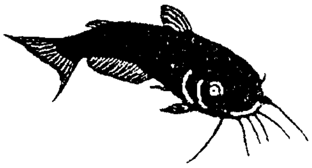
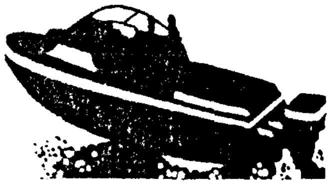
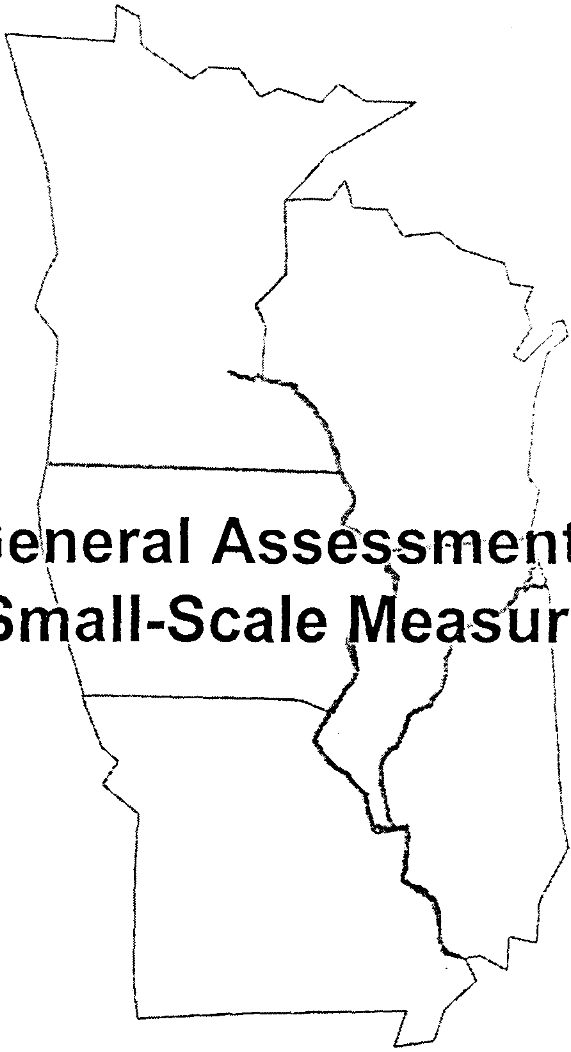
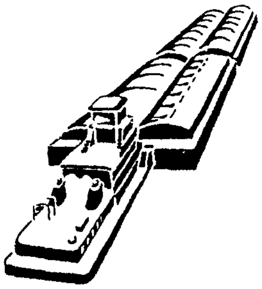
Interim Report For The Upper Mississippi River - Illinois Waterway System Navigation Study







General Assessment of Small-Scale Measures



June 1995

US Army Corps of Engineers

St. Paul District
Rock Island District
St. Louis District

FOREWORD

The purpose of this report is to identify small scale improvement measures for reducing delays associated with passing traffic through lock facilities on the Upper Mississippi River and the Illinois Waterway, to qualitatively assess each measure's potential, and to recommend those measures with the greatest potential for further study. This effort is in support of the Upper Mississippi River - Illinois Waterway Navigation Study (UMR-IWW NAV Study), a system feasibility study of potential capital investment needs during the period 2000-2050.

June 1995

SUMMARY

This assessment, a sub-effort of the Upper Mississippi River and Illinois Waterway System Navigation Study, identifies small-scale measures which seek to reduce delays or congestion that commercial barge traffic experience when transiting locks on the Upper Mississippi River and Illinois Waterway. The assessment process included: a historical records review; visits to two locks (one on each waterway); meetings with industry, environmental, and regulatory agency representatives; identification of potential small-scale measures; and recommendations for further study of a screened list of small scale measures.

Ninety-two measures were identified during the course of the assessment through document research, discussion, and an October 1994 multi-interest brainstorming session. The number of small-scale measures was narrowed down to 16 which are recommended for further study based on a qualitative screening process that focused on identifying those measures with greatest potential for reducing lockage times. The screening process eliminated those measures which:

(1) have no potential to reduce delays at locks,
(2) are not technically feasible,
(3) are not safe,
(4) are not environmentally acceptable,
(5) are economically inefficient,
(6) are not cost effective,
(7) should be pursued through industry cooperation rather than Corps of Engineers requirements, or
(8) are addressed through the Corps of Engineers Operations and Maintenance Program.

In applying the screening criteria, the measures recommended for further study are:

1. **Optimizing Decisions (Scheduling Program)**

2. **Towboat Power:**
    - Helper Boats
    - Switchboats
    - Self Help

3. **Tow Haulage Equipment:**
   - Powered Traveling Kevel
   - Endless Cable
   - Extended Guidewall

4. **Mooring Facilities (Adjacent to Lock Approach)**

5. **Crew Elements:**
   - Universal Couplers/Hand Winches
   - *Standardized Training for Crews*

6. Tolls & Reports:
   - Congestion Tolls
   - Excess Lockage Time Charges
   - Lockage Time Charges
   - Publish Lockage Times

7. **Recreational Vessels:**
   - Scheduling of Recreational Vessel Usage
   - Recreational Craft Landing Above and Below Lock

This qualitative assessment recommends that each of these measures be subjected to an indepth analysis to determine their investment potential. The remaining summary text gives the reader an overview of how this small-scale assessment fits into the overall study process.

This General Assessment of Small-Scale Measures represents the qualitative screening of a broad spectrum of small-scale measures. This screened list of small-scale measures, as well as a screened list of large-scale measures (such as new lock structures) being developed under a separate effort within this navigation study, will be evaluated in more detail as part of further plan formulation efforts of the UMR-IWW System Navigation Study.

The plan formulation process consists of six general steps: identify problems and opportunities; define existing conditions; formulate alternative plans; evaluate plans; compare plans, and select a recommended plan. The early qualitative screening process for these small-scale measures is part of the preliminary efforts of formulating alternative plans. Detailed information for both the small- and large-scale short lists will be developed in subsequent efforts within the UMR-IWW System Navigation Study. These small- and large-scale measures will be assessed separately and in various combinations in order to develop an array of alternative plans for comparison.

The alternative plans will be evaluated in consideration of the following four criteria: completeness; effectiveness; efficiency; and acceptability. Completeness is the extent to which a given an alternative plan provides and accounts for all necessary investments or other actions to ensure the realization of the planned effects. Effectiveness is the extent to which alternative plan alleviates the specified problems and achieves the specified opportunities. Efficiency is the extent to which an alternative plan is the most cost-effective means of alleviating the specified problems and realizing the specified opportunities, consistent with protecting the Nation's environment. Acceptability is the workability and viability of the alternative plan with respect to acceptance by state and local entities and the public and compatibility with existing laws, regulations, and public policies. Economic, environmental, engineering, and public input considerations are integral to this evaluation process. Of those feasible plans, the selected plan will be that plan which is the best balanced for reducing delays/congestion on the navigation system in consideration of the above stated criteria.

Table of Contents

TABLE OF CONTENTS

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

LIST OF FIGURES

LIST OF FIGURES (continued)

Section I

I INTRODUCTION

This report identifies small-scale measures with potential for reducing traffic delays associated with passing traffic through locks on the Upper Mississippi River (UMR) and Illinois Waterway (IWW) Navigation System. The system is depicted in Figure I-1. This effort is in support of the UMR-IWW Navigation Study's assessment of potential capital investment needs during the period 2000-2005. Recommended measures' delay reducing potential will be assessed under subsequent efforts of the UMR-IWW Navigation Study.

A. ASSESSMENT TEAM

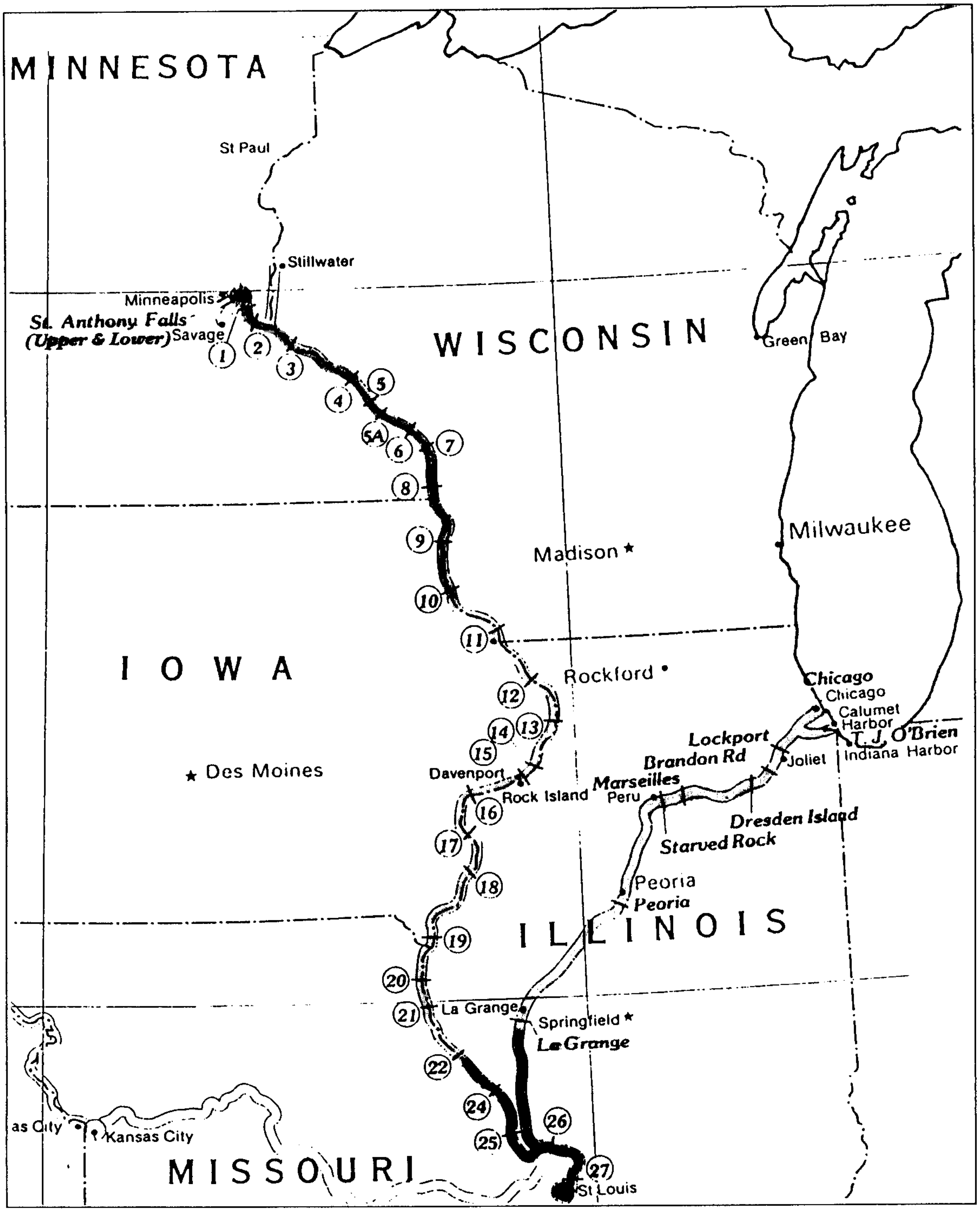
This effort included review and contribution by both public and private interested parties. Army Corps of Engineers participants included Economic, Environmental, Operational, and Engineering interests from the St. Louis, Rock Island, and St. Paul Districts. The Corps efforts were supported by Sverdrup, a St. Louis based engineering consulting firm. Other participating federal agencies included the U.S. Fish and Wildlife Service, the Coast Guard, and the Environmental Protection Agency. State agency participants included representatives from departments of transportation and conservation/natural resources from Missouri, Illinois, Iowa, Wisconsin, and Minnesota. Towing industry participation included representatives from several towing companies. Non-Corps participants' written comments are included as Appendix VII.

B. STUDY PROCESS

The study effort consisted of four phases: reviewing background reports; examining the locking process; identifying potential measures; and qualitatively assessing identified measures.

1. Review of Background Reports

The following documents were reviewed to identify potential measures and develop an appreciation for the qualitative methods used in the analysis portion of previous studies. A summary of the previous assessment measures and their cross reference to this study are shown in Figure I-2.



Upper Mississippi River and Illinois Waterway
Figure I-1

Corps of Engineers

- *St. Paul District*
- *Rock Island District*
- *St. Louis District*

Source: "Inventory of Potential Structural and Non-Structural Alternatives for Increasing Navigation Capacity – Upper Mississippi River"

a. Inventory of Potential Structural and Non-Structural Alternatives for Increasing Navigation Capacity - Upper Mississippi River System Master Plan, Louis Berger & Associates, Inc., April 1981,

b. Comprehensive Master Plan for the Management of the Upper Mississippi River System, Technical Report A: Navigation and Transportation, U.S. Army Corps of Engineers, (no date indicated),

c. Upper Mississippi River Transportation Economics Study, Supplement 2: Efficiency Measure Analysis, Leeper, Cambridge & Campbell, Inc., April 1989, and

d. Evaluation of Operational Improvements at Lock and Dam No. 26, Mississippi River, Peat, Marwick, Mitchell & Co., July 1975.

