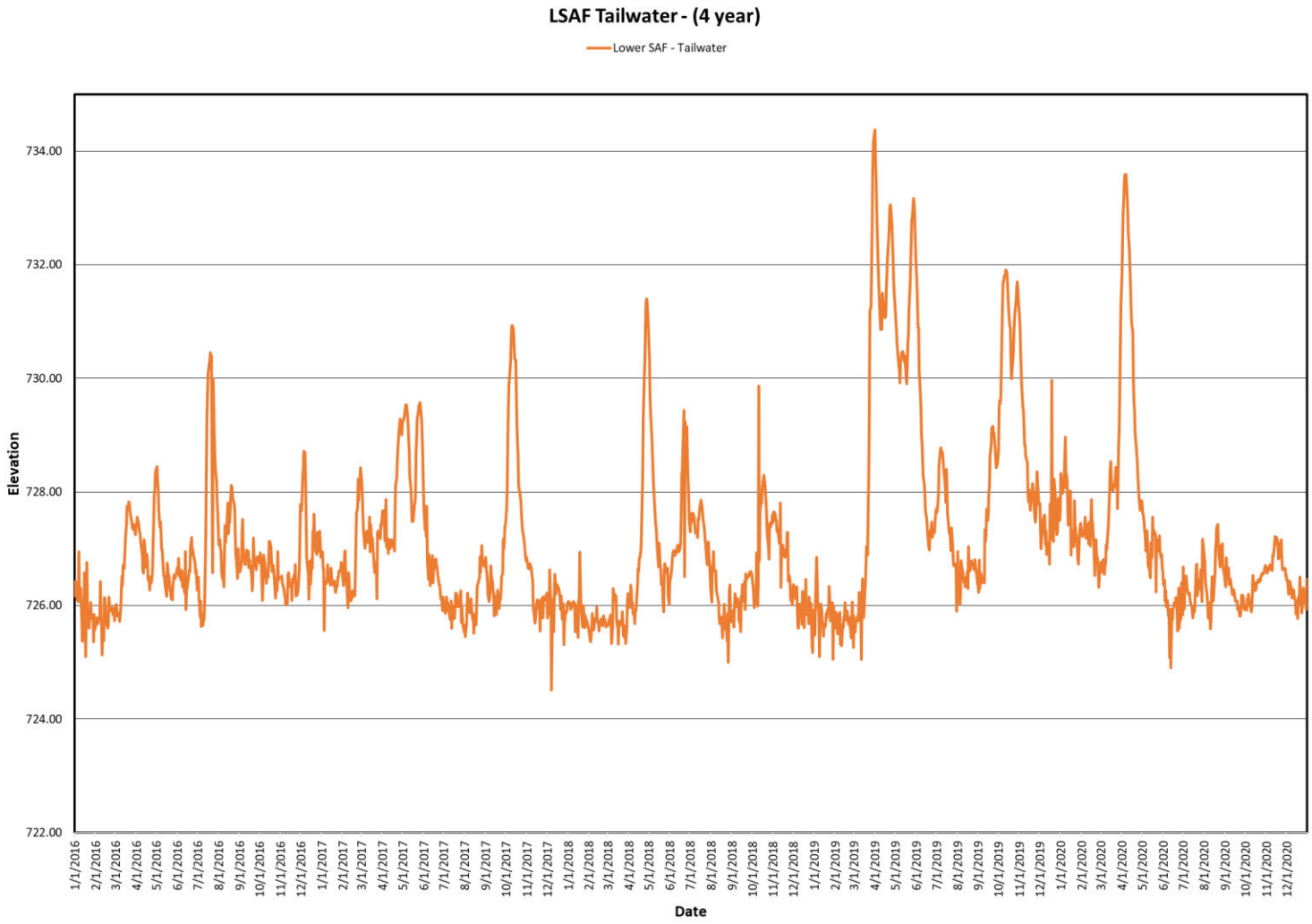
D. A. Freund, P.E.
Supervising Engineer-Electrical

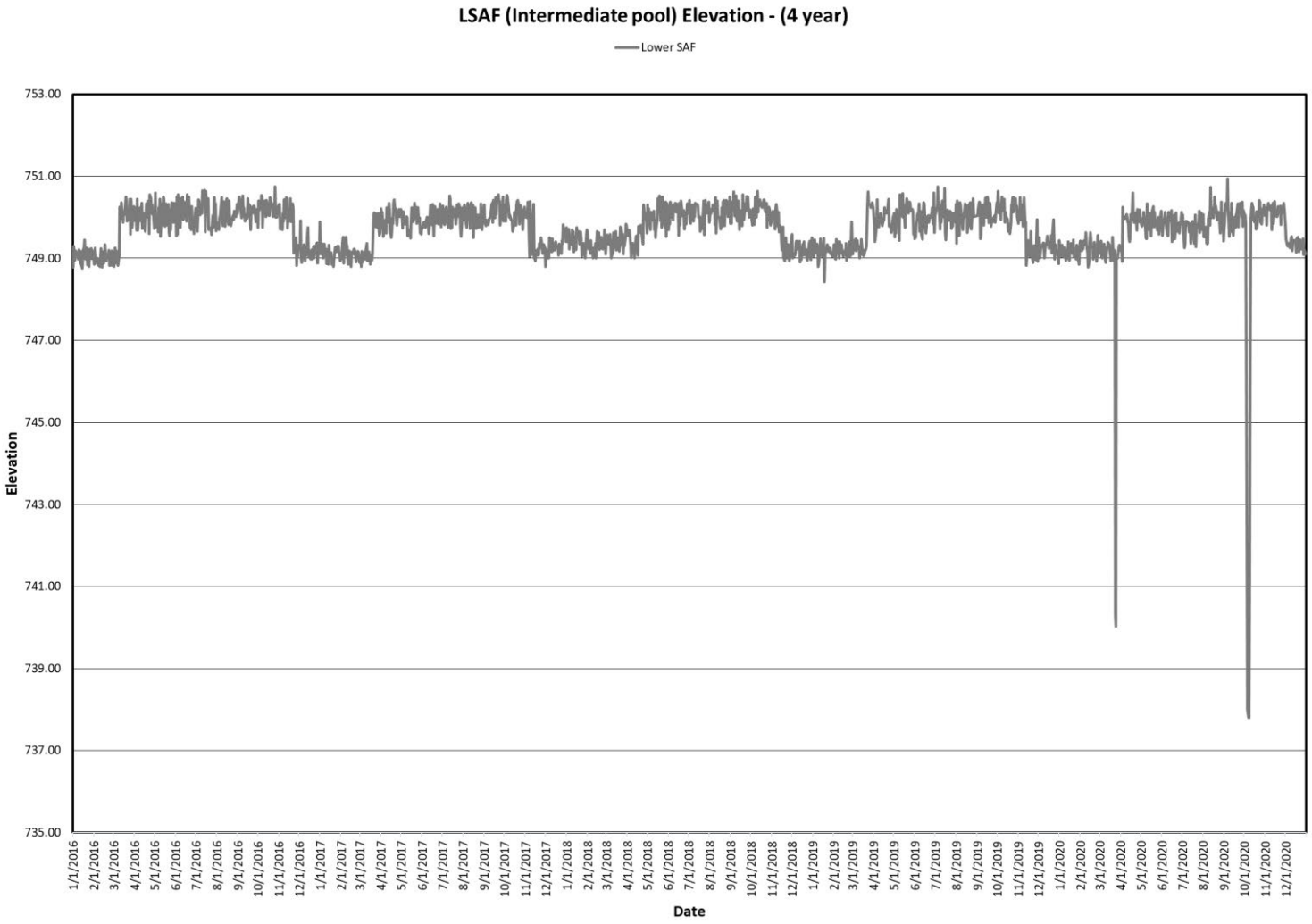
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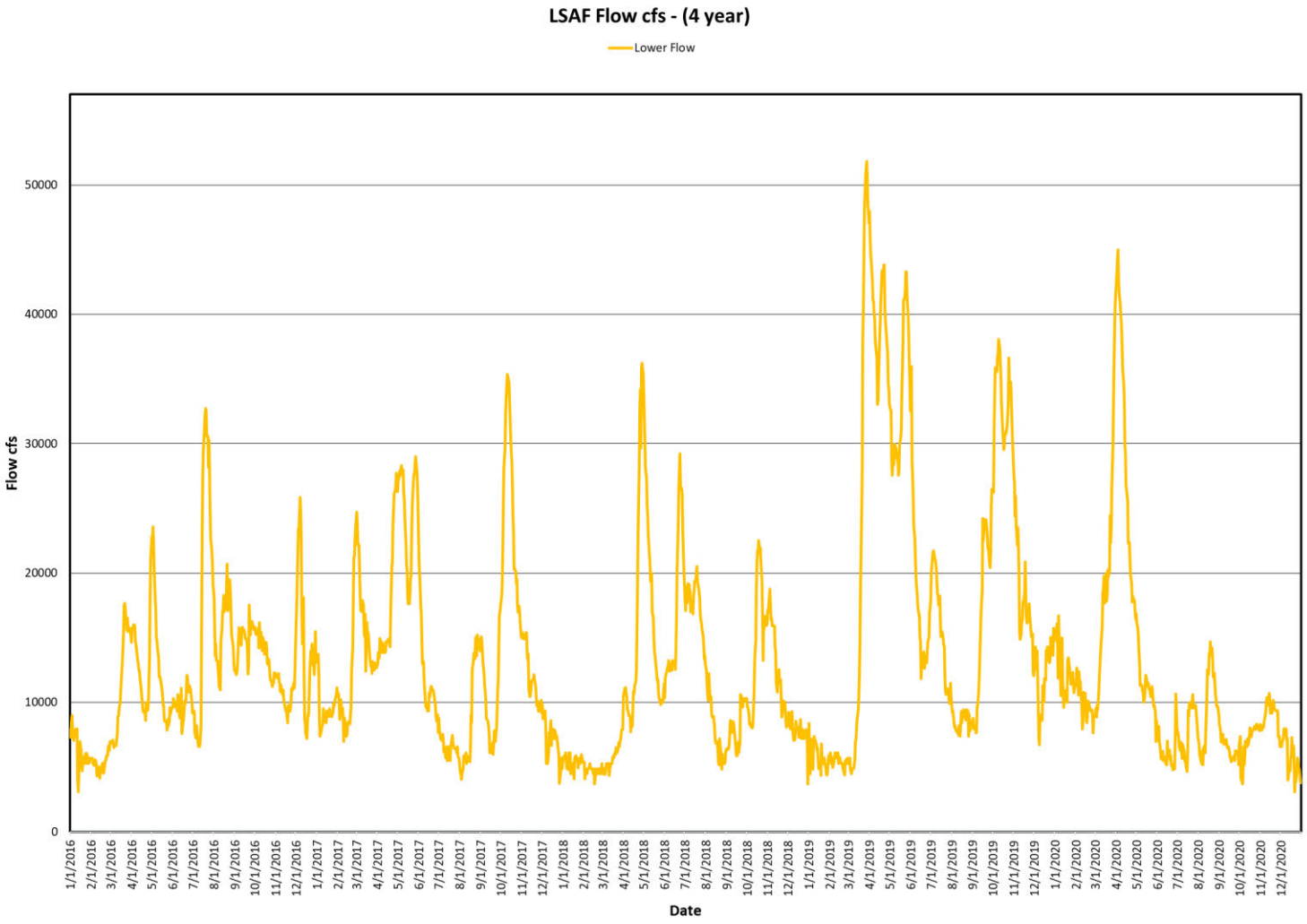
cc: L. F. Wadsworth
H. M. Brandes
G. A. Headrick

USAF Elevation - (4 year)




LSAF Tailwater - (4 year)
Lower SAF - Tailwater
Elevation
734.00
732.00
730.00
728.00
726.00
724.00
722.00
Date
1/1/2016
2/1/2016
3/1/2016
4/1/2016
5/1/2016
6/1/2016
7/1/2016
8/1/2016
9/1/2016
10/1/2016
11/1/2016
12/1/2016
1/1/2017
2/1/2017
3/1/2017
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4/1/2019
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6/1/2019
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8/1/2019
9/1/2019
10/1/2019
11/1/2019
12/1/2019
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3/1/2020
4/1/2020
5/1/2020
6/1/2020
7/1/2020
8/1/2020
9/1/2020
10/1/2020
11/1/2020
12/1/2020


LSAF (Intermediate pool) Elevation - (4 year)
Lower SAF
753.00
751.00
749.00
747.00
745.00
743.00
741.00
739.00
737.00
735.00
Elevation
1/1/2016
2/1/2016
3/1/2016
4/1/2016
5/1/2016
6/1/2016
7/1/2016
8/1/2016
9/1/2016
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5/1/2020
6/1/2020
7/1/2020
8/1/2020
9/1/2020
10/1/2020
11/1/2020
12/1/2020
Date


LSAF Flow cfs - (4 year)
Lower Flow
Flow cfs
50000
40000
30000
20000
10000
0
1/1/2016
2/1/2016
3/1/2016
4/1/2016
5/1/2016
6/1/2016
7/1/2016
8/1/2016
9/1/2016
10/1/2016
11/1/2016
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9/1/2019
10/1/2019
11/1/2019
12/1/2019
1/1/2020
2/1/2020
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11/1/2020
12/1/2020
Date

System-Wide Low-Flow Management Plan
Mississippi River above St. Paul, Minnesota
Revised June, 2015

Introduction

During extreme low-flow events on the Mississippi River above St. Paul, Minnesota, hydropower operations and adjustments to reservoir control structure gates have the potential to cause large percentage changes in river flow. Large flow fluctuations, especially during periods of low flow, can have significant negative impacts on instream fish and wildlife, and create water supply problems for downstream (as well as upstream, within the same reservoir) users. Droughts and associated low flows are inevitable, but artificial flow fluctuations can exacerbate the negative impacts.

Purpose

The hydropower facilities on the Mississippi River licensed by the FERC are required to operate "run-of-river", meaning that instantaneous inflow equals instantaneous outflow to the greatest possible extent. The purpose of this low-flow plan is to help ensure that "run-of-river" operations are strictly maintained during periods of low flow to minimize artificial flow fluctuations and protect the aquatic resources and other values of this nationally important river. Collaboration with other water users has proven to be instrumental in communicating the potential for negative impacts on their operations. Other water users include (upstream to downstream) Sherco Generating Station, Monticello Nuclear Generating Plant, City of St. Paul, City of Minneapolis and the Riverside Generating Plant. Other water users being added to the plan in the St. Anthony Upper Pool area include the Minneapolis Park Board and the University of Minnesota's St. Anthony Falls Laboratory.

Planning Process

Prevention of artificial flow fluctuations was raised as an issue during the federal relicensing process for several hydropower facilities on the Mississippi River. The current Federal Energy Regulatory Commission (FERC) licenses for the Rapids Energy Center (previously known as Blandin Paper) facility at Grand Rapids, (the Brainerd Dam, previously known as Potlatch Corporation, Missota Paper and Wausau), and Minnesota Power at Little Falls require development of a low-flow management plan in cooperation with the U.S. Army Corps of Engineers (USACE) and the Minnesota Department of Natural Resources (DNR).

To facilitate coordinated, system-wide planning, the DNR and the USACE co-sponsored a meeting of hydropower operators in Brainerd on September 20, 1995. All the hydropower representatives agreed to participate in a low-flow planning effort. A follow-up meeting was held in Brainerd on February 28, 1996. Participants agreed that improved communication among operators of both hydropower facilities and dams, and access to good flow information, were important in achieving the goals of this low-flow planning effort.

Additional meetings have been held (2004, 2007, and 2010, 2014 with Upper St. Anthony Falls participants and water users, and 2015) in order to keep the lines of communication updated and open-ended.

Plan Update/Revision

River conditions are monitored by the DNR during periods of low flow to evaluate how well this plan is being implemented and whether it achieves the purpose of minimizing artificial fluctuations in river flow. When the need for plan updates or revisions becomes evident, the DNR will facilitate a plan review process in cooperation with Mississippi River hydropower facility and dam operators. This year's revision includes Appendix A (page 7) which will be a log and description of previous revisions.

2015 Need and Overview for Revisions

The three purposes of this March, 2015 plan revision are:
1) to acknowledge new ownership of and update signatures from the Sartell (International Paper now owned by Eagle Creek Renewable Energy), Brainerd, and the Ford Dam (now owned by Twin Cities Hydro) facilities;

2) to coordinate a communication plan among the water users in the St. Anthony Falls upper pool (in October 2014 a meeting was held at the City of Minneapolis water softening plant in response to low flow issues experienced there in 2013. It was found that not only do upstream gate changes impact downstream flows, but that downstream changes in the same pool can have huge effects as well.); and

3) to revise trigger flows (on the matrix) for more consistency (due to the varied periods of record for the USGS gages), and to better represent increased flows in the last 10 years). New triggers:

- Grand Rapids – 400 cfs (unchanged)
- Brainerd – 900 cfs (up from 800)
- Royalton – 1500 cfs (gage change because Ft. Ripley not maintained)
- St. Cloud – 1700 cfs (up from 1400 cfs)
- Bklyn Park @ 610 – 2300 cfs (previously known as the Anoka gage; up from 2000).

Other minor revisions made in the document simply correct outdated information.

Low-Flow Operating Principles

1) Trigger Flows

This plan will be in effect when the instantaneous river flow is at or below the trigger flow at ANY of the gage sites listed in the attached matrix.

Trigger flows for this plan are measured at the closest active United States Geological Survey (USGS) gaging station and roughly approximate the annual 90% exceedance flow at each gage. (The 90% exceedance flow or Q90, is also the current "minimum flow" level used by the DNR Waters for suspension of certain surface water appropriations. The original trigger flow of 2000 cfs at Anoka (renamed by the USGS in 2014 as Mississippi River at Hwy 610 in Brooklyn Park, MN) corresponded to the “drought watch” phase described in the DNR Drought Response Plan.

The question has come up regarding the variability between the original Trigger Flow and the Q90 values. The gage records do not cover the same period of record and it has been suggested that we re-evaluate the flows with similar periods of record. DNR worked with the USGS to come up with more consistent trigger flows. We are proposing changes to the trigger flows due to changing conditions since the mid 1990’s, and to provide consistency in implementing the plan.

USACE: The USACE has adopted low-flow guidelines for the headwaters reservoirs (including Winnibigoshish and Pokegama) that are triggered by reservoir water levels. The guidelines suggest minimum release flow values for various reservoir levels. The minimum release flow values for the Winnibigoshish and Pokegama Dams (based on an Order of the Commissioner of Conservation, State of Minnesota dated April 19, 1963) were originally shown in the attached matrix in place of trigger flows. However, for consistency and clarity, the trigger flow of 400 cfs at Grand Rapids is now shown for the USACE reservoirs, and the minimum release information is included under the “NOTES” column of the matrix.

2) Reservoir Operating Bands

As stated above, all of the hydropower facilities are required to operate "run-of-river". Moderate incremental adjustments in gate settings and turbine operations are performed to mimic natural inflows to a facility and provide relatively stable reservoir levels and gradually varied flow conditions downstream. Reservoir operating bands are specified in most FERC hydropower licenses. Where no operating band is currently prescribed for a gated reservoir, the operating band for the purpose of this plan is normal pool $\pm$0.25 feet. Reservoir operating bands are contained in the attached matrix.

3) Ramping Rates

Ramping rates limit the artificial changes in flow through the facility so that sudden, unexpected increases or decreases in river flow can be avoided. Where no ramping rate is currently prescribed, the ramping rate for the purposes of this plan is no more than a 10% gradual change in flow over a two-hour period. Ramping rates are

contained in the attached matrix. These ramping rates apply to artificial increases and decreases in flow through the facility.

Due to equipment failure or variation in precipitation across the state, flow could drop to trigger or near-trigger levels on certain reaches of the Mississippi River while remaining within a normal range on other reaches. Operators and the USACE will notify all participating facilities immediately, and DNR as soon as possible, whenever emergency circumstances cause or require a deviation from the ramping rates set forth in this plan.

4) St. Anthony Falls Upper Pool

In early October 2012, the Minneapolis Water Fridley Plant experienced a loss of suction when the river elevation reached 795.9 at their intakes (85.6 local gage reading). River flows at the Brooklyn Park gage were in the 1700-2400 cfs range at the time. In response to the incident, stakeholders, including Minneapolis Water, USACE, Xcel, USGS and DNR, decided to include Minneapolis Water in the communication protocol for this Low Flow Plan. The USGS has established a new 3-season stream gage 05288670 at the raw water pump station named 'Mississippi River abv 37th Ave. NE in Fridley, MN' (http://waterdata.usgs.gov/mn/nwis/uv?05288670). As of March 2015, stage information is currently available, but discharge data will not be available until a stage-discharge relation is established at the site. (Stage at Minneapolis Water's intake is more important than flow from perspective of maintaining submergence on pump suction.)