In addition, the following additional documents were referenced during the course of the study;

a. Upper Mississippi River Navigation Charts, U.S. Army Corps of Engineers, 1989,

b. Charts of the Illinois Waterway, U.S. Army Engineer District, Corps of Engineers, Chicago, IL, 1974,

c. Regulations Prescribed by the Secretary of the Army for Ohio River, Mississippi River above Cairo, Ill. and their Tributaries (33 CFR 207.300), U.S. Army Corps of Engineers,

d. Lock and Dam No. 24, Periodic Inspection Report No. 8, U.S. Army Corps of Engineers, November 1993,

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

f. Towpaths and Towboats: A History of American Canal Engineering, The American Canal and Transportation Center, 1992, and

g. American Merchant Seaman's Manual, 6th Edition, Cornell and Hoffman, 1982.

No.	PREVIOUS MEASURES	SOURCE				THIS STUDY
		LBA	COE	LCC	PMM	
1	Institute N-up/N-down Policy	X	X	X		1a
2	Provide Helper Boats and Institute N-up/N-down Policy	X	X			2a,1a
3	Provide Switchboats	X	X		X	2b
4	Institute Ready to Serve (Self Help) Policy	X	X		X	1b,1c
5	Improve Tow Haulage Equipment	X		X		2c,2d,2e
6	Increase Lock Staffing	X				10a
7	Institute Lock Scheduleing Procedures	X		X		1d,5e
8	Improve Approach Channels	X	X	X		3a
9	Provide Adjacent Mooring Facilities	X				3b
10	Provide Funnel Shaped Guidewalls	X				3c
11	Install Wind Deflectors in Approaches	X				3d
12	Mandate Use of Bow Thrusters	X				5a
13	Mandate use of Bow Thrusters (Prototype)	X				5b
14	Promote Tow Size Standardization	X				5c
15	Encourage Cooperative Scheduling & Sharing of Equip.	X		X		5d
16	Institute Waterway Traffic Management	X				5e
17	Increase Number and Capacity of Fleeting Area	X				5f
18	Improve Bridge Design and Maintenance	X	X			4g
19	Modify Wall Ports and Intake/Outlet Structures	X				6a,6b,6c
20	Install Self-Cleansing Trash Racks	X		X		6d
21	Expedite Operations in Ice Conditions	X	X			7a,7b
22	Install Air Bubbler System	X				7c
23	Install Floating Mooring Bits	X				6h
24	Improve Lock Operating Equipment	X				6i,6j
25	Install Gate Wickets in Miter Gates	X				6k
26	Provide Explicit Operating Guides	X				6l
27	Fenders, Energy Absorbers	X				6m
28	Require Vessels to Stay Clear of Fill & Empty Systems	X				6n
29	Reduce Interference from Recreational Users	X				8b,8d
33	Provide Longitudinal Hydraulic Assistance	X				2f
34	Encourage Use of Univeral Coupler or Hand Winches	X				5n
35	Increase Channel Widths	X				4e
36	Increase Installation of Radar Reflectors	X				3h
37	Increase Speed Limits in Restricted Reaches	X				5o
38	Isolate Rec. Facilities & Marinas Away From Channels	X				4f
39	Reduce Liability of Tow Operators for Damage	X				5p
40	Install Electronic Guidance Systems	X				3i
41	Remove/Adjust Bends, One-Way Reaches, Bridges	X				4a
42	Apply Congestion Tolls	X				9a
43	Require Minimum Crew Size and Training	X		X		5q
44	Fuel Monitoring and Management			X		5g
45	Use of Heavy Fuels			X		5h
46	New Barge and Boat Bottom Treatments			X		5i
47	Improved Barge and Boat Hull Designs			X		5j
48	Improved Boat and Barge Rigging			X		5n
49	Barge Stacking for Backhauls			X		5k
50	Improve Navigation Aids and Channel Markings			X		4b
51	Real-Time Channel Depth and Weather Monitoring			X		10d
52	Modularized Floating Ship Lifts			X		8a
53	Low Head Hydroelectric Units			X		9c
54	Automated Lock Control			X		6g
55	Container Movements			X		5l
56	New Backhaul Opportunities			X		5m
57	Privatization of Lock Operations			X		9d
58	Allocation of Operations and Maintenance Costs			X		9b
59	Innovative Dredging Strategies			X		4c
60	Water Flow Management Policies			X		4d
61	Extend Guidewalls	X	X	X	X	3e

Key:
LBA – Louis Berger & Associates Report
COE – Corps of Engineers Report
LCC – Leeper, Cambridge & Campbell Report
PMM – Peat, Marwick, Mitchell Report

NOTE: Letter designation under "This Study" corresponds to item location in this report.

Figure I-2

2. Examine Locking Process

Engineering personnel conducted site visits to Starved Rock Lock and Dam on the Illinois Waterway and Lock 24 on the Upper Mississippi River. The purpose of these visits was to observe locking operations, interview Operations personnel, and witness the collection of Lock Performance Monitoring System (LPMS) data. Detailed trip summaries can be found in Section IV of this report.

3. Identify Measures

Based on review of background reports and examining locking operations, engineering personnel compiled a list of potential small-scale measures. The Corps of Engineers then hosted a brainstorming session in St. Louis, Missouri on october 24, 1994. The brainstorming session was intended to identify additional measures and to gain feedback concerning the advantages and disadvantages of each measure. These measures are described in Section V of this report.

4. Qualitative Assessments

Corps of Engineers economists, environmentalists, and engineers established criteria for assessing each measure's potential for reducing traffic delays at navigation locks. The assessment process was discussed at an open meeting in St. Louis on December 14, 1994. The Corps of Engineers considered all participants concerns in preparing this, the final edition of the General Assessment of Small-Scale Measures Reports.

Section II

II THE LOCKING PROCESS

A. HISTORY

1. Upper Mississippi River

The Mississippi River once flowed freely from its headwaters near Lake Itasca in upper Minnesota, to the Gulf of Mexico. The Upper Mississippi is that portion of the Mississippi River north of the confluence of the Mississippi River and the Ohio River. This stretch of the river serves as the boundary for five states; Minnesota, Wisconsin, Iowa, Illinois, and Missouri. Along the way, it is fed by several rivers and streams including the Minnesota, St. Croix, Chippewa, Wisconsin, Rock, Des Moines, Illinois, and Missouri. These tributaries provide waterway access to the Great Lakes to the East and as far West as Montana, Wyoming, and Colorado. One hundred and seventy nine miles below St. Louis, the Mississippi is joined by the Ohio and nearly doubles in volume. It is here that the Upper Mississippi River becomes the Lower Mississippi, the "mile-wide tide" made famous by Mark Twain.

In its early days, the Upper Mississippi was a temperamental river; subject to drought, flooding, and shoaling. In dry seasons, it was too shallow to navigate. During floods, trees washed into the river, creating dangerous "snags" that could easily damage the vessels that plied its waters. Sand bars constantly shifted as the river adjusted its course with the seasons and the years. The river's current could become swift and dangerous, especially along the 11 mile stretch known as the Des Moines Rapids and the 14 mile Rock Island Rapids.

The average depth on the Upper Mississippi was 3 feet and, during some periods of the year, averaged as little as 1 foot along a 200 mile stretch below St. Paul, Minnesota. As a result, raw materials from the Midwest could not reach the ports and industrial centers of the world on a reliable basis using river transportation. Dependable, year-round navigation of the Upper Mississippi was a major agenda item of regional commercial interests. The nation's economy was fueled by the farming communities of the Upper Mississippi drainage basin, a region as large as the nations of Great Britain, France, Germany and Italy combined.

The Federal Government assumed responsibility for eliminating troublesome spots on the Upper Mississippi in the early nineteenth century. In 1838, Lieutenant Robert E. Lee supervised the underwater demolition of the Des Moines Rapids. The Corps of

Engineers blasted and dredged the river in its most dangerous locations to create a navigable channel. The 4-foot channel project soon became the 4.5-foot channel project, and then the 6-foot channel project by 1907.

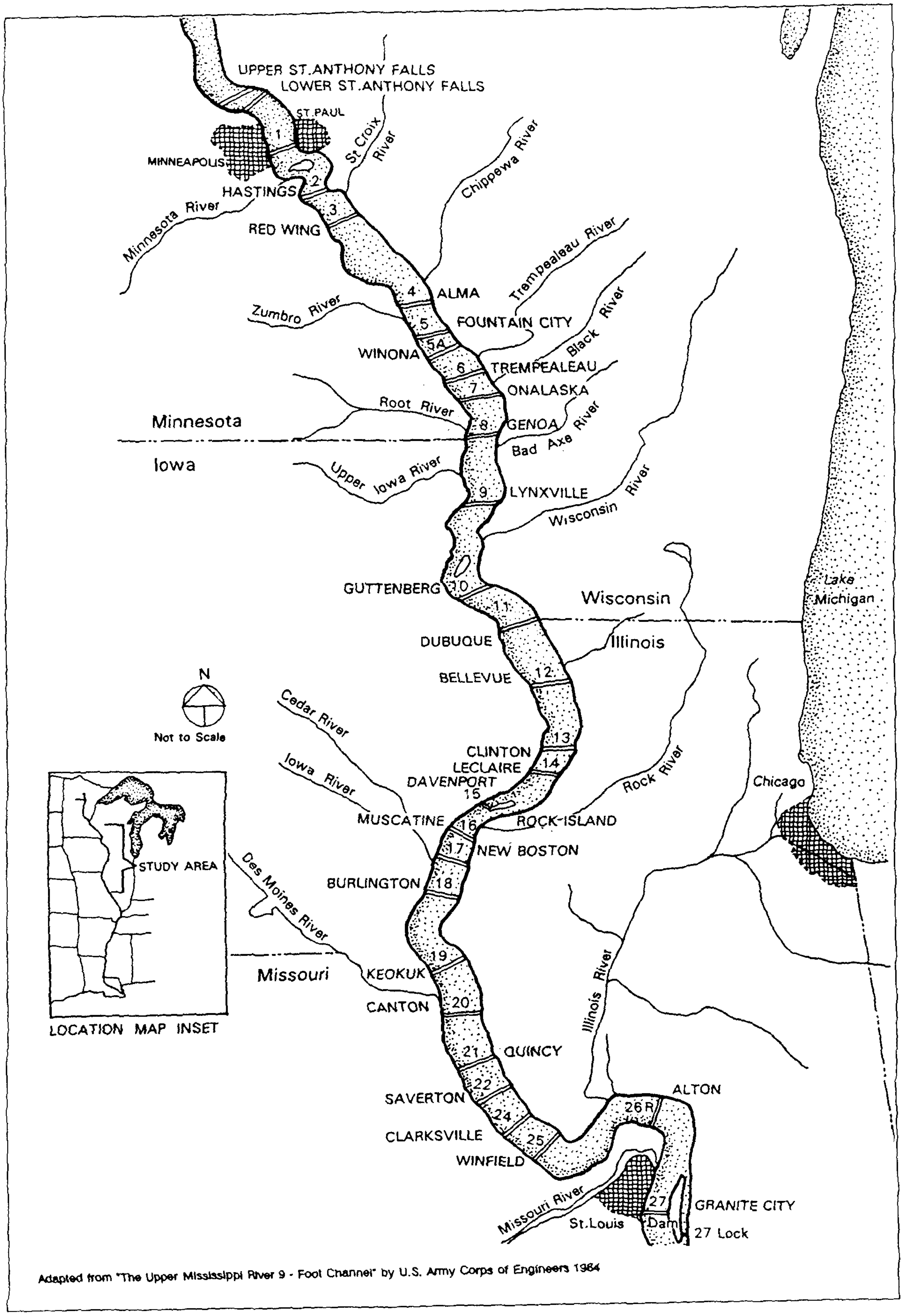
Both the 4.5-foot and 6-foot channel were achieved by a system of wing and closing dams, along with continual dredging. Wing dams were built using timber and brush (later rocks), extended in a line from the shoreline, to constrict the flow of the river, speed the current, and provide a clear channel. Closing dams used the same materials to prevent the river from leaving the main channel and entering sloughs and side channels.

However, the 9-foot channel maintained on the Lower Mississippi required barge fleet operators going up river to either begin their journey with smaller boats or transfer their cargo to smaller boats in the vicinity of St. Louis in order to make the entire journey up the river. Either option cost time and money. Shippers thus turned to trains to move their cargo. By the 1920's, the national farm crisis, the Great Depression, and the opening of the Panama Canal convinced many that the current river navigation system was inadequate and a 9-foot channel on the Upper Mississippi River was economically imperative.

The Upper Mississippi River 9-Foot Channel Project, authorized under the Rivers and Harbors Act of 1930, was designed and constructed by the U.S. Army Corps of Engineers between 1930 and 1940. A system of locks and dams converted the once free-flowing river into a series of interconnected pools that ensure enough water for fully loaded, modern barges. The completion of the 9-Foot Channel turned the upper reaches of one of the world's largest rivers into an intra-continental channel. (See Figure II-1)

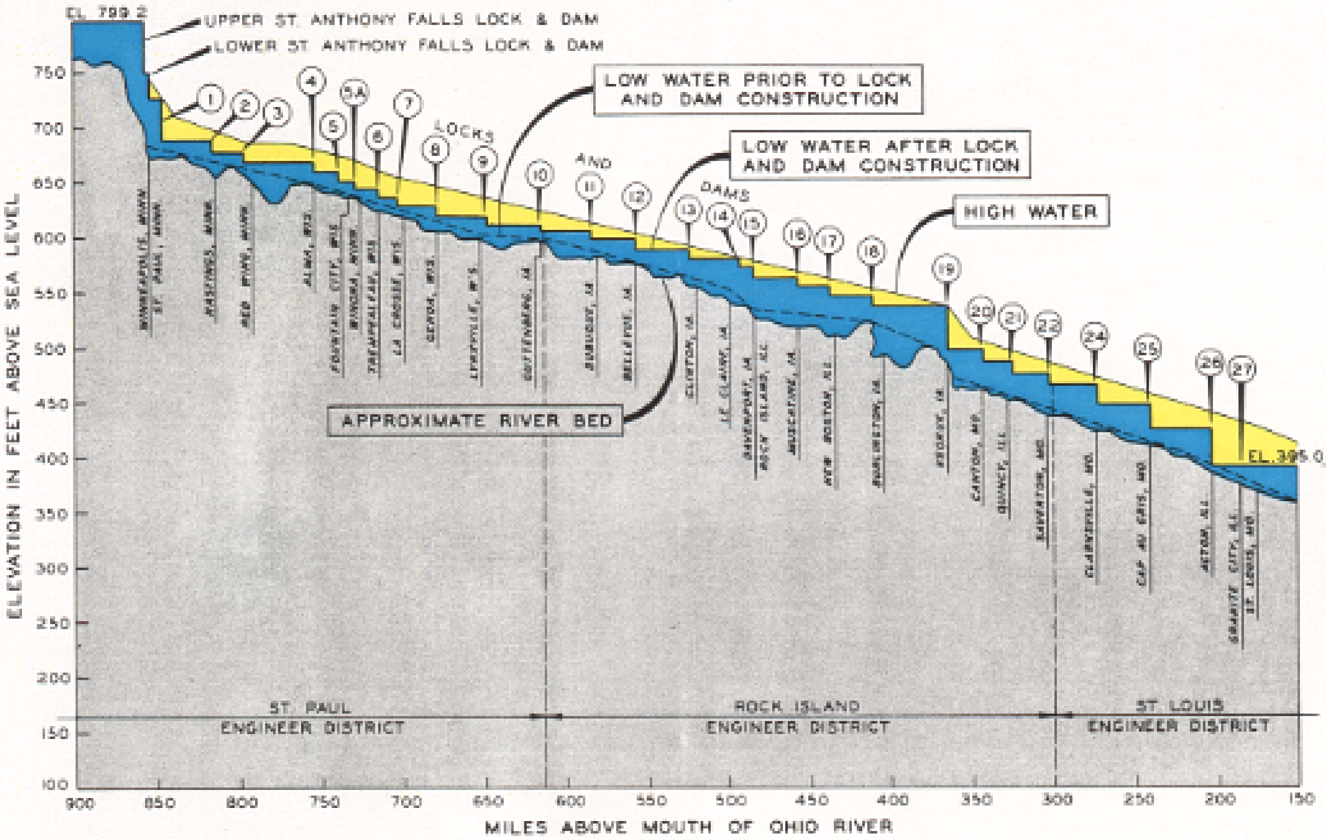
The lock and dam system creates a kind of stairway up the river. The dams create the pools of water and the locks provide the means for vessels to be lifted or lowered to the next pool. The system extends across a 669 mile stretch of river between Minneapolis and St. Louis, and has a vertical fall of about 400 feet. (See Figure II-2)

As originally planned in the 1920's, the 9-Foot Channel Project consisted of 26 locks and dams from St. Paul Minnesota to Alton, Illinois. In 1937, Congress authorized a 4.6 mile upstream extension to add both Upper and Lower St. Anthony Falls Locks and Dams. In 1953, the system was expanded to the south, to St. Louis, with the addition of Lock 27 on the Chain of Rocks Canal and Dam 27, also known as the Chain of Rocks Dam. (See Figure II-3)



9-Foot Channel System, Upper Mississippi River

Figure II-1



Stairway of Water

Makes navigation possible between Minneapolis, Minnesota and St. Louis, Missouri.

Figure II-2

UPPER MISSISSIPPI RIVER

LOCK	MILEPOST (from Cairo, IL)	BANK (Descending)	DIMENSIONS (W x L)
Upper St. Anthonys	853.6	R	56' x 400'
Lower St. Anthonys	853.4	R	56' x 400'
1	847.6	R R	56' x 400' 56' x 400'
2	815.2	R	110' x 600'
3	796.0	R	110' x 600'
4	752.8	L	110' x 600'
5	738.1	R	110' x 600'
5A	728.5	R	110' x 600'
6	714.3	L	110' x 600'
7	702.5	R	110' x 600'
8	679.2	L	110' x 600'
9	647.9	L	110' x 600'
10	615.1	R	110' x 600'
11	583.0	R	110' x 600'
12	556.7	R	110' x 600'
13	522.5	L	110' x 600'
14	493.3	R R	110' x 600' 80' x 320'
15	482.9	L L	110' x 600' 110' x 360'
16	457.5	L	110' x 600'
17	437.1	L	110' x 600'
18	410.5	L	110' x 600'
19	364.3	R	110' x 1200'
20	343.2	R	110' x 600'
21	324.9	L	110' x 600'
22	301.2	R	110' x 600'
24	273.4	R	110' x 600'
25	241.4	R	110' x 600'
Melvin Price	200.8	L L	110' x 1200' 110' x 600'
27	185.5	L L	110' x 1200' 110' x 600'

Figure II–3

The project brought economic benefits and recreational opportunities to the entire Midwest region and served as the impetus for upgrading municipal drinking water and sewage disposal systems in nearby cities and towns. It also received criticism from the railroads because of commercial and right-of-way interests. The 9-Foot Channel provides what the river in its natural state could not: a dependable 9-foot navigation depth on the Upper Mississippi River.

2. Illinois Waterway

In 1673, two French explorers, Louis Jolliet and Father Jacques Marquette published a written record of their explorations after proving that the Mississippi River flowed south into the Gulf of Mexico. They had traveled north on the Mississippi River, up the Illinois River, and up the Des Plaines River. At a point now known as the Chicago portage, they found a low divide separating the Des Plaines River from the Chicago River which flowed into Lake Michigan. They described a canal that could connect the waters of Lake Michigan to the Des Plaines river and would allow water travel from the Great Lakes to the Gulf of Mexico.

When Illinois became a State in 1818, a canal was high on its agenda. The Illinois and Michigan (I & M) Canal was built between 1836 and 1848. It began at the mouth of the Chicago River and climbed 12 feet to a summit level which it followed overland to Lockport and then dropped down to the Des Plaines River Valley through a flight of four locks. The channel continued its descent through Joliet, Channahon, and Ottawa via eleven more locks before joining the Illinois River at LaSalle. The 15 locks were 110' long, 18' wide, and handled varying lifts.

Waterborne commerce on the rivers and canal was a boom to the City of Chicago. In 1833, Chicago had 1200 residents. By 1845, that number had risen to 12,000. In 1848, there were 20,000 inhabitants, and by 1854, that number had risen to 74,000. Chicago became the nations largest inland port. Canal towns from Joliet south to Peoria grew as well.

However, the canal's successes soon caused its demise. The City of Chicago was pumping its sewage into the slow-flowing Chicago River which ran into Lake Michigan, the city's source of drinking water. Water pollution caused the deaths of 5% of Chicago's population in 1854 and 12% in 1885.

The city then looked for ways to divert its sewage to the Illinois River. Because railroads began to provide a more economical means of transporting goods, and barges were too big for the canal, the state initiated construction of the much larger Chicago Sanitary and Ship Canal from Chicago to Joliet in 1892. The new canal was completed in 1901 and the old I & M Canal was abandoned as a traffic artery. Passenger steamboat traffic was big business on the rivers of the Midwest. In 1918, the wreck of the steamboat Columbia killed 87 people and led to calls for a deep navigable waterway in Illinois.

In 1920, the State of Illinois began its own 9-foot deep channel project on the modern Illinois Waterway. This waterway is the navigable link from the Mississippi River, up the Illinois, up the Des Plaines River, through the Chicago Sanitary and Ship Canal, to Lake Michigan. By 1929, the state had finished 66% of the project and spent 80% of the funds. In 1930, the entire project was turned over to the U.S. Army Corps of Engineers. The Corps of Engineers resumed construction and opened the waterway on June 22, 1933. The project actually has two outlets to Lake Michigan. One outlet is via the south branch of the Chicago River and then through the Chicago Harbor Lock, to Lake Michigan. The other outlet is via the Calumet Sag Channel, through the T. J. O'Brien Lock to Lake Calumet and then to Lake Michigan. The latter is the primary commercial traffic route. (See Figure II-4)

The waterway contains 8 navigation locks and dams of varying sizes. The dams are designed to hold back pools of water to allow at least 9 feet of navigable water. Unlike the rest of the dams on the Illinois Waterway and those on the Upper Mississippi River, the dams at LaGrange and Peoria are special "wicket dams" that are lowered to the river bottom so that vessels can travel over them in high water conditions.

Most of the locks are 110' wide and 600' long although there are a few exceptions. (See Figure II-5) These locks raise and lower vessels across the 163' elevation difference between Lake Michigan and the Mississippi. (See Figure II-6)

The modern Illinois Waterway serves as today's link between Lake Michigan and the Mississippi River. Commercial traffic volume continues to grow with grain, coal, and petroleum as the leading commodities.

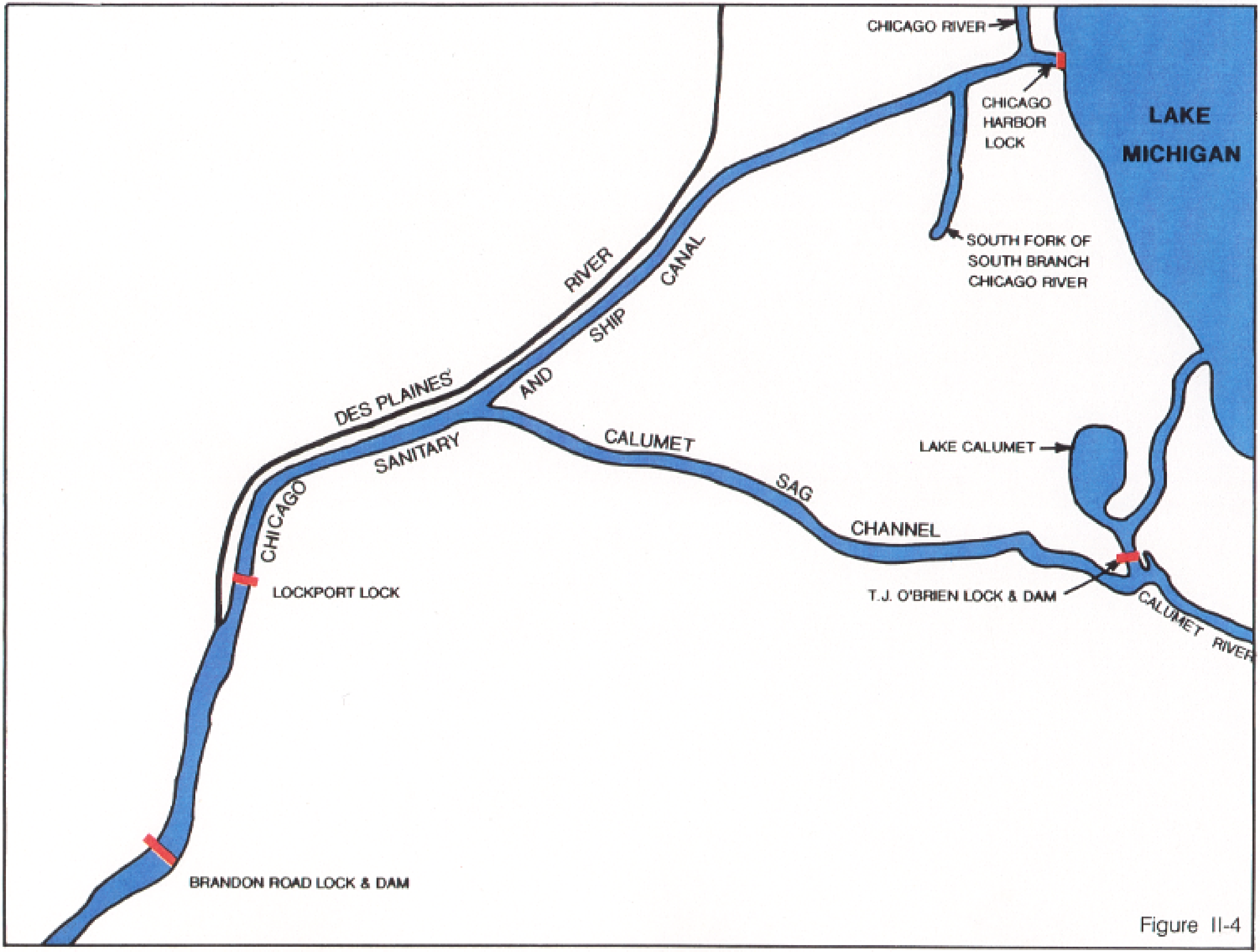

CHICAGO RIVER
CHICAGO HARBOR LOCK
LAKE MICHIGAN
SOUTH FORK OF SOUTH BRANCH CHICAGO RIVER
DES PLAINES RIVER
CHICAGO SANITARY AND SHIP CANAL
CALUMET SAG CHANNEL
LAKE CALUMET
T.J. O'BRIEN LOCK & DAM
CALUMET RIVER
LOCKPORT LOCK
BRANDON ROAD LOCK & DAM