There are changes in river flows and reservoir elevations at the Minneapolis Water Plant in Fridley that occur naturally (i.e., flooding) or from man-made fluctuations (i.e., replacement of flashboards). Xcel Energy shall notify the Minneapolis Water Plant directly of events in their control that would reduce the reservoir level enough to significantly impact operations. Problems at the Water Plant begin to occur at an elevation of 86.0 ft (local gage datum) or at an elevation of 795.9 ft. (datum unknown) at the Water Plant. The reduced reservoir levels may be due to the replacement of dam flashboards or other dam maintenance work that may be required. Xcel Energy will also notify stakeholders via the Facility Operators Log for the System-Wide Low-Flow Management Plan. Minneapolis Water operations staff will also use the log to record its activities that affect river flows and the Upper St. Anthony pool elevation.

Communication

Phone numbers for key organizations and agencies are listed in the table at the end of this document. Additional phone numbers and e-mail addresses for facility operators and phone numbers for gaging stations with remote access are contained in the matrix. Agency internet addresses that may be useful are:

USGS Real-Time Flow data:	http://waterdata.usgs.gov/mn/nwis/ current?type=flow
USACE Real Time:	http://rivergages.mvr.usace.army mil/WaterControl/new/layout.cfm
DNR Climate Data:	http://climate.umn.edu/
NWS River Information for MN:	http://water.weather.gov/ahps/region.php?state=mn

Click on relevant river gage point for
- Current readings and forecast
- Probabilistic forecast for low flow levels (click "how low can the water get" link)

The DNR Division of Ecological and Water Resources (EWR) will provide a general alert to all Mississippi River facilities when river conditions are receding and there is a likelihood that flow will fall to the trigger flow value at any of the Mississippi River gages used in the attached matrix. Facility operators will notify DNR EWR when the instantaneous flow is within 10% of the trigger flow value at their particular facility.

Again, operators and the USACE will notify the next downstream (and adjacent) facilities immediately, and DNR Division of EWR as soon as possible, whenever emergency circumstances (or planned construction activities) cause or require a deviation from the operating criteria set forth in this plan. Emergencies include emergency power demands made under the Mid-Continent Area Power Pool Agreement. E-mail correspondence is encouraged for notification purposes, allowing all facilities to learn of conditions both upstream and downstream of their facilities.

DNR Website: This Plan, and an interactive matrix, will be posted on the DNR-sponsored web page, http://www.dnr.state.mn.us/waters/surfacewater_section/stream_hydro/mississippi_low_flow_links html. When low-flow conditions are identified (and during any flow conditions if desired), Hydro Operators shall log all

flow changes immediately on the "Facility Operator Input Form" (riverpowerapp) linked from the web page. This log will serve as a communication tool as well as a record of past operations.

NWS Chat Room Opportunity: If the hydro operators can access this system they would be able to communicate easily with each other 24/7. The website is https://nwschat.weather.gov/ and the specifics for participating are on that page. There is a separate "chat room" for hydropower operators to access.

USGS Opportunity to be alerted to Trigger Flows: All USGS streamgage data in Minnesota are transmitted hourly. Consequently, a relatively new USGS application allows users to access the latest streamgage data. Subscribing to USGS WaterAlert enables users to be automatically notified via SMSText or email when flows exceed their user-defined threshold. Subscribers may go to http://water.usgs.gov/wateralert/, or subscribe by clicking on the "WaterAlert" button on the streamgage web page. With a smartphone, sending a text message to waternow@usgs.gov with the USGS station identifier in the message body will return the latest stage and discharge readings from the streamgage.

Record Keeping

Several FERC-licensed facilities already are required to maintain records of flow and headwater and tailwater elevations on an hourly basis during all flow conditions. This documentation is especially important during periods of low flow. All facilities agree to ensure that records of flow and headwater and tailwater elevation are maintained on an hourly basis when flow at their facility is less than the trigger value.

USACE Operations

The St. Paul District Army Corps of Engineers is committed to managing the six Mississippi River Headwaters Reservoirs at Lake Winnibigoshish, Pokegama Lake, Leech Lake, Big Sandy Lake, Cross Lake, and Gull Lake consistent with the operating principles contained in this low-flow plan, except when compliance with this plan would be inconsistent with existing federal mandates (with the understanding that USACE facilities are not subject to FERC or DNR regulatory jurisdiction). The USACE will end lockages through the Upper St. Anthony Falls Lock and Dam on June 10, 2015 as mandated by the Water Resources Reform and Development Act of 2014. The USACE may have to restrict lockages through Lower St. Anthony Falls Lock & Dam and Lock & Dam #1 during periods of low flow. The decision to restrict lockages would be coordinated through the Corps' Locks and Dam Project Manager's office, and any adjacent and downstream hydropower facilities.

Participating Parties

The following parties (listed upstream to downstream on pages 5-6) have participated in the development of the System-Wide Low-Flow Management Plan for the Mississippi River above St. Paul originally dated September 1996 and revised March 11, 2004, and agree to make good faith efforts to implement its provisions (individual signature pages for all Parties to this Plan are included and made a part of this agreement):

This document is a copy of the most recent update available as of November 2019

For future reference updated versions of this Low Flow Management Agreement will be made available at the following link:

https://files.dnr.state.mn.us/natural_resources/climate/drought/Mississippi_River_Low_Flow_Management_Plan.pdf

MnDNR Waters
judy.boudreau@dnr.state.mn.us

STANDING INSTRUCTIONS TO THE PROJECT OPERATORS FROM WATER MANAGEMENT

PROJECT UPPER AND LOWER ST. ANTHONY FALLS

1. Background and Responsibilities.

    a. General Information. These Standing Instructions to the Project Operator for Water Management are written in compliance with Paragraph 9-2 of EM-1110-2-3600 (Engineering and Design, Management of Water Control Systems) and with ER 1110-2-240 (Engineering and Design, Water Control Management). A copy of these Standing Instructions must be kept on hand at the project site at all times. Any deviation from these Standing Instructions will require approval of the District Commander.

    b. Project Purposes. The St. Anthony Falls lock and dams were authorized for navigation under the River and Harbors Act of 1930 (PL 71-250). This was expanded to include recreation under the Flood Control Act of 1944 (PL 78-534). The Water Resources Reform and Development Act of 2014 ordered the Upper St. Anthony Falls lock to close due to continued decline of commercial barge traffic and environmental efforts. The Upper St. Anthony Falls lock is still authorized for flood mitigation.

    c. Chain of Command. Regulation of the intermediate pool at Lower St. Anthony Falls (LSAF) is the responsibility of the Corps of Engineers. At Lower St. Anthony Falls the Project Operator is responsible to the Water Manager for all water control actions. In the instance of Upper St. Anthony Falls Xcell Energy is responsible to the Corp Project Operator who is then responsible to the Water Manager for water control actions. Daily communication with Water Management is not necessary.

    d. Structure. Lower St. Anthony Falls Lock and Dam is located on the Mississippi River, 853.4 river miles above the mouth of the Ohio River, and 5.8 river miles above Lock and Dam No. 1. Upper St. Anthony Falls Lock and Dam is located on the Mississippi River 0.7 river miles above the lower lock, 854.1 river miles above the mouth of the Ohio River, and 3.4 miles below the upstream limit of the nine-foot channel project at river mile 857.5.

    e. Operation and Maintenance (O&M). In the upper pool is the St. Anthony Falls Hydroelectric Project is owned, operated, and maintained by Xcel Energy. Only the lock chamber and associated facilities as well as channel protection are operated and maintained by USACE St. Paul District.
    At lower St. Anthony Falls all associated operation and maintenance is the responsibility of USACE St. Paul District. For Additional information see chapter 7.

    f. Role of the Project Operators.
    Upper St. Anthony Falls. Water Control will direct the opening of the lock tainter gate to flow during high water events. Because of damage to the lock chamber when passing flow, opening of the lock chamber may be delayed depending on the forecasted inflow hydrograph. The operating plan calls for opening gate when the discharge exceeds

40,000 cfs; however, if the forecast indicates inflow will only exceed 40,000 cfs for a brief period of time, the lock chamber may remain closed. If inflow is forecasted to be over 52,000 cfs, it is very likely that Water Control will direct opening of the gate.

Lower St. Anthony Falls. Gate operation is to follow a sequential order. For flows below 6,200 cfs all flow will be directed through the hydropower. During this low flow the hydropower will regulate the pool to maintain the pool between elevations 749.0 feet and 751.0 feet. Between flows of 6,201 cfs and 36,000 cfs, gates 1 through 3 will be used to regulate and the hydropower will be at full capacity. Flow is to be balanced across these three gates with no gate differential greater than one-foot. The project pool elevation of 750.0 feet (1912 adjustment) will be targeted; however, the pool will be allowed to fluctuate between elevations 749.0 feet and 751.0 feet. When flow exceeds 36,000 cfs, the hydropower turbines are pulled and the auxiliary gate draft tubes are to be opened. Flow is to be balanced across these four gates. As flow continues to increase, these four gates are opened in an effort to maintain a maximum pool elevation of 751.0 feet. When all the gates are raised clear of the water, and the pool is allowed to climb to elevation 751.5 feet after which the main lock gate is to be opened. At this time discharge will be around 60,000 cfs. The remaining four gates are to be placed back into the water and the flow is to be balanced across the five gates. The pool is to be maintained between elevation 749.0 and 751.0 feet. If discharge continues to increase, all gates are raised until they are all clear of the water. See Table 7-2.

2. Data Collection and Reporting

   a. General. The Corps of Engineers is required to maintain pool and tailwater elevations at all lock and dam projects. Lower St. Anthony Falls (LSAF) pool and tailwater gages are located in concrete gage houses on the upper and lower guide walls (Figures 5-1 and 5-2). The gages are stilling wells that feed their information back to the Central Control Station (CCS) where it is recorded on a PAV-C Strip Chart (Figure 5-4). Because the intermediate pool is so short, LSAF's pool gage serves as the tailwater gage for Upper St. Anthony Falls (USAF). At USAF, both Xcel Energy and the Corps of Engineers have pool gages. The Corps' gage is a stilling well located beneath a trap door in the guide wall (Figure 5-3). Like LSAF, information is sent back to the CCS where it is recorded on a PAV-C Strip Chart (Figures 5-4 and 5-5).

   b. Daily Reporting. Water Management archives the data electronically into individual files. The data is also manipulated into an electronic "daily log sheet for St. Anthony Falls Locks and Dams". It is available from the Water Management website at http://www.mvp-wc.usace.army.mil/ or at the national access to water website here http://water.usace.army.mil/a2w/f?p=100:1:1. Table 5-2 lists the data, the data intervals, and the start time for each data set. All 0800-hour data is actually collected at 0600-hours. Max-min air temperature is taken at 1900-hours.

   c. Gage Verification. The Project Operation should perform gage reading verification by comparing the pool level automated instrumentation gage reading and staff gage readings. This should be completed on a regulate basis, Water Management suggest at least once weekly.

d. Regional Hydro-Metrological Conditions. Topography for the St. Anthony Fall's pools watershed consists of a large amount of paved surface area. Heavy rainfall events can make a substantial increase in short term flows and flash flood scenarios. While wind may not have any significant impact on the intermediate pool, it definitely impacts pool levels at USAF. Because of the bluffs along the river, winds tend to be channeled either up river or down river. See Chapter 4 for additional information.

3. Water Control Action and Reporting.

a. Normal Conditions. The Project Operator should follow the relevant Water Control Manual for normal water control actions covered in chapter 7. Daily communication with Water Management is not necessary. Both Upper and Lower St. Anthony Falls maintain a logbook that includes most of the daily operational information. Lower St. Anthony Falls (LSAF) does project data entry for both sites via a remote computer. The data entry interval varies from once a day to every four hours. Four-hour data includes elevations for the Xcel Energy (NSP) pool gage, the Corps' upper pool gage, the intermediate pool, the lower tailwater, and the discharge. Four-hour data begins at 0400-hours. Xcel Energy calls LSAF every day at midnight with that day's pool elevations.

b. Emergency Conditions. The Emergency Action Plan is a stand-alone document entitled *Emergency Plan for the Locks and Dams at St. Anthony Falls, Minneapolis, Minnesota*, March 1987. 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 Upper and Lower St. Anthony Falls Locks and Dams include structural damage, sabotage, extreme storm, excess seepage, and failure due to scouring.

c. Inquiries. All significant inquiries received by the Project Operator from citizens, constituents, or interest groups regarding water control procedures or actions must be referred directly to Water Management or Public Affairs Office as soon as practical.

d. Water Control Problems. In the event of equipment malfunction or if additional computational support is needed by the Project Operator please contact Water Management. Below is the relevant contact list.

Water Control Personnel and Relevant Telephone Numbers

Name	Cell Phone	Office Telephone
[redacted]		
E.O.C. 24-hour	NA	651-290-5220
Xcel Energy	NA	612-330-6166

U.S. ARMY CORPS ENGINEERS

UPPER MISSISSIPPI RIVER

MISSISSIPPI VALLEY DIVISION



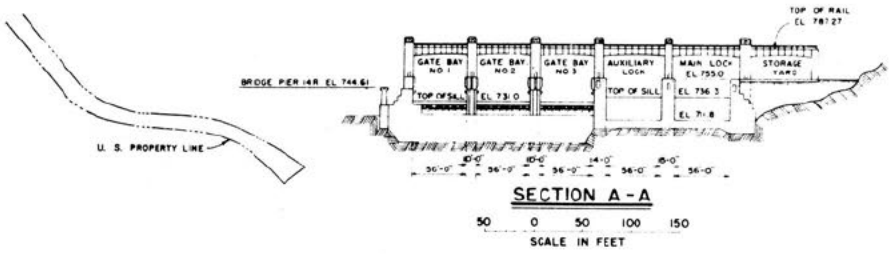
2019

BUOY POSITIONS ON CHARTS ARE APPROXIMATE, SEE NOTICE IN LEGEND

SCALE : 1" = 2000'

0 2,000 4,000 6,000 Feet

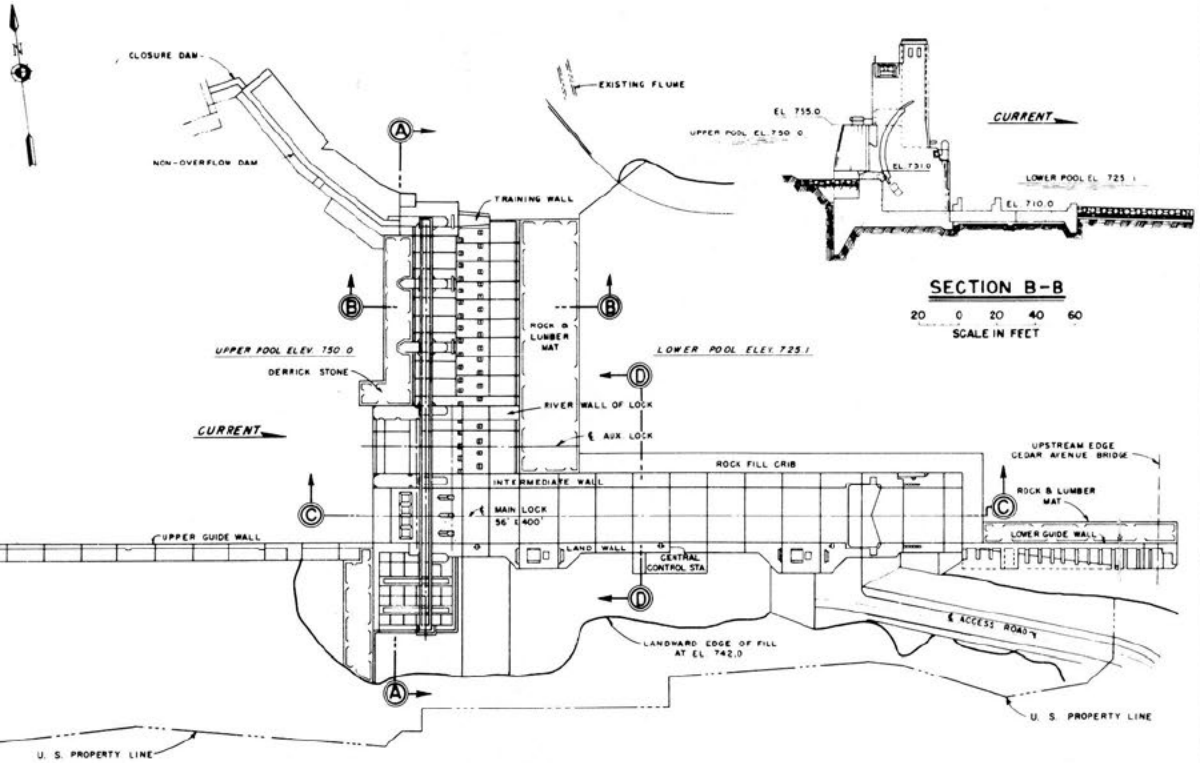
Plate 2-1



SECTION A-A

50 0 50 100 150

SCALE IN FEET



PLAN

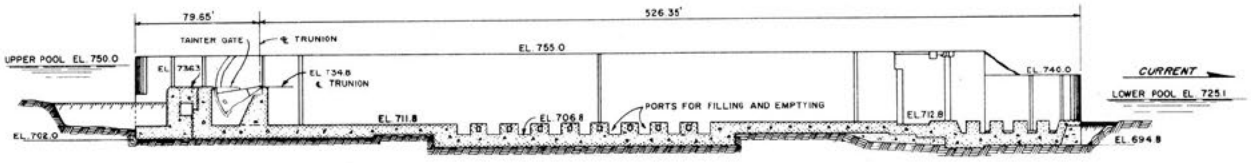
50' 0 50' 100' 150'

SCALE IN FEET

SECTION B-B

20 0 20 40 60

SCALE IN FEET



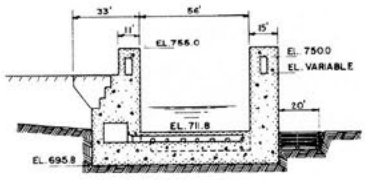
SECTION C-C

30' 25' 0 50' 100'

SCALE IN FEET

DEPTH ON UPPER GATE SILL	13.70	(U.P. EL. 750.00)
DEPTH ON LOWER GATE SILL	12.30	(L.P. EL. 725.10)
ELEVATION UPPER GATE SILL	736.30	
ELEVATION LOWER GATE SILL	712.80	

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



SECTION D-D

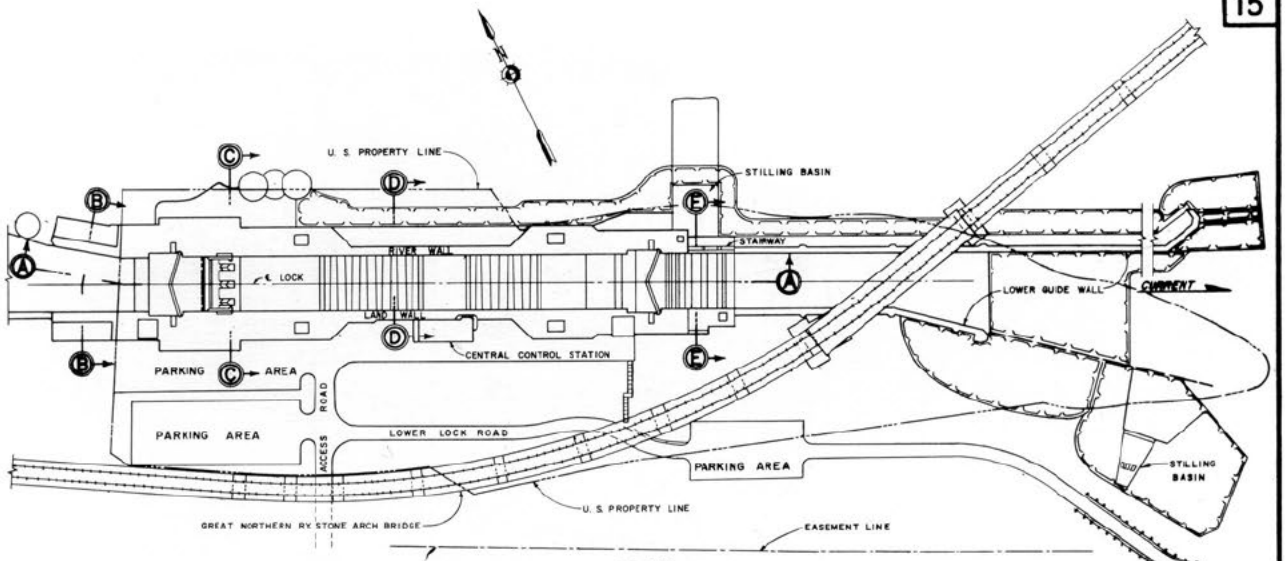
40' 20' 0 40' 80'