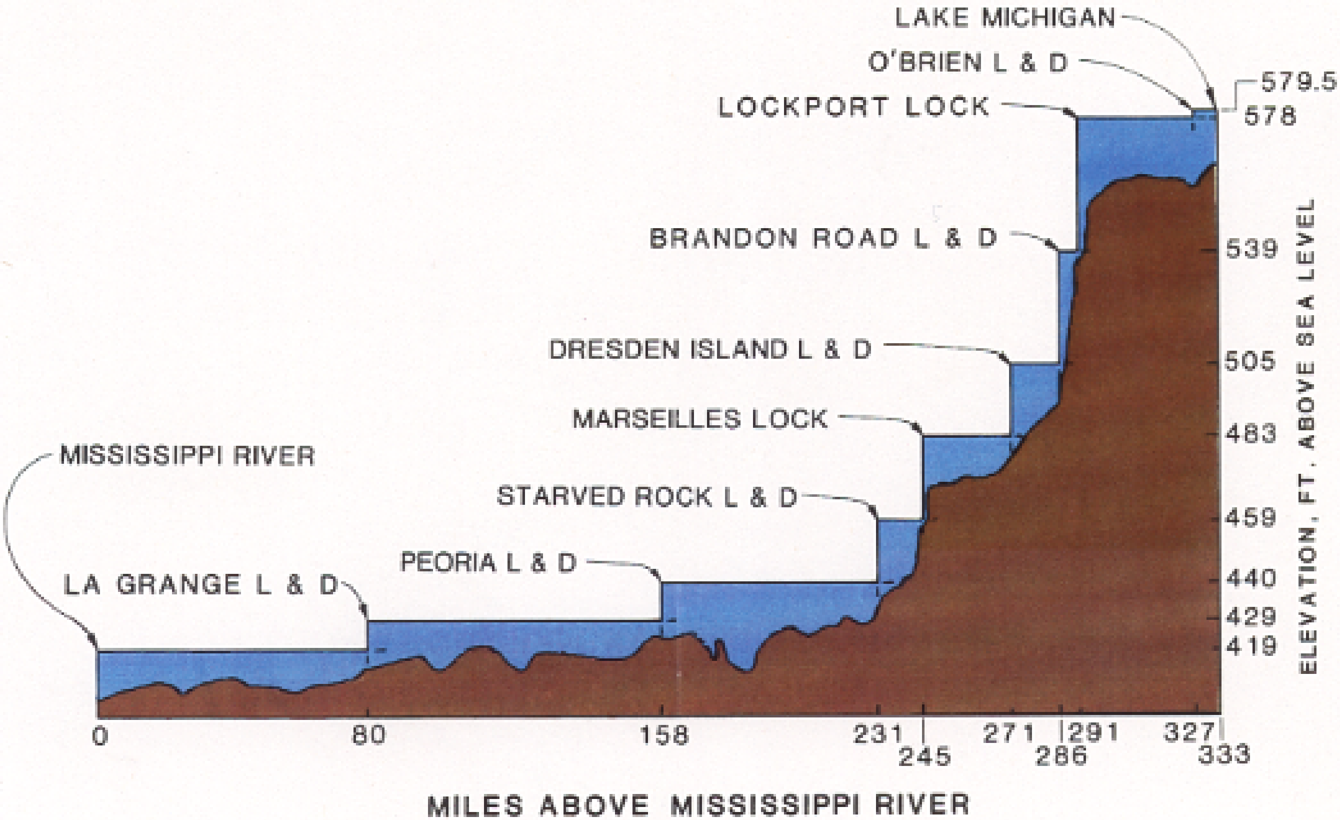
Figure II-4

<u>ILLINOIS WATERWAY</u>

LOCK	MILEPOST (from Mississippi River)	BANK (Descending)	DIMENSIONS (W x L)
Chicago Harbor	327.2	R	80' x 600'
O'Brien	326.5	R	110' x 1000'
Lockport	291.1	L	110' x 600'
Brandon Road	286.0	R	110' x 600'
Dresden Island	271.5	L	110' x 600'
Marseilles	244.6	L	110' x 600'
Starved Rock	231.0	R	110' x 600'
Peoria*	157.7	L	110' x 600'
LaGrange*	80.2	R	110' x 600'

*These locks have dams that are navigable in high water conditions.

Figure II–5



Illinois Waterway Profile

Figure II-6

B. ELEMENTS OF A LOCK

Dams constructed on the waterways to provide a navigable pool of water also restrict the flow of traffic. In order to move vessels from one pool to the next, the vessels must either be lifted or lowered the corresponding difference in elevation between pools. The locks on the Upper Mississippi River and the Illinois Waterway operate on the same principles though some vary slightly in their actual configuration and ancillary equipment.

The major elements of a lock include the Upstream and Downstream Approaches, the Main Lock Chamber including upstream and downstream miter gates, and the Filling and Emptying System. (See Figures II-7 and II-8)

The approaches are those areas where the vessels prepare and position themselves for entry into the lock chamber or ready themselves for departure from the area. The lock chamber is the basin in which the vessel is actually raised or lowered from one pool to the next. The filling and emptying system is used to control and direct the flow of water into and out of the main lock chamber.

1. Upstream Approach

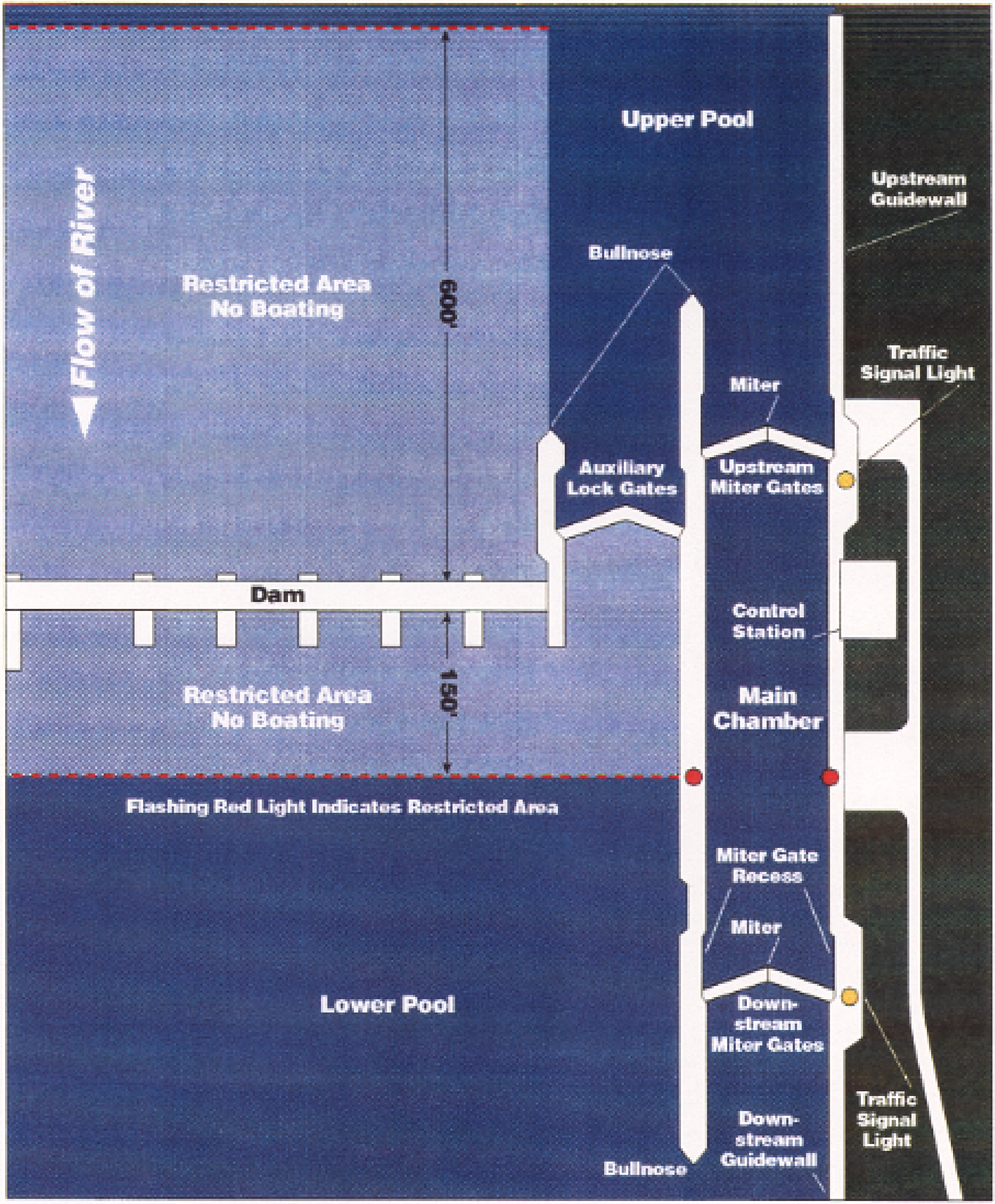
The upstream approach consists of the approach channel, guidewall, and bullnose. Some locks also have guardwalls or approach cells.

a. Approach Channel

The approach channel is a cleared and sometimes dredged channel that aligns with the lock chamber. Flow control structures may be found in the approach channel and are used to control the flow of water in the approach channel so as to assist in properly aligning the vessel for proper approach.