SCALE IN FEET

Upper Mississippi River
Nine-Foot Navigation Project

Lower St. Anthony Falls
Cross Sections

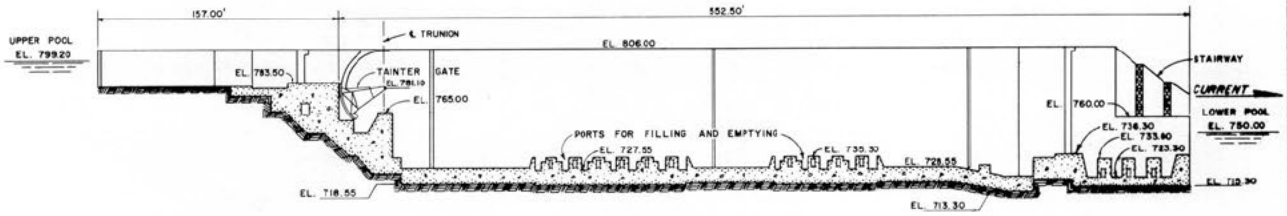
US Army Corps of Engineers
St. Paul District - 30 Sept 1988



PLAN

50 0 50 100 150

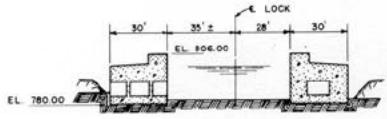
SCALE IN FEET



SECTION A-A

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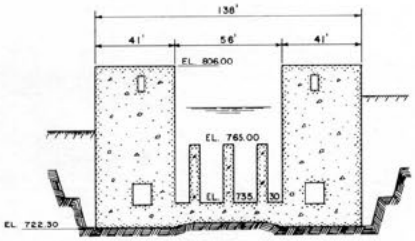
SCALE IN FEET



SECTION B-B

40' 20' 0 40' 80'

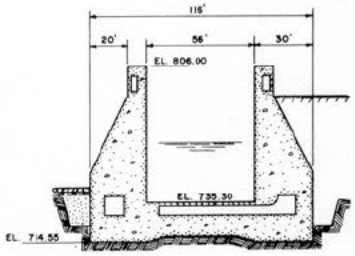
SCALE IN FEET



SECTION C-C

40' 20' 0 40' 80'

SCALE IN FEET



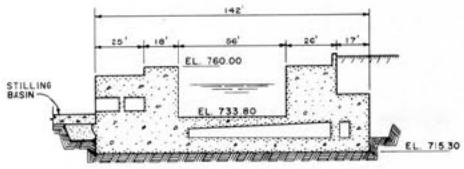
SECTION D-D

40' 20' 0 40' 80'

SCALE IN FEET

DEPTH ON UPPER GATE SILL	15.70	(U.P. EL. 799.20)
DEPTH ON LOWER GATE SILL	13.70	(L.P. EL. 750.00)
ELEVATION UPPER GATE SILL	783.50	
ELEVATION LOWER GATE SILL	736.30	

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



SECTION E-E

40' 20' 0 40' 80'

SCALE IN FEET

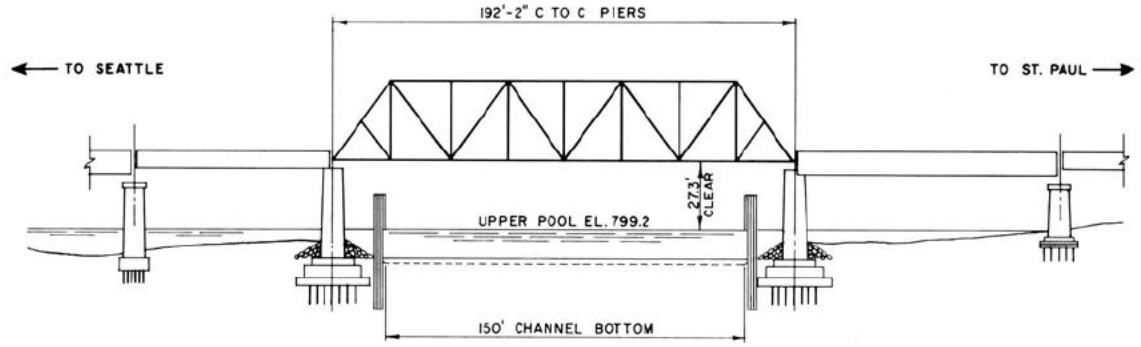
Upper Mississippi River
Nine-Foot Navigation Project

Upper St. Anthony Falls Cross Sections

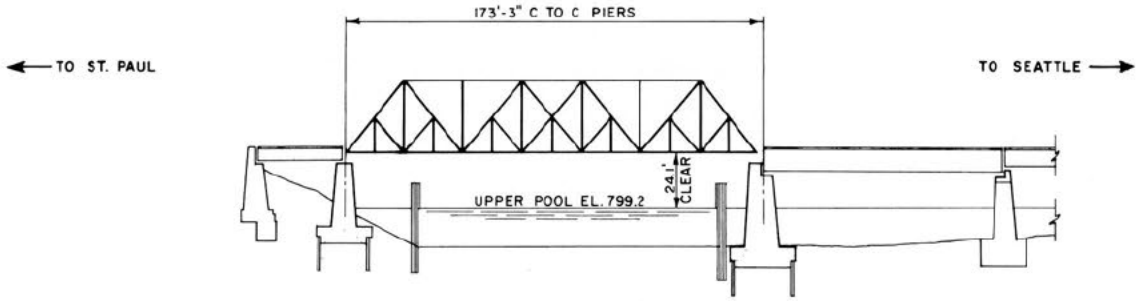
US Army Corps of Engineers
St. Paul District - 30 Sept 1977

Plate 2-3

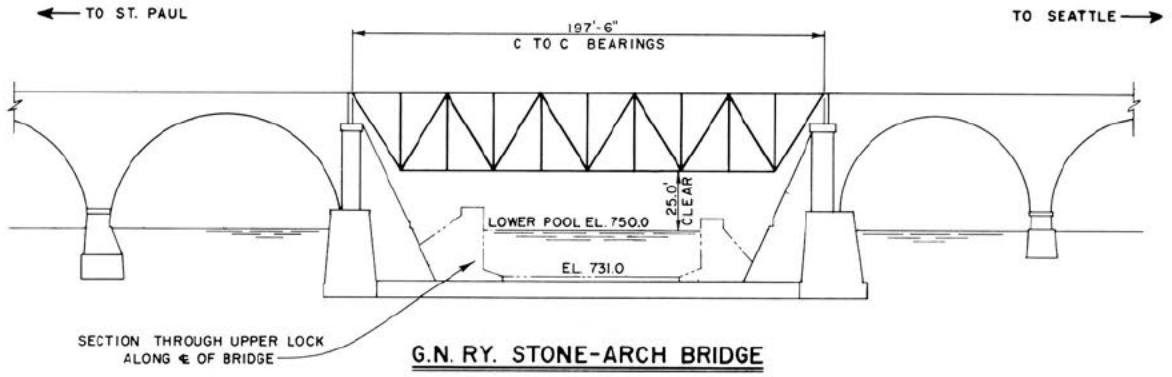
15A



UPPER N.P. RY. BRIDGE



UPPER G.N. RY. BRIDGE



G.N. RY. STONE-ARCH BRIDGE

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

Upper Mississippi River
Nine-Foot Navigation Project

Saint Anthony Falls
R.R. Bridge Alterations

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

Legend

Elevation

- -6.08 - -4.99
- -7.169 - -6.08
- -8.259 - -7.169
- -9.349 - -8.259
- -10.438 - -9.349
- -11.528 - -10.438
- -12.617 - -11.528
- -13.707 - -12.617
- -14.797 - -13.707
- -15.886 - -14.797
- -16.976 - -15.886
- -18.066 - -16.976
- -19.155 - -18.066
- -20.245 - -19.155
- -21.335 - -20.245
- -22.424 - -21.335
- -23.514 - -22.424
- -24.604 - -23.514
- -25.693 - -24.604
- -26.783 - -25.693
- -27.872 - -26.783
- -28.962 - -27.872
- -30.052 - -28.962
- -31.141 - -30.052
- -32.231 - -31.141
- -33.321 - -32.231
- -34.41 - -33.321
- -35.5 - -34.41

N W E S

Upper Mississippi River
Nine-Foot Navigation Project

St. Anthony Falls
2015 Lock and Dam Soundings
Intermediate Pool

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

0 0.1 0.2 0.4 0.6 0.8 Miles

Plate 2-5

Legend

Elevation

- -9.817 - -9.58
- -10.055 - -9.817
- -10.292 - -10.055
- -10.53 - -10.292
- -10.767 - -10.53
- -11.005 - -10.767
- -11.242 - -11.005
- -11.48 - -11.242
- -11.717 - -11.48
- -11.955 - -11.717
- -12.192 - -11.955
- -12.43 - -12.192
- -12.667 - -12.43
- -12.905 - -12.667
- -13.142 - -12.905
- -13.38 - -13.142
- -13.617 - -13.38
- -13.855 - -13.617
- -14.092 - -13.855
- -14.33 - -14.092
- -14.567 - -14.33
- -14.805 - -14.567
- -15.042 - -14.805
- -15.28 - -15.042
- -15.517 - -15.28
- -15.755 - -15.517
- -15.992 - -15.755
- -16.23 - -15.992