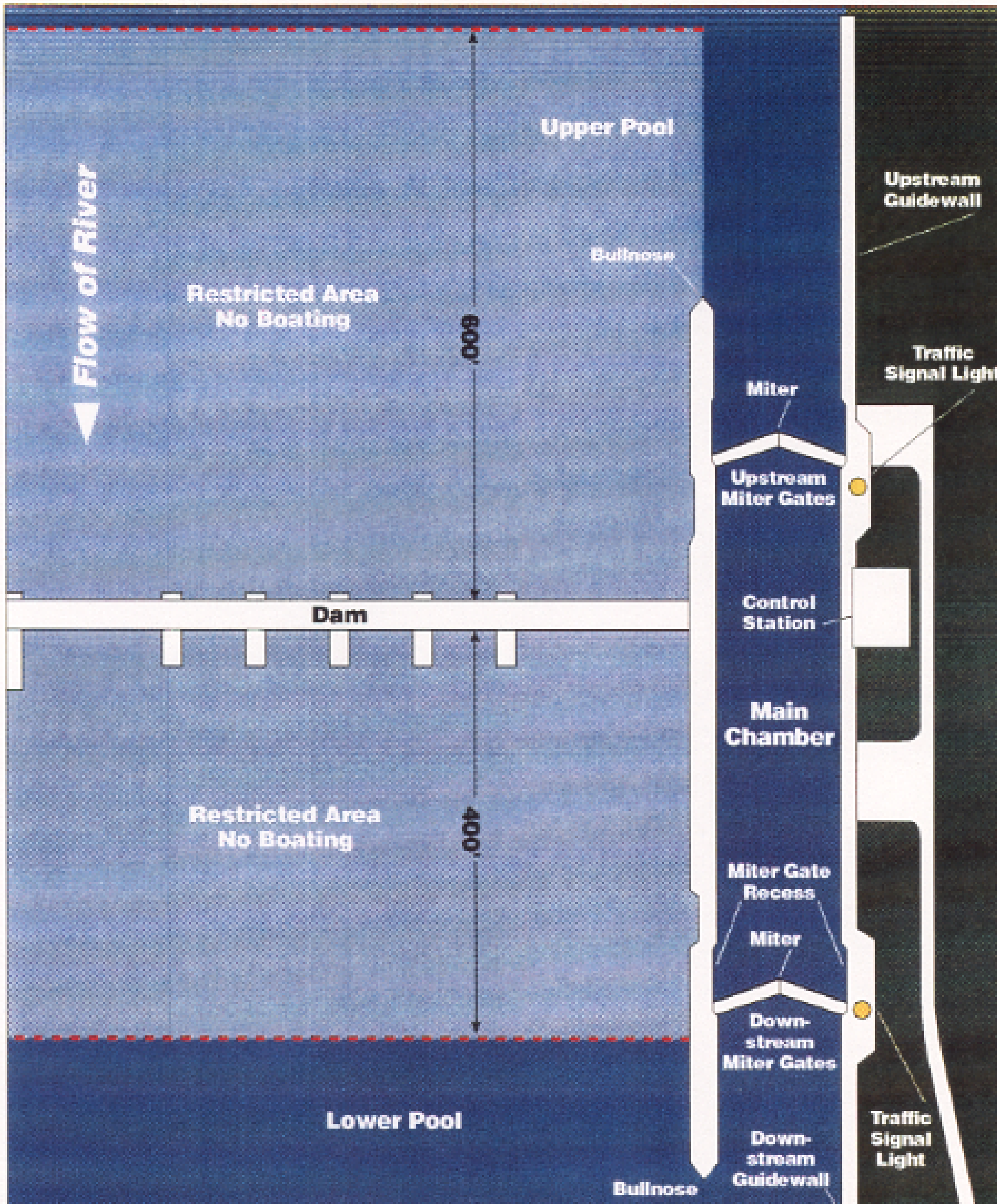
b. Guidewalls

The guidewall is generally a concrete wall extending upstream and in line with the landside wall of the lock chamber. On the Upper Mississippi River and Illinois Waterway, the guidewalls are on the land side of the approach channel. They are typically 600 feet in length each, to match the length of the chamber, but may be as long as 1200' long for those locks with a 1200' chamber. (See Figure II-9)



Typical Lock Configuration, Upper Mississippi River
Figure II-7

11-1736-094-4



Typical Lock Configuration,
Illinois Waterway
Figure II-8

These walls are used by the towboats to physically guide their fleet of barges into the lock chamber in a straight line. If the barges were not straight, then they may not fit in chamber. Approaching vessels face-up against the wall in preparation for entry into the lock. Sometimes vessels are required to tie-up against the guidewall while awaiting their turn into the lock. The guidewalls often have armor plating to protect them from the constant rubbing of the barges.

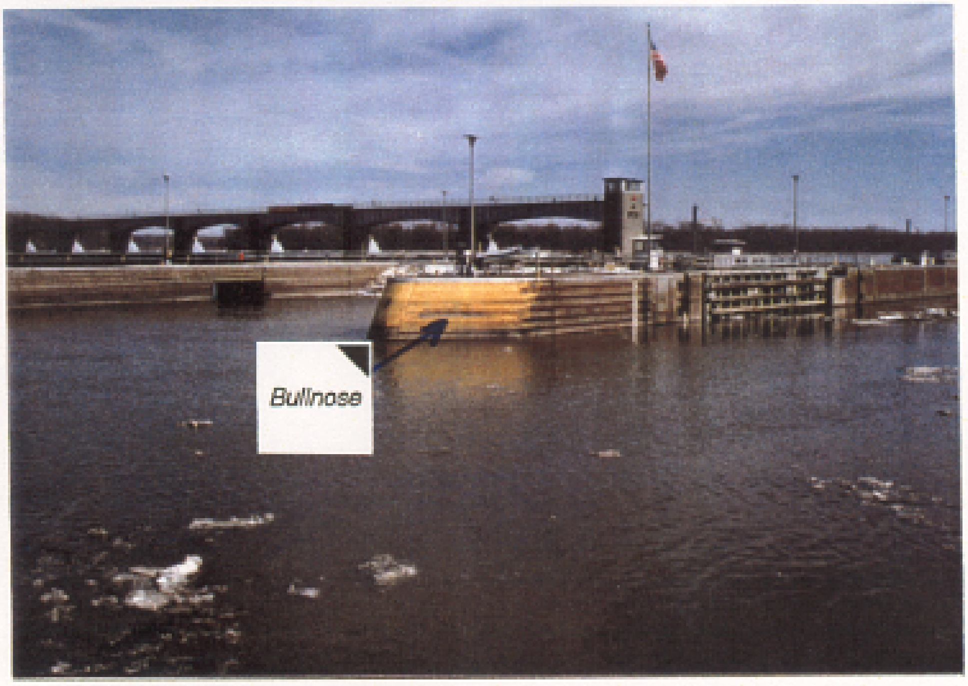
Guidewalls are also used to tie off unpowered cuts. As described later, an unpowered cut is a section of barges (usually 9 of them) that is taken from the front end of the towboats 15 barge group and locked through without a towboat attached to them. These cuts are designed to fill the whole lock and must be pulled out, or "extracted" by lock machinery and the manpower of lock personnel and deckhands (the towboat's crew). After the unpowered cut is raised or lowered, it is pulled out along the guidewall and tied-off there, waiting for the towboat and its remaining barges (the powered cut) to lock through. When the powered cut is finished locking through, the gates open and the two halves are reattached. However, since the unpowered cut and guidewall are typically 600' long each, the second cut usually remains partially inside the lock chamber while the two cuts are reattached. This means that the lock can not be used for other vessels until the two cuts are secured to each other and the towboat, now with its full fleet of 15 barges, moves out of the lock area.

c. Bullnose

The bullnose is the mass concrete element on the riverside of the approach and acts as protection for the lock structure. (See Figure II-10) At the upper end of the lock, though, the water in the river wants to pull vessels away from the guidewall and out towards the dam. This condition is called "outdraft". The short bullnose here gives the tow some room to get aligned on the guidewall without being constrained by two walls.

Bullnose design on the Upper Mississippi River is different from that on the Illinois Waterway. The bullnose on the Upper Mississippi is pointed, allowing glancing barges to be pushed back into position. The bullnose on the Illinois Waterway has a blunt end.

Upstream Guidewall, Starved Rock Lock
Figure II-9



Upstream Bullnose, Lock 24
Figure II-10

d. Guardwalls

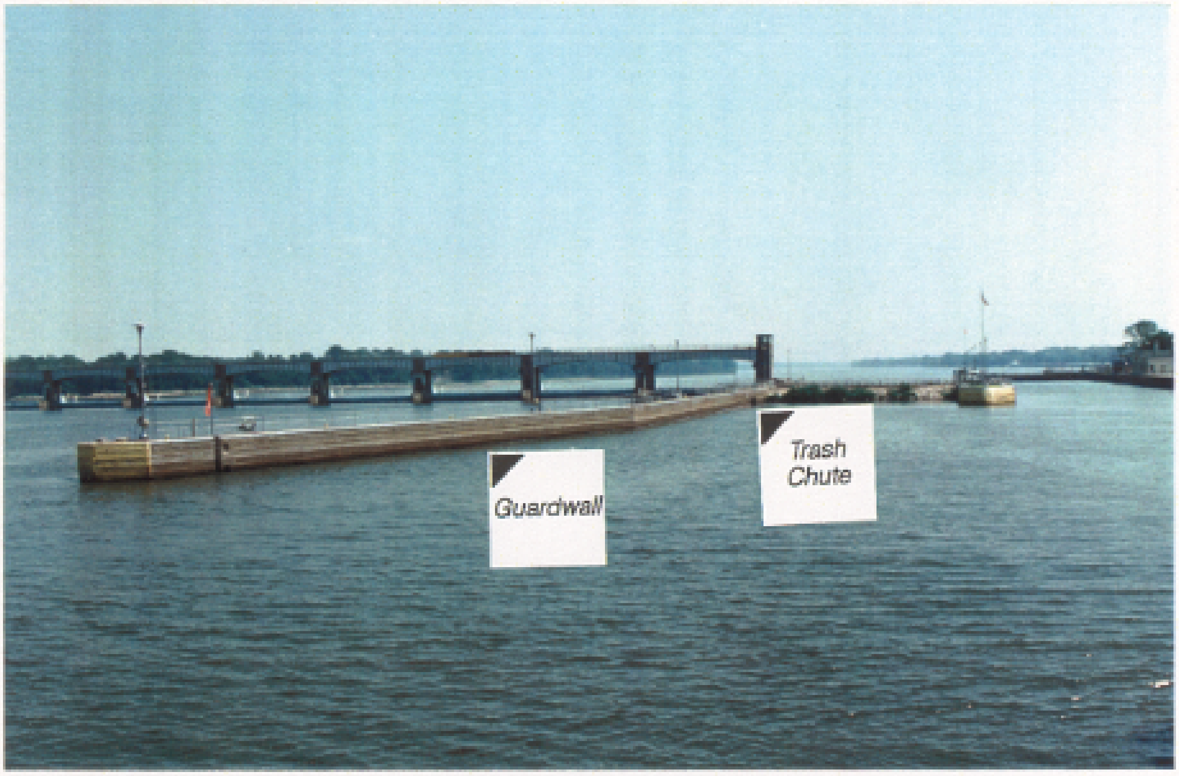
The guardwall is a structure located on the riverside of the approach channel. (See Figure II-11) Guardwalls are constructed with openings below the waterline. These openings allow water to flow into the channel and then pass out through the openings under the walls, or between the cells. This flow will tend to pull the vessel against the wall or cells, either aligning the vessel for entry into the lock chamber or preventing breakaway barges from entering the dam. Frequently an opening at water level is constructed at the end of the guardwall nearest the lock. This opening is called a trash chute, because its purpose is to allow floating debris that has been trapped by the presence of the guardwall to flow back into the river before entering the lock chamber. (See Figure II-12)

e. Guide Cells

Cells, whether they be guide cells or mooring cells, are typically made up of sheet-piling that has been driven in circular cells and then filled with earth and concrete. They form a sort of "column" up from the river bed. Guide cells are typically placed just above the bullnose, on the upstream end, and provide the same distance of opening to the guidewall as does the bullnose.

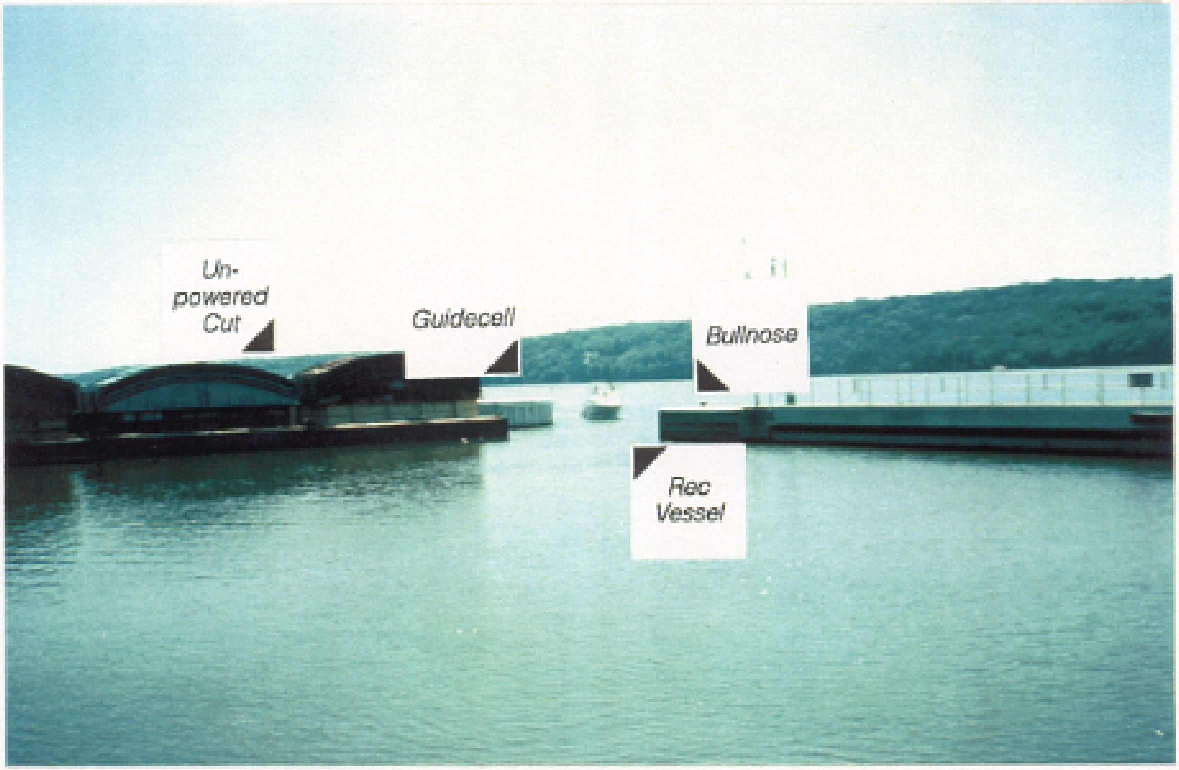
Towboats traveling downstream use them as a guide, and unpowered cuts that are going upstream and have been pulled out of the chamber use them as insurance against the effects of outdraft. As long as the stern of an upbound unpowered cut does not go past the guide cell, and the head is held to the guidewall, then the stern will not be pulled towards the dam by the outdraft.

Another advantage to having a cell instead of an extended bullnose, is that barges can use it as a guide while allowing recreational vessels to pass into the lock. The small boats pass from the upper pool of the river into the lock by slipping between the guide cell and the bullnose. They can then be locked down in the middle of locking a double cut upstream. The towboat on the downstream side must give permission for this and must move his forward end away from the downstream bullnose in order for the recreational vessels to get out of the lock and back into the river once the gates are opened at the downstream end. (See Figure II-13)



Upstream Guardwall, Lock 24
Figure II-11

Trash Chute in Upstream Guardwall, Lock 24
Figure II-12



Starved Rock Lock Forebay

Recreational vessel moves into lock by passing behind unpowered cut (held between guidewall and guidecell).

Figure II-13

2. Downstream Approach

The downstream approach is essentially the same as the upstream approach, with the exception of the guardwall. The downstream guardwall is generally solid to the bottom of the channel. In this way, the guardwall serves to prevent the discharge flow from the dam or powerhouse from creating turbulent conditions in the approach channel.

3. Lock Chamber

The lock chamber is made up of a series of concrete structures that create a basin that is generally 110' wide and 600' or 1200' feet long. The upstream and downstream ends of the chamber consist of structures that include miter gates, intake and discharge ports, and valves. The individual concrete structures that make up the lock chamber are referred to as monoliths.

a. Chamber Monolith

The chamber monoliths may be independent wall elements where the base of the chamber is founded on rock. For other foundation conditions, the monolith includes both wall and a base or floor element. Each wall element includes a portion of the conduit for the filling and emptying system, and ports connecting the conduit to the main lock basin.

b. End Monoliths

The end monoliths may be a single element or several elements having separate functions. The Gate Monoliths support the Upstream or Downstream lock gate. The Intake and Discharge Monoliths include ports located above the upper gate and below the lower gate. These ports permit the flow of water into and out of the lock filling and emptying conduit. The Valve Monoliths house the valves that control the flow of water through the filling and emptying system.

c. Ancillary Components

Each lock chamber has a variety of ancillary components at various locations within the chamber. These components include fixed ladders, floating mooring bitts, hooks, bitts, posts, buttons, timberheads and kevels. These components are described in more detail later in this report.

C. LOCK OPERATING EQUIPMENT

In order to perform its primary function, each lock includes two primary operating elements. These are the lock chamber gates and the lock filling and emptying system. The lock gates are opened to permit vessel access to the lock chamber, and are closed to prevent the unwanted entry or loss of water from the chamber. These elements may be operated from a central control facility or from control stations at the ends of the chamber. (See Figure II-14)

1. Lock Chamber Gates

Large gates, fabricated of steel, form the upstream and downstream closure elements of the lock chamber. These gates prevent the unwanted flow of water into or out of the lock chamber. Three styles of gates are used in the project area. The gate styles are miter, sector and lift. The gates in use on locks of the Upper Mississippi River and Illinois Waterway are primarily of the miter gate design. Gates at the T. J. O'Brien lock have sector gates and some of the gates at Lockport, 19, Melvin Price, and 27 are lift gates.

a. Miter Gates

Miter gates are a pair of large steel "doors" that are mounted on hinges within a recess in the lock wall providing full chamber width clearance. When the gates are open they recess fully into pockets in the lock wall. When the gates are closed they come together at a slight "miter" angle. In this position, the force imposed by higher water upstream of the gate is carried along the axis of the gate to the hinge area. This action aids in sealing the gates against the lock wall and each other. (See Figure II-15)

Miter gates must be operated in still water. Since the gate leaf is a flat element, much like a set of double doors, a difference in water level on either side of the gate will force the gate toward the closed position at an ever increasing rate.

b. Sector Gates

A sector gate has the plan shape of a large piece of pie or a sector of a circle. As with miter gates, sector gates are mounted on hinges at recesses in the lock wall. The hinge point on the gate is at the apex of the sector. Sector gates also open into recesses in the lock wall but these recesses are much larger than for miter gates because of the unique shape.

Valve/Gate Control System, Lock 25
Figure II-14

Leaking Miter Gate, Lock 24
Figure II-15

Sector gates are used where the water elevation above and below the lock is relatively small (2 to 10 feet). Unlike miter gates, sector gates can be operated in flowing water. The shape of the upstream face of the sector gates directs the force of the water to the hinge rather than causing the gates to close at a faster rate of speed.

Sector gates also serve as the filling and emptying system. The gates holding back a water differential are opened slowly allowing water to flow into or out of the lock chamber. Since the sector gates double as the filling and emptying system, locks with sector gates do not require a mid-body structure. Generally the mid-body of a sector gate lock is a sheet pile cellular wall tied into the two gate monolith elements. The mid-body may also consist of an earthen channel.

c. Lift Gates

Lift gates consist of either a single leaf or a series of leaves that span the full width of the lock and are lifted into place from the bottom of the lock. The lifting machinery is attached to the upper leaf. As the upper leaf is raised it engages the second leaf which travels upwards with the first. Each successive leaf is engaged and lifted in a similar manner. Lift gates can be raised and lowered with a difference in water elevation but this process is not generally used to fill or empty the lock chamber. A lift gate is most frequently used in the upstream gate position.

The upper surface of the top leaf is formed in the smooth shape of a weir. When necessary, the gate is lowered to just below the upper water surface. The water spilling over the top of the gate carries floating debris or ice with it, thus clearing the upstream approach channel.

2. Filling and Emptying System

Each lock is provided with some form of filling and emptying system. This system is used to control the water level within the lock chamber area. For most locks, the filling and emptying system consists of ported conduit formed into the concrete wall structure of the lock. Valves near the upper and lower ends of the conduit control the flow of water through it. Locks with sector gates do not have independent filling and emptying systems.

a. Culverts

Culverts are the "pipes" which carry the flow of water into and out of the lock. They are really voids formed into the wide base of the concrete walls. The voids are aligned to form a continuous tunnel along each side of the lock. The culvert starts above the upper lock gates and end below the lower gates.

The culverts may be as much as 14' high and can be either circular or square in shape. Ports in the culverts connect it to the lock chamber and the upstream and downstream approach channels.

b. Intake Ports

The intakes are a series of ports near the bottom of the upstream approach channel that allow water to flow from the upstream pool into the lock conduits. These ports may be located on either the channel and/or back face of both the landside and riverside lock wall. The intake ports are typically covered with a heavy-duty metal "screen" that keeps debris from flowing into and blocking the culvert. The screens are made of metal bars and are bolted in place. They require regular cleaning in order to keep them clear of debris that would impede the flow of water into the system.

c. Filling/Emptying Ports

The filling/emptying ports are the holes in the walls of the lock chamber that allow water to flow between the culvert and the lock chamber. The are usually along the bottom of the lock chamber itself.

d. Discharge Ports

The discharge ports permit water to flow from the lock conduit into the downstream channel. These outlets are usually not screened because they are used to remove water (which has already been screened by the intakes) from the lock. If trash were to enter the lock system, a screen on the outlet would trap the material in the culvert.

The culvert may empty through outlets on either side of the bullnose and guidewall. Lock 24, for example, has 8 outlets on the riverside of the guidewall, 2 outlets on the landslide of the guidewall that empty into a stilling basin, and 4 outlets on either side of the downstream bullnose.

e. Valves

The valves used in lock operations on the Upper Mississippi River are of the "tainter valve" type. The valves on the Illinois Waterway are "slide-gate" type valves. They are positioned in the culvert between the intake ports and the filling/emptying ports and again between the filling/emptying ports and the discharge ports. The valves are opened or closed by electric motors or hydraulic actuators. The gates have seals on them to keep the water from escaping around the edges. Bulkheads can be lowered down into slots upstream and downstream of the valve so that the valve can be inspected or removed for maintenance and repair. (See Figure II-16)

A typical lock has four of these valves. There is one on each side of the upstream end of the lock. They are opened to fill the chamber. The other two are located on each side of the downstream end of the lock. These are used to empty the lock.

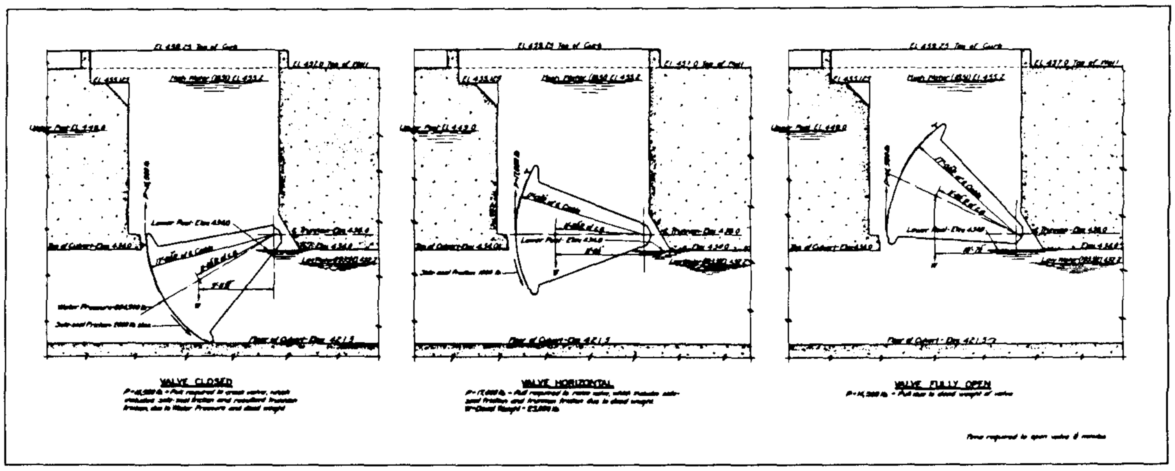
When the upstream valves are open and the lower valves and all gates are closed, the water passes through the intakes, into the culvert and out through the filling/emptying ports into the lock chamber and fills it. When the downstream valves are open and the upstream valves and all gates are closed, water leaves the chamber through the filling/emptying ports, flows into the culvert, and out through the discharge ports, emptying the chamber. All flow is gravity induced.

D. ANCILLARY LOCK EQUIPMENT

1. Tow Haulage Equipment

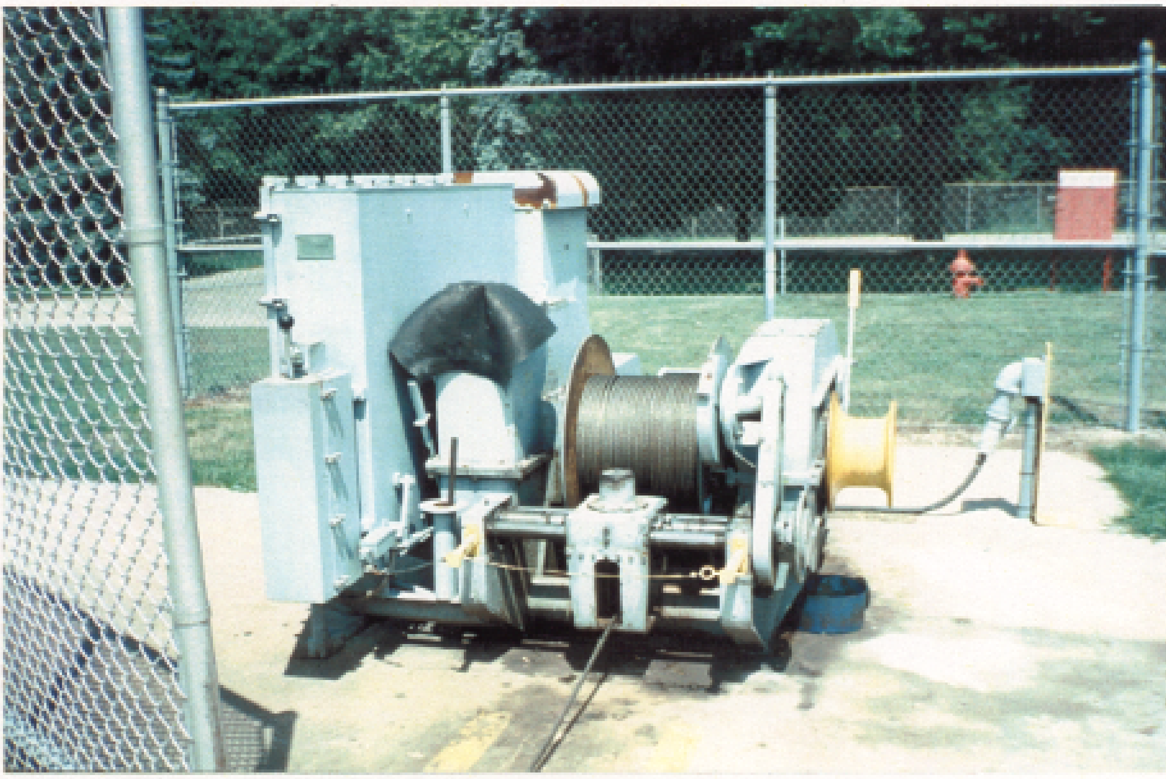
Tow Haulage Equipment is the name given to any number of mechanical devices used to pull unpowered cuts of barges out of the lock chamber. These devices include winches, capstans, powered kevels, trucks and poles. All of them transfer force from some land based power source to the unpowered barges through a mechanical connection. The most common of these devices is a single line cable winch. (See Figure II-17)

The winch type tow haulage unit is a heavy-duty, constant tension, electric winch with a spool of wire rope. The winch is most frequently located at a point where the guidewall joins the lock itself, near the gates. The cable is led through a sheave on a fixed plate block on the guidewall. It is then led from the sheave assembly, along the guidewall, over the gates, and along the lock wall, where it is then attached to the barge. (See Figure II-18)



Tainter Valve
Figure II-16

Note: *In some culverts the valve is reversed*



Tow Haulage Winch, Starved Rock Lock
Figure II-17

Sheave Assembly, Starved Rock Lock
Figure II-18

Some locks lead the cable across the closed gates and tend it while the gates are opened. Others wait until the gates are fully opened before leading the cable down the wall by hand or by electric cart. Because the sheave is on the wall outside of the chamber, the wire must be led by hand over the top of the gates, if they are closed.