N W E S

Upper Mississippi River
Nine-Foot Navigation Project

Upper St. Anthony Falls
2015 Lock and Dam Soundings
Upper Pool

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

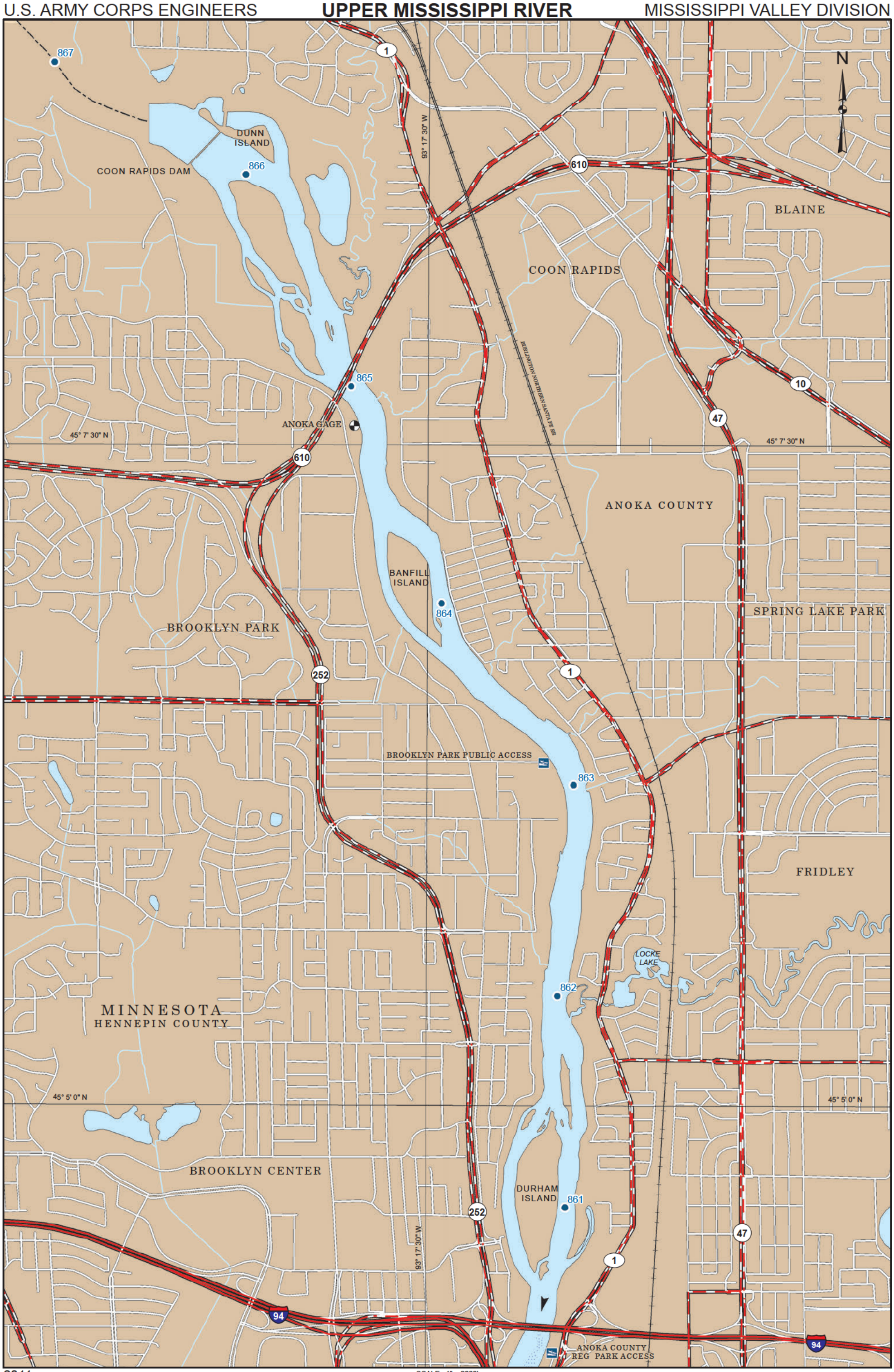
0 0.0375 0.075 0.15 0.225 0.3 Miles

Plate 2-6

U.S. ARMY CORPS ENGINEERS

UPPER MISSISSIPPI RIVER

MISSISSIPPI VALLEY DIVISION



2011

BUOY POSITIONS ON CHARTS ARE APPROXIMATE, SEE NOTICE IN LEGEND

SCALE : 1" = 2000'