Some locks wait until the gate is completely open before running the wire down the lock wall to the cut. This is because the configuration on the lock wall is such that they can not run their electric carts along the edge of the wall until the gate is fully in the recess, providing a platform to run on. They choose not to handle the cable by hand.

2. Traveling Kevels

Traveling kevels are devices that barges can be tied off to and that move on rails along the guidewalls. They are typically located only on the upper guidewalls and are used during the extraction of an unpowered cut traveling upstream. By securing a breasting line from the barges to a traveling kevel, the connecting line will not require tending as the barges are moved along the guidewall. (See Figure II-19)

The outdraft on the upper guidewall, caused by the water moving away from the guidewall and towards the dam, tends to pull the head of the unpowered cut away from the guidewall. If the barges are being pulled out of the lock with the tow haulage equipment, then the head of the barge must be kept along the wall as it moves out. The traveling kevel provides this feature and is a safe, efficient measure for securing the barges. If a traveling kevel is not installed, then a line to the head of the barges must be constantly shifted from one mooring point to the next as the barge travels down the wall. (Note: Traveling kevels on the Upper Mississippi River and Illinois Waterway are unpowered.)

3. Floating Mooring Bits

Floating mooring bits are tie off points within the lock chamber that move up and down with the level of the water during the filling or emptying process. These devices were not included in the original design of many of these locks, and so a number of locks have been "back-fitted" with the floating mooring bits. There are usually two or three of them along the landslide wall of the lock chamber. Newer locks may have them on both walls.

Floating mooring bits usually have two stages. The bit closest to the water level is used for full barges that sit lower in the water. The upper stage is higher and is used to tie off empty barges which sit higher out of the water. This two stage bit is a single unit that rises and falls as one piece. (See Figure II-20)

4. Fittings

The river industry has a terminology all its own. Items such as kevels, buttons, timberheads, steamboat ratchets and pelican hooks are all names of critical pieces of equipment used on barges, towboats and locks.

Kevels are mooring points that look like anvils. They can be about 18" long and 6-8" high. A vessel's lines are wrapped around them in a series of "figure eights" to tie the vessel off or to "check" (slow down) its "headway" (forward momentum). Kevels are used on lock walls as well as on barges. (See Figure II-21)

Buttons are another mooring point for vessels and are about 8-10 inches high. The "eye of a line" (a loop that has been spliced into the end) is thrown over the top of the button on the lock wall, and the other end of the line is usually secured to a kevel on the barge. Buttons are also used as points around which to "bend" a line. (See Figure II-22)

Timber heads are two solid posts that are used liked kevels to secure a line. The can be as much as 12" tall. The line is wrapped around the timber head in a series of figure-eights.

5. Deicing Equipment

Locks may have a number of different methods to combat the problem of ice interference in their operations. These devices include air bubblers, pike poles, heat plates, heated water jets, and/or mechanical cutting devices.

a. Air Bubblers

Air bubbler systems are installed at many of the locks to combat ice conditions in the winter. This system consists of an air compressor, lines or hoses, and pipes that run in selected areas along the bottom of the lock chamber. These pipes supply air through holes in the underside of the pipe. This design keeps silt from accumulating in the pipes.

Traveling Kevel, Starved Rock Lock
Figure II-19

Floating Mooring Bit, Lock 24
Figure II-20

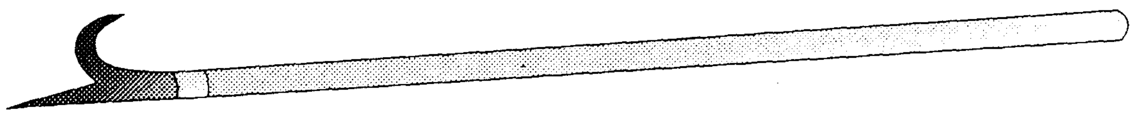
Kevel on Lock Wall, Lock 24
Figure II-21

Button on Lock Wall, Lock 24
Figure II-22

Air bubbler pipes are often placed across the upstream end of the lock, just above the recesses for the upper gates. They may also be located along the upstream edge of the upper gates (attached along the bottom), at the miter seams, and in the gate recesses. Their purpose is to create "open water" (from the motion of air and water) in an ice environment, so that floating ice can be moved around. Lock personnel skillfully coordinate various air bubbler lines to move ice away from gates so that they can be opened.

b. Pike Poles

A pike pole is a long wooded pole with a sharp metal spike on one end. It is used to move ice and floating debris around in the lock chamber.



Pike Pole
Figure II-23

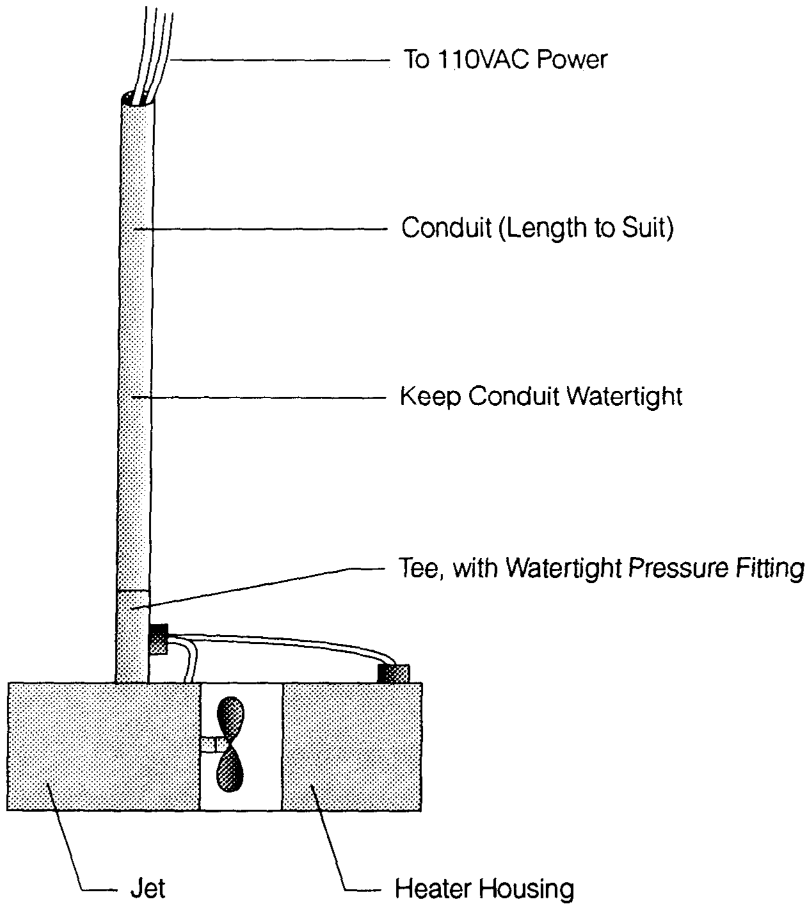
11-1736-094-2

c. Heat Plates

A heat plate is an experimental device used to keep ice from accumulating on the walls of the lower gate recesses. As the chamber is emptied, wet concrete is exposed to the cold air. This water freezes on the lock wall forming sheets of ice. At the top of this "wetting zone", the ice builds up into a ledge that can significantly interfere with opening the gates into their recesses and reduces the clear width of the lock chamber. When this happens, locks have to implement a 70' wide restriction (as opposed to the 105' normally available for tows). Towboats can then only bring in fleets of barges two-wide instead of three.

d. Heated Water Jets

Heated water jets are used to clear ice build-up from specific areas around the lock. Heated water is directed against areas of ice build-up to both melt and dislodge the ice from its points of attachment. (See Figure II-24) Occasionally, steam will be used in place of heated water.



Heated Water Jet

(F. Donald Haynes, Mechanical Engineer, COE CRREL)

Figure II-24

11-1736-094-1

e. Mechanical Cutting Devices

Mechanical cutting devices serve the same purpose as heated water jets, in that they are used to remove accumulated ice from areas of the lock and lock equipment. After the built-up ice is dislodged, it is still necessary to dispose of it. Generally, it is flushed through the lock by systematically opening and closing gates and valves.

f. Flushing

Flushing involves introducing warmer water from the bottom of the upstream channel into the lock chamber and the downstream channel. The water in the lock chamber is first lowered to the lower pool elevation, and one or both of the lower miter gates are opened. The lower valves are closed and then either or both of the upper valves are opened slightly. Water is drawn from the bottom of the upstream channel into the culvert where it flows out into the lock chamber creating a slight hydraulic gradient. The warmer water rises naturally and flows from the chamber to the downstream channel by virtue of the hydraulic gradient.

6. Other lock features

Lock facilities may be equipped with some means of allowing vessels to tie off while waiting for their turn to lock through. These items include mooring cells, mooring buoys, and timber piles. These mooring facilities provide a place for the towboat to attach itself and/or its barges with a line. Without such devices, towboats must either push into the river bank or wait out in the currents of the river. Both options use more fuel (and thus create more pollution while the engines are idling) and can cause scour of the bank by the vessels propwash (water churned through the propeller).

a. Mooring Cells

Mooring cells are constructed in the same manner as guide cells but are located at a greater distance from the lock than the guide cells. The distance and location must be sufficient to permit a vessel departing the lock to safely pass the vessel moored to the cell.

b. Mooring Buoys

Mooring buoys serve the same purpose as mooring cells. They are often found in areas where the river bottom conditions are less suitable for mooring cell construction. The mooring buoy assembly consists of an anchor or anchor pile(s) connected to a large floating buoy with a heavy anchor chain. The buoy is fitted with a mooring ring or other point to which the tow can attach a mooring line.

c. Timber Piles

Timber piles can be use in a wide variety of ways, but one of the most common is in clusters to provide a point of mooring. To create a substantial mooring 7, 19 or 61 piles are driven in a cluster. Wire rope is tightly wrapped around each of the concentric ring of piles and secured to the piles with staples. The single center pile is generally longer than the rest and provides a post around which a line may secured. Mooring devices such as rings are attached to the outer piles to allow vessels to moor to the cluster. Timber pile clusters are less costly than cells but have a substantially shorter useful life.

E. LOCK USERS

Each lock on the inland waterways system is available for use by a wide variety of watercraft ranging from very large vessels and floating equipment to the smallest of personal watercraft.

1. Commercial Vessels

By far the most common users of most locks on the Upper Mississippi and Illinois Waterway are the commercial vessels, particularly tows made up of up to 15 jumbo river barges and a single towboat. Commercial passenger vessels include excursion boats like the Delta Queen and Mississippi Queen.

a. Types

Tows may be made up of box or rake cargo barges carrying a wide variety of bulk cargoes and manufactured items. Other tows are made up of specialty cargo barges used primarily for bulk petroleum products.

b. Dimensions

The general cargo barges commonly used on the inland waterways are 35 feet wide and between 185 and 200 feet long. The most common combination of these barges is in a 15 barge 3x5 configuration. This flotilla measures 105 feet wide and just under 1000 feet long. When a towboat is positioned behind this fleet the total length increases to about the 1200 feet, the same length as the largest locks on the waterway system.

Barges in bulk liquid service are frequently 52.5 feet wide and come in a wide variety of lengths as befit their specialty service. When these tows are longer than 600 feet, they are locked through in two side-by-side segments in the smaller locks.

c. Equipment

The barges of a tow are lashed together with steel cables, referred to as wires. An eye on one end of a wire is fastened to a fitting on one barge, then wrapped back and forth around fittings on adjacent barges, terminating at a winch or to a deck fitting through a tensioning ratchet.

2. Corps of Engineers Vessels

The Corps of engineers operates a large fleet of working boats and barges. These vessels conduct dredging and other maintenance work on the waterway.

3. Recreational Vessels

Recreational vessels include a wide variety of sizes and shapes of privately owned vessels designed for the pleasure of its users. These may be small outboard motor boats like small fishing boats, to very large yachts capable of sleeping several families at a time.

4. Personal Water Craft

Personal watercraft include items such as canoes, inner tubes, wet bikes, jet skies, wave runners and the like. At lock facilities, these craft are handled with special care and under specific regulations designed to assure the safety of the vessels and their users.

F. ELEMENTS OF LOCKING

1. Basic Operation

Locks are operated through a system of valves, culverts, gates, intake, filling/emptying and discharge ports. The lock's filling and emptying systems utilize the principle that water seeks the lowest elevation. The emptying and filling systems use the culverts and valves to guide and control the movement of the water. No pumping is required. (See Figure II-25)

For a vessel traveling downstream (a downbound vessel), the lock chamber is first filled, if it is not already at the upper pool level, by closing the upper and lower lock gates and the downstream valves, and opening the upstream or filling valves. The level of water in the chamber rises to the upstream level, as the water from the upper pool flows through the culverts and into the lock chamber. The upper gates then open and the vessel proceeds into the chamber.

Once the vessel is secured inside the lock chamber the upstream gates are closed. The vessel is then lowered by closing the filling valves and opening the downstream or emptying valves. The water in the chamber flows back into the culvert and then out into the lower pool, lowering the water level within the chamber until it is equal to the water downstream of the lock. When the water level in the lock chamber is even with the lower level, the lower gates are opened and the vessel proceeds out. The process is reversed for vessels going upstream (upbound vessels).

2. Priority of Vessels

The use of locks is conducted in accordance with published regulations. These regulations set priorities based on the classification of the vessel requesting the lockage. In general the vessel arriving first at the lock has the preference to be the first to be locked through. However, precedence is first given to vessels of the United States. Licensed commercial vessels operating on a published schedule or in regular "For Hire" service are given precedence over cargo tows and like craft. Cargo vessels are given precedence over recreational craft.

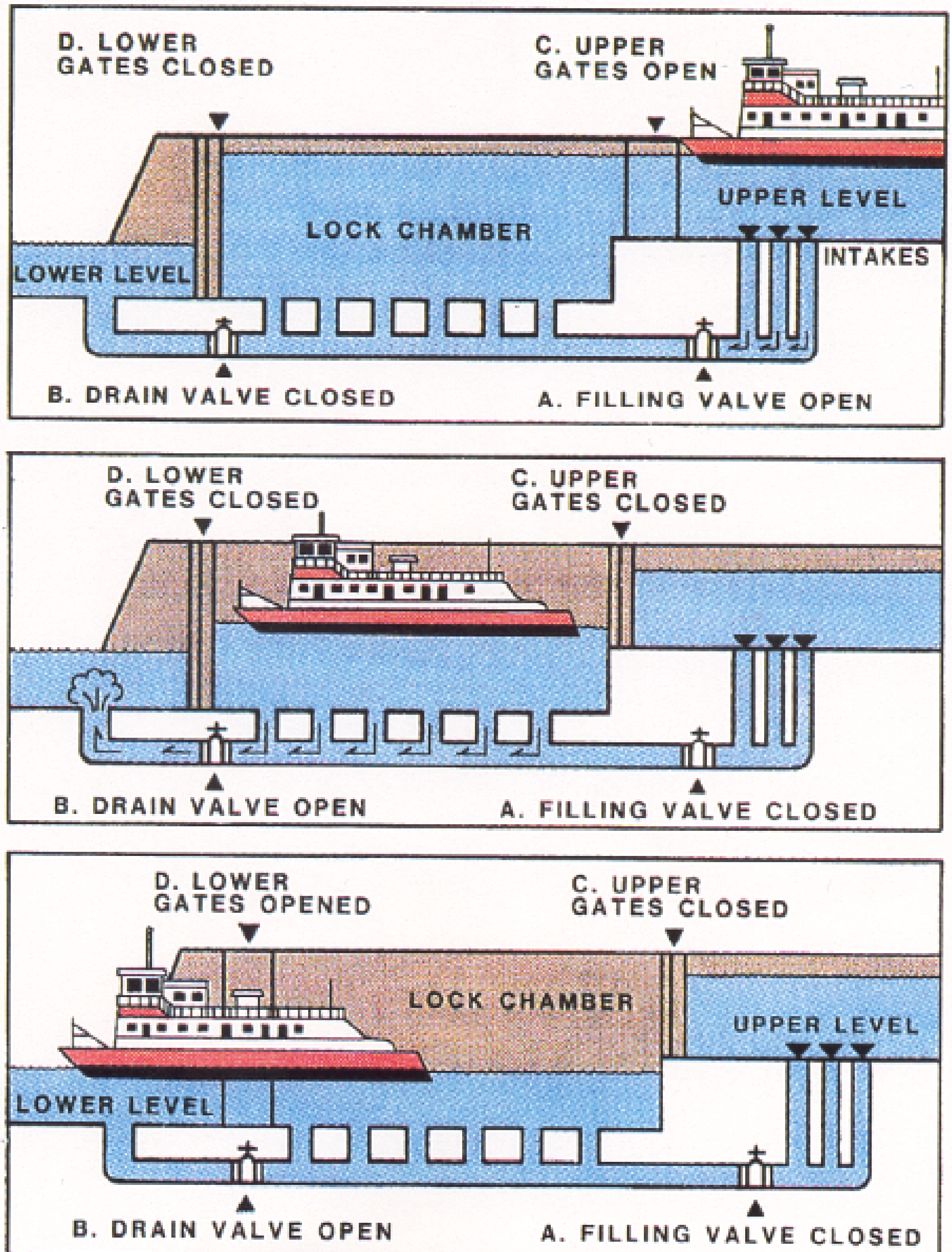

D. LOWER GATES CLOSED
C. UPPER GATES OPEN
UPPER LEVEL
LOCK CHAMBER
INTAKES
LOWER LEVEL
B. DRAIN VALVE CLOSED
A. FILLING VALVE OPEN
D. LOWER GATES CLOSED
C. UPPER GATES CLOSED
B. DRAIN VALVE OPEN
A. FILLING VALVE CLOSED
D. LOWER GATES OPENED
C. UPPER GATES CLOSED
LOCK CHAMBER
UPPER LEVEL
LOWER LEVEL
B. DRAIN VALVE OPEN
A. FILLING VALVE CLOSED

Figure II-25

Section III

III FACTORS AFFECTING LOCKAGE TIME

A. LOCKING PROCEDURES

Locking procedures are typically a matter of policy and are not within the scope of this report. Current policy does, however, effect the lock efficiency improvements suggested. One in particular, "N-up/N-down" policies such as 4-up/4-down, dictates the number of lockages accomplished in one direction before the lock operates for tows in the opposite direction. Some of the methods suggested in this report may be more effective depending on the type of lockage policy in place. This report does not suggest changes to existing policy measures, but rather identifies those policies which have a bearing on the efficiency of the recommended measure.

B. TOW CONFIGURATION

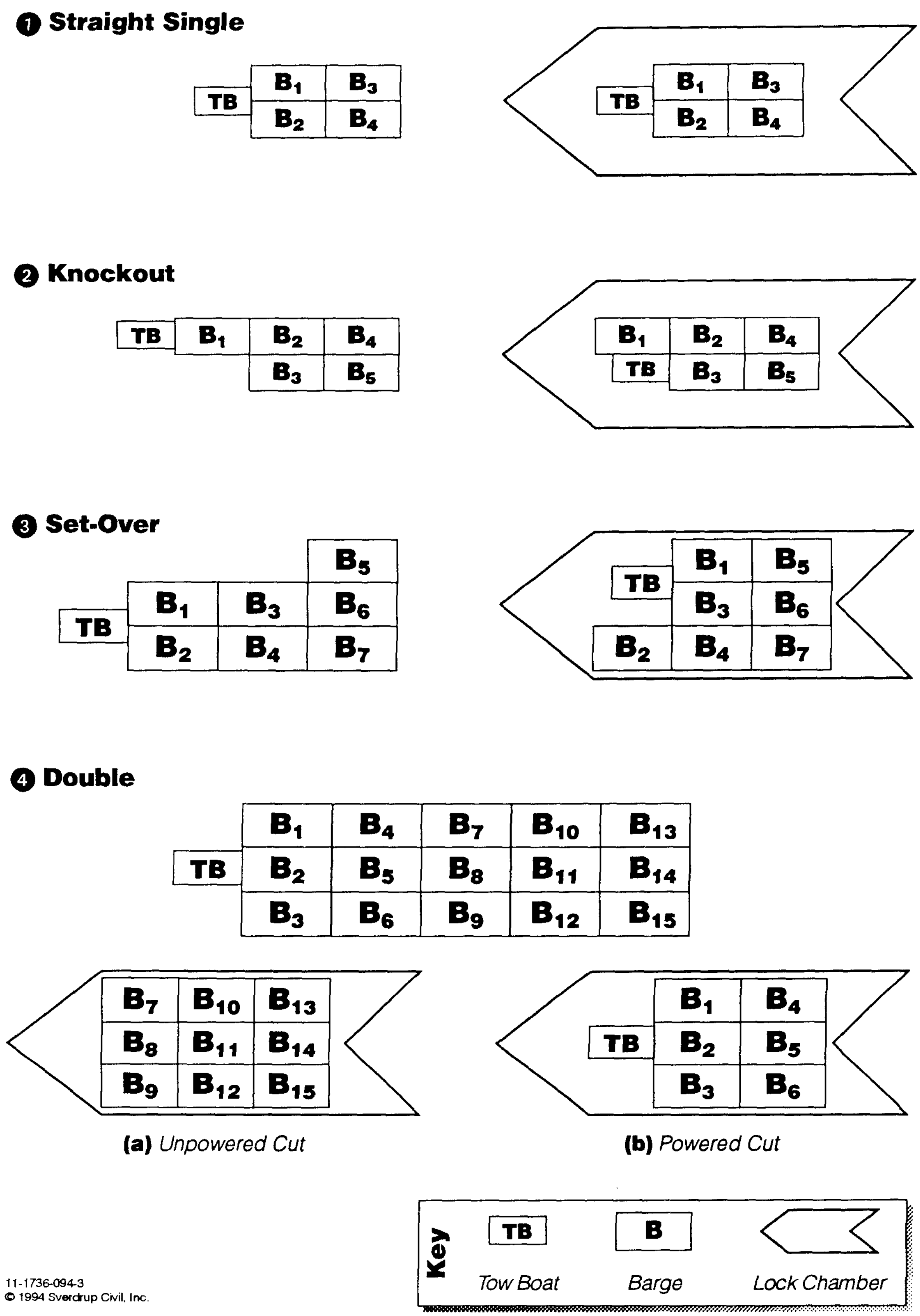
There are several different types of tow configurations for lockage. Most of the locks on the Upper Mississippi and the Illinois Waterway are 110'x 600' locks. Only three locks on the Mississippi River (19, Melvin Price, and 27) have 110'x 1200' chambers. In addition, ice accumulation on the lock walls in the winter tends to narrow the available space for tows in the chambers. Because of the size limitations of the locks, many of the tows must be reconfigured before and after locking in order to fit in the chamber. (See Figure III-1)

1. Straight Single

In this configuration, a tow's length and width does not exceed the size of the lock chamber it is preparing to enter. It therefore does not require reconfiguration and can enter the lock in an expeditious manner.

2. Knockout Single

In a knockout configuration, the combined length of barges and towboat is too long for the lock. A knockout can meet the length and width requirements of a lock by moving the towboat off the end of the barges and into a "notch", a hole in the barge configuration. Only the towboat is required to move in a knockout configuration.



Locking Configurations for 600' Chamber
Figure III-1

3. Set-over Single

In a set-over tow, the towboat and one or more of its barges are separated as a unit from the remaining barges to be "set over" to one side in order to fit the lock.

4. Double (or Mulitple)

In a double lockage, the length and/or width of the tow exceed the limits of the lock and the tow is usually locked through in two or more segments. The most common form of double lockage is for 15 barge tows through 600' locks. The first 9 barges (3 wide and 3 long) are locked through as the "unpowered cut". The unpowered cut is secured to the guidewall after lockage while the "powered cut" (the towboat and remaining 6 barges) locks through.

C. TYPE OF LOCKAGE

There are three types of entries/exits that a vessel can make at the lock; fly, turnback, and exchange.

1. Fly

A fly entry occurs when the tow approaches an idle lock which is already at the proper pool level to receive it. A fly exit is when the lock will be idle following the vessel's departure