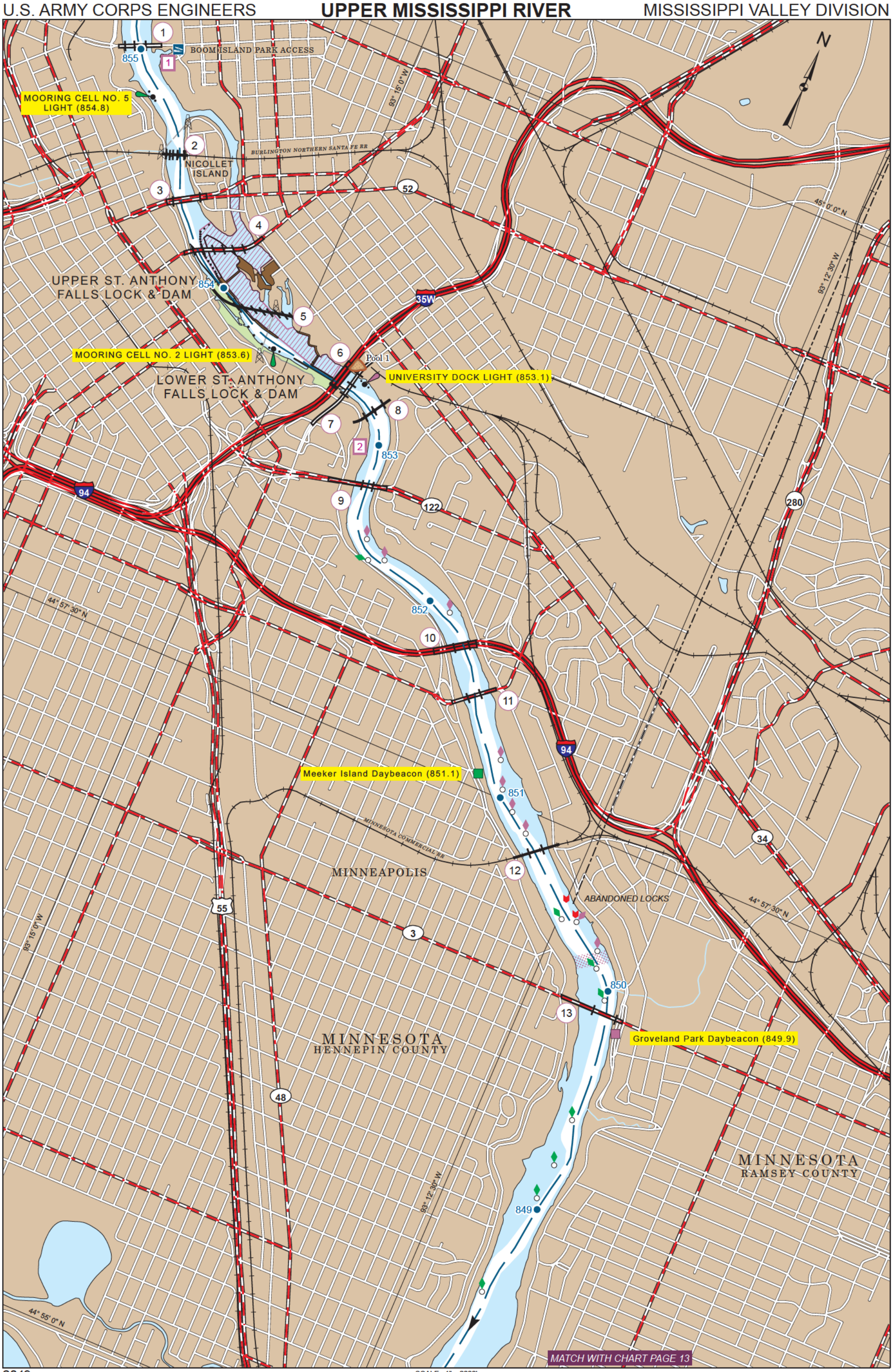
0 2,000 4,000 6,000 Feet

Plate 2-7

U.S. ARMY CORPS ENGINEERS

UPPER MISSISSIPPI RIVER

MISSISSIPPI VALLEY DIVISION



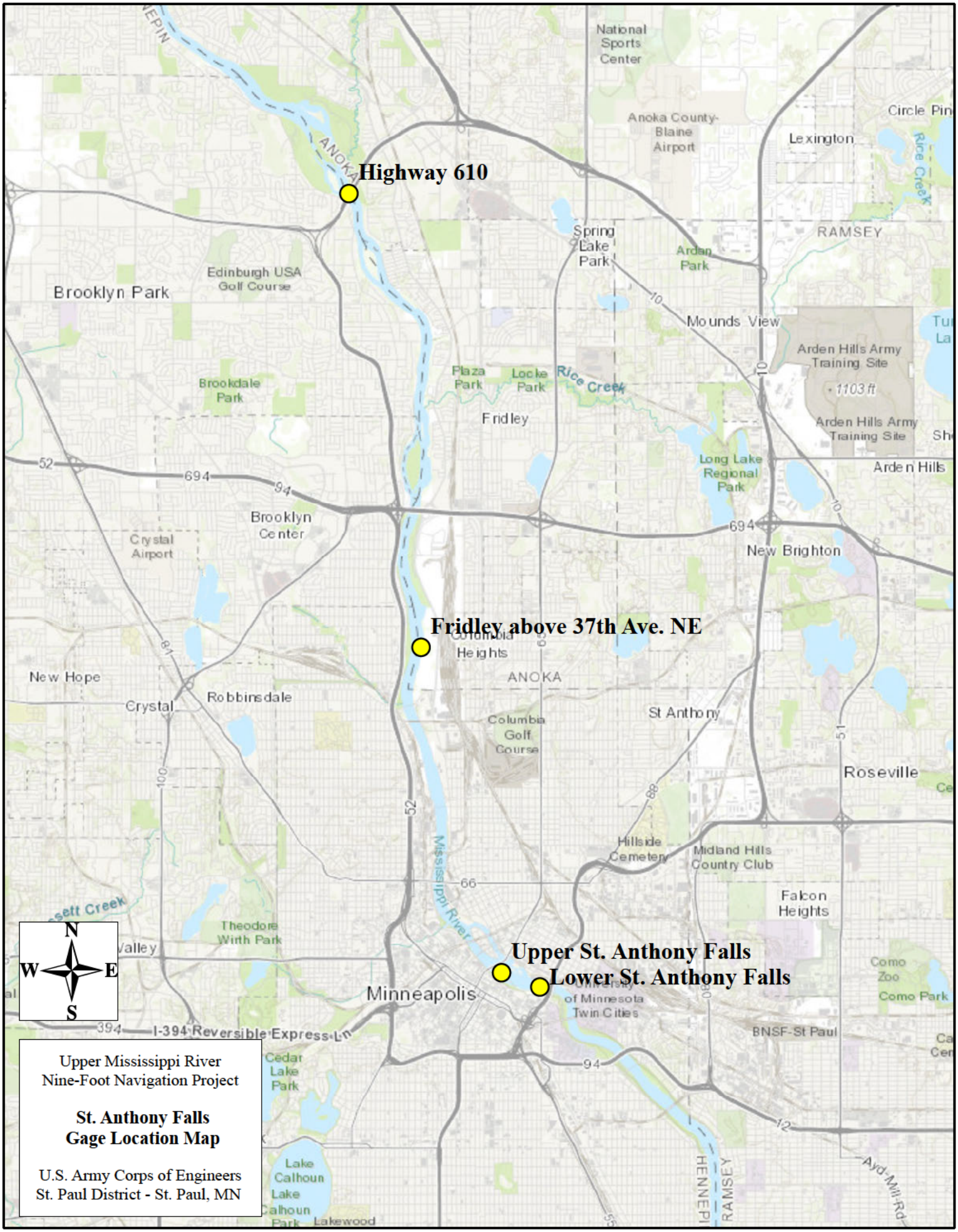
2019

BUOY POSITIONS ON CHARTS ARE APPROXIMATE, SEE NOTICE IN LEGEND

SCALE : 1" = 2000'

0 2,000 4,000 6,000 Feet

Plate 2-8



Upper Mississippi River
Nine-Foot Navigation Project

St. Anthony Falls
Gage Location Map

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

Plate 5-1

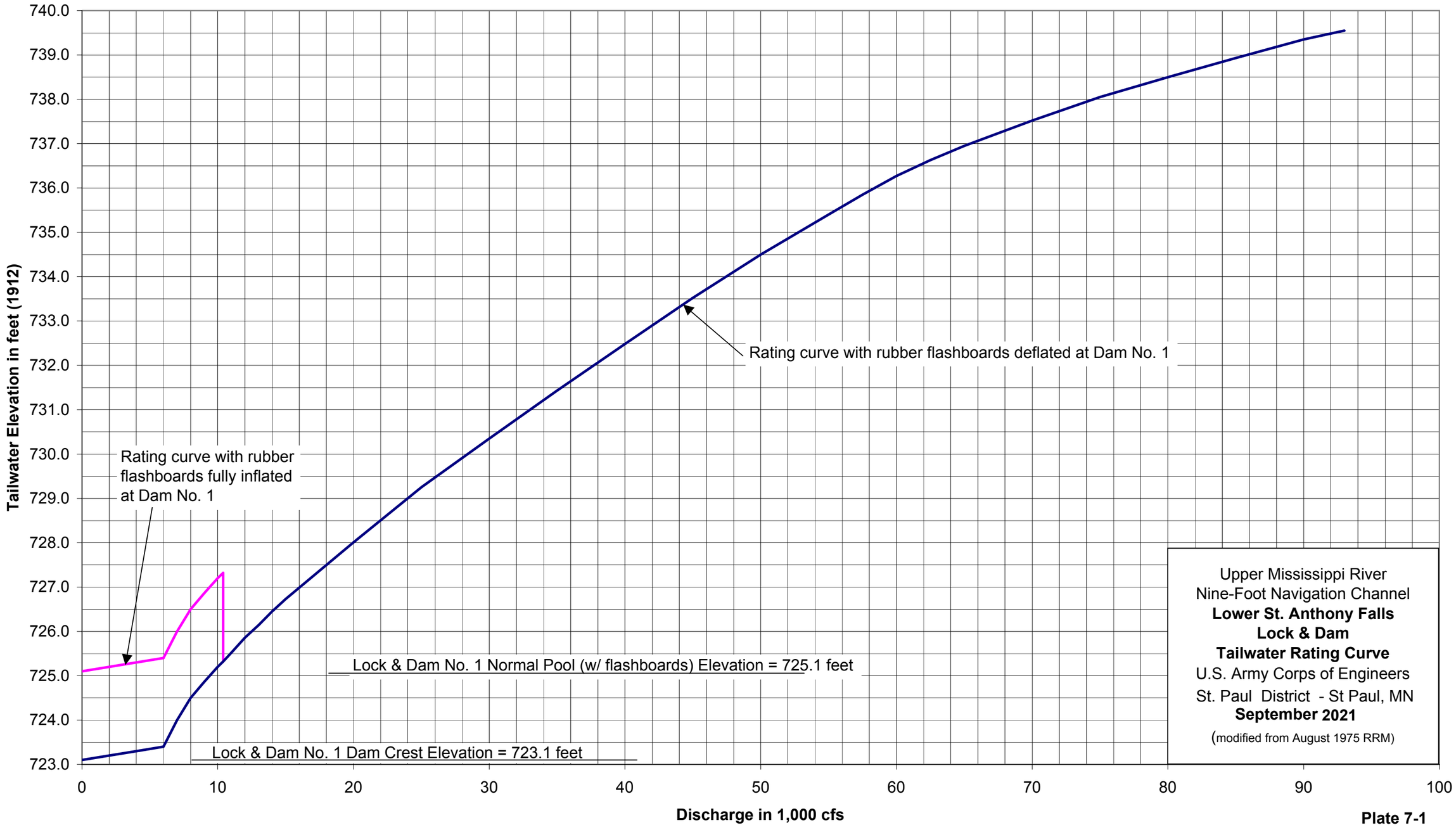

Tailwater Elevation in feet (1912)
740.0
739.0
738.0
737.0
736.0
735.0
734.0
733.0
732.0
731.0
730.0
729.0
728.0
727.0
726.0
725.0
724.0
723.0
0
10
20
30
40
50
60
70
80
90
100
Discharge in 1,000 cfs
Rating curve with rubber flashboards deflated at Dam No. 1
Rating curve with rubber flashboards fully inflated at Dam No. 1
Lock & Dam No. 1 Normal Pool (w/ flashboards) Elevation = 725.1 feet
Lock & Dam No. 1 Dam Crest Elevation = 723.1 feet
Upper Mississippi River
Nine-Foot Navigation Channel
Lower St. Anthony Falls
Lock & Dam
Tailwater Rating Curve
U.S. Army Corps of Engineers
St. Paul District - St Paul, MN
September 2021
(modified from August 1975 RRM)

Plate 7-1

Plate 7-2

Lower St. Anthony Falls Lock and Dam
Tainter Gate Discharge per Foot Opening

Head (ft)	Flow (cfs)	Head (ft)	Flow (cfs)	Head (ft)	Flow (cfs)	Head (ft)	Flow (cfs)	Head (ft)	Flow (cfs)	Head (ft)	Flow (cfs)
1.00	100	**3.00**	300	**5.00**	500	**7.00**	690	**9.00**	870	**11.00**	1,040
.05	105	.05	305	.05	505	.05	695	.05	874	.05	1,044
.10	110	.10	310	.10	510	.10	699	.10	878	.10	1,048
.15	115	.15	315	.15	515	.15	704	.15	882	.15	1,052
.20	120	.20	320	.20	520	.20	718	.20	886	.20	1,056
.25	125	.25	325	.25	525	.25	713	.25	890	.25	1,060
.30	130	.30	330	.30	530	.30	717	.30	894	.30	1,064
.35	135	.35	335	.35	535	.35	722	.35	898	.35	1,068
.40	140	.40	340	.40	540	.40	726	.40	902	.40	1,072
.45	145	.45	345	.45	545	.45	731	.45	906	.45	1,076
.50	150	.50	350	.50	550	.50	735	.50	910	.50	1,080
.55	155	.55	355	.55	555	.55	740	.55	914	.55	1,084
.60	160	.60	360	.60	560	.60	744	.60	918	.60	1,088
.65	165	.65	365	.65	565	.65	749	.65	922	.65	1,092
.70	170	.70	370	.70	570	.70	753	.70	926	.70	1,096
.75	175	.75	375	.75	575	.75	758	.75	930	.75	1,100
.80	180	.80	380	.80	580	.80	762	.80	934	.80	1,104
.85	185	.85	385	.85	585	.85	767	.85	938	.85	1,108
.90	190	.90	390	.90	590	.90	771	.90	942	.90	1,112
.95	195	.95	395	.95	595	.95	776	.95	946	.95	1,116
2.00	200	**4.00**	400	**6.00**	600	**8.00**	780	**10.00**	950	**12.00**	1,120
.05	205	.05	405	.05	605	.05	785	.05	955	.05	1,124
.10	210	.10	410	.10	609	.10	789	.10	959	.10	1,127
.15	215	.15	415	.15	614	.15	794	.15	964	.15	1,131
.20	220	.20	420	.20	618	.20	798	.20	968	.20	1,134
.25	225	.25	425	.25	623	.25	803	.25	973	.25	1,138
.30	230	.30	430	.30	627	.30	807	.30	977	.30	1,141
.35	235	.35	435	.35	632	.35	812	.35	982	.35	1,145
.40	240	.40	440	.40	636	.40	816	.40	986	.40	1,148
.45	245	.45	445	.45	641	.45	821	.45	991	.45	1,152
.50	250	.50	450	.50	645	.50	825	.50	995	.50	1,155
.55	255	.55	455	.55	650	.55	830	.55	1,000	.55	1,159
.60	260	.60	460	.60	654	.60	834	.60	1,004	.60	1,162
.65	265	.65	465	.65	659	.65	839	.65	1,009	.65	1,166
.70	270	.70	470	.70	663	.70	843	.70	1,014	.70	1,169
.75	275	.75	475	.75	668	.75	848	.75	1,018	.75	1,173
.80	280	.80	480	.80	672	.80	852	.80	1,022	.80	1,176
.85	285	.85	485	.85	677	.85	857	.85	1,027	.85	1,180
.90	290	.90	490	.90	681	.90	861	.90	1,031	.90	1,183
.95	295	.95	495	.95	686	.95	866	.95	1,036	.95	1,187

Plate 7-2

Table 7-2 (continued)
Lower St. Anthony Falls Lock and Dam
Tainter Gate Discharge per Foot Opening

Head (ft)	Flow (cfs)	Head (ft)	Flow (cfs)	Head (ft)	Flow (cfs)	Head (ft)	Flow (cfs)	Head (ft)	Flow (cfs)	Head (ft)	Flow (cfs)
13.00	1,190	**15.00**	1,320	**17.00**	1,440	**19.00**	1,560	**21.00**	1,680	**23.00**	1,800
.05	1,194	.05	1,323	.05	1,443	.05	1,563	.05	1,683	.05	1,803
.10	1,197	.10	1,326	.10	1,446	.10	1,566	.10	1,686	.10	1,806
.15	1,201	.15	1,329	.15	1,449	.15	1,569	.15	1,689	.15	1,809
.20	1,204	.20	1,332	.20	1,452	.20	1,572	.20	1,692	.20	1,812
.25	1,208	.25	1,335	.25	1,455	.25	1,575	.25	1,695	.25	1,815
.30	1,211	.30	1,338	.30	1,458	.30	1,578	.30	1,698	.30	1,818
.35	1,215	.35	1,341	.35	1,461	.35	1,581	.35	1,701	.35	1,821
.40	1,218	.40	1,344	.40	1,464	.40	1,584	.40	1,704	.40	1,824
.45	1,222	.45	1,347	.45	1,467	.45	1,587	.45	1,707	.45	1,827
.50	1,225	.50	1,350	.50	1,470	.50	1,590	.50	1,710	.50	1,830
.55	1,229	.55	1,353	.55	1,473	.55	1,593	.55	1,713	.55	1,833
.60	1,232	.60	1,356	.60	1,476	.60	1,596	.60	1,716	.60	1,836
.65	1,236	.65	1,359	.65	1,479	.65	1,599	.65	1,719	.65	1,839
.70	1,239	.70	1,362	.70	1,482	.70	1,602	.70	1,722	.70	1,842
.75	1,243	.75	1,365	.75	1,485	.75	1,605	.75	1,725	.75	1,845
.80	1,246	.80	1,368	.80	1,488	.80	1,608	.80	1,728	.80	1,848
.85	1,250	.85	1,371	.85	1,491	.85	1,611	.85	1,731	.85	1,851
.90	1,253	.90	1,374	.90	1,494	.90	1,614	.90	1,734	.90	1,854
.95	1,257	.95	1,377	.95	1,497	.95	1,617	.95	1,737	.95	1,857
14.00	1,260	**16.00**	1,380	**18.00**	1,500	**20.00**	1,620	**22.00**	1,740	**24.00**	1,860
.05	1,263	.05	1,383	.05	1,503	.05	1,623	.05	1,743	.05	1,863
.10	1,266	.10	1,386	.10	1,506	.10	1,626	.10	1,746	.10	1,866
.15	1,269	.15	1,389	.15	1,509	.15	1,629	.15	1,749	.15	1,869
.20	1,272	.20	1,392	.20	1,512	.20	1,632	.20	1,752	.20	1,872
.25	1,275	.25	1,395	.25	1,515	.25	1,635	.25	1,755	.25	1,875
.30	1,278	.30	1,398	.30	1,518	.30	1,638	.30	1,758	.30	1,878
.35	1,281	.35	1,401	.35	1,521	.35	1,641	.35	1,761	.35	1,881
.40	1,284	.40	1,404	.40	1,524	.40	1,644	.40	1,764	.40	1,884
.45	1,287	.45	1,407	.45	1,527	.45	1,647	.45	1,767	.45	1,887
.50	1,290	.50	1,410	.50	1,530	.50	1,650	.50	1,770	.50	1,890
.55	1,293	.55	1,413	.55	1,533	.55	1,653	.55	1,773	.55	1,893
.60	1,296	.60	1,416	.60	1,536	.60	1,656	.60	1,776	.60	1,896
.65	1,299	.65	1,419	.65	1,539	.65	1,659	.65	1,779	.65	1,899
.70	1,302	.70	1,422	.70	1,542	.70	1,662	.70	1,782	.70	1,902
.75	1,305	.75	1,425	.75	1,545	.75	1,665	.75	1,785	.75	1,905
.80	1,308	.80	1,428	.80	1,548	.80	1,668	.80	1,788	.80	1,908
.85	1,311	.85	1,431	.85	1,551	.85	1,671	.85	1,791	.85	1,911
.90	1,314	.90	1,434	.90	1,554	.90	1,674	.90	1,794	.90	1,914
.95	1,317	.95	1,437	.95	1,557	.95	1,677	.95	1,797	.95	1,917

Plate 7-3

LSAF Discharge Over One Submerged Tainter Gate							
Head	Flow	Head	Flow	Head	Flow	Head	Flow
1.00	600	**3.00**	1,420	**5.00**	2,600	**7.00**	4,050
.05	610	.05	1,450	.05	2,640	.05	4,090
.10	630	.10	1,470	.10	2,670	.10	4,130
.15	640	.15	1,500	.15	2,700	.15	4,170
.20	660	.20	1,530	.20	2,740	.20	4,210
.25	680	.25	1,550	.25	2,770	.25	4,250
.30	690	.30	1,580	.30	2,800	.30	4,290
.35	710	.35	1,610	.35	2,840	.35	4,330
.40	730	.40	1,630	.40	2,870	.40	4,370
.45	740	.45	1,660	.45	2,910	.45	4,410
.50	760	.50	1,690	.50	2,940	.50	4,450
.55	780	.55	1,720	.55	2,980	.55	4,490
.60	800	.60	1,750	.60	3,010	.60	4,530
.65	820	.65	1,770	.65	3,050	.65	4,570
.70	840	.70	1,800	.70	3,080	.70	4,610
.75	860	.75	1,830	.75	3,120	.75	4,650
.80	880	.80	1,860	.80	3,150	.80	4,690
.85	900	.85	1,890	.85	3,190	.85	4,740
.90	920	.90	1,920	.90	3,220	.90	4,780
.95	940	.95	1,950	.95	3,260	.95	4,820
2.00	960	**4.00**	1,980	**6.00**	3,300	**8.00**	4,860
.05	980	.05	2,010	.05	3,330	.05	4,900
.10	1,000	.10	2,040	.10	3,370	.10	4,940
.15	1,020	.15	2,070	.15	3,400	.15	4,990
.20	1,040	.20	2,100	.20	3,440	.20	5,030
.25	1,060	.25	2,130	.25	3,480	.25	5,070
.30	1,090	.30	2,160	.30	3,520	.30	5,110
.35	1,110	.35	2,190	.35	3,550	.35	5,160
.40	1,130	.40	2,220	.40	3,590	.40	5,200
.45	1,150	.45	2,250	.45	3,630	.45	5,240
.50	1,180	.50	2,280	.50	3,670	.50	5,290
.55	1,200	.55	2,310	.55	3,700	.55	5,330
.60	1,220	.60	2,340	.60	3,740	.60	5,370
.65	1,250	.65	2,370	.65	3,780	.65	5,410
.70	1,270	.70	2,410	.70	3,820	.70	5,460
.75	1,300	.75	2,440	.75	3,860	.75	5,500
.80	1,320	.80	2,470	.80	3,900	.80	5,550
.85	1,350	.85	2,500	.85	3,930	.85	5,590
.90	1,370	.90	2,540	.90	3,970	.90	5,630
.95	1,400	.95	2,570	.95	4,010	.95	5,680

Plate 7-3

Table 7-3 continued Discharge Over One Submerged Tainter Gate							
Head	Flow	Head	Flow	Head	Flow	Head	Flow
9.00	5,720	**11.00**	7,590	**13.00**	9,640	**15.00**	11,850
.05	5,770	.05	7,640	.05	9,690	.05	11,910
.10	5,810	.10	7,690	.10	9,740	.10	11,970
.15	5,860	.15	7,740	.15	9,790	.15	12,020
.20	5,900	.20	7,790	.20	9,860	.20	12,080
.25	5,950	.25	7,840	.25	9,910	.25	12,140
.30	5,990	.30	7,890	.30	9,960	.30	12,200
.35	6,040	.35	7,940	.35	10,010	.35	12,250
.40	6,080	.40	7,990	.40	10,070	.40	12,310
.45	6,130	.45	8,040	.45	10,120	.45	12,370
.50	6,170	.50	8,090	.50	10,180	.50	12,430
.55	6,220	.55	8,140	.55	10,230	.55	12,480
.60	6,260	.60	8,190	.60	10,290	.60	12,540
.65	6,310	.65	8,240	.65	10,340	.65	12,600
.70	6,350	.70	8,290	.70	10,400	.70	12,660
.75	6,400	.75	8,340	.75	10,450	.75	12,720
.80	6,450	.80	8,390	.80	10,500	.80	12,780
.85	6,490	.85	8,440	.85	10,550	.85	12,840
.90	6,540	.90	8,490	.90	10,610	.90	12,900
.95	6,590	.95	8,540	.95	10,660	.95	12,960
10.00	6,630	**12.00**	8,600	**14.00**	10,720	**16.00**	13,020
.05	6,680	.05	8,650	.05	10,770	.05	13,080
.10	6,730	.10	8,700	.10	10,830	.10	13,140
.15	6,780	.15	8,750	.15	10,890	.15	13,190
.20	6,820	.20	8,800	.20	10,950	.20	13,250
.25	6,870	.25	8,850	.25	11,000	.25	13,310
.30	6,910	.30	8,900	.30	11,060	.30	13,370
.35	6,960	.35	8,950	.35	11,110	.35	13,430
.40	7,010	.40	9,000	.40	11,170	.40	13,490
.45	7,060	.45	9,050	.45	11,220	.45	13,550
.50	7,110	.50	9,110	.50	11,280	.50	13,610
.55	7,150	.55	9,160	.55	11,340	.55	13,670
.60	7,200	.60	9,210	.60	11,400	.60	13,730
.65	7,250	.65	9,260	.65	11,450	.65	13,790
.70	7,300	.70	9,320	.70	11,510	.70	13,850
.75	7,350	.75	9,370	.75	11,560	.75	13,910
.80	7,390	.80	9,430	.80	11,620	.80	13,980
.85	7,440	.85	9,480	.85	11,680	.85	14,040
.90	7,490	.90	9,530	.90	11,740	.90	14,100
.95	7,540	.95	9,580	.95	11,790	.95	14,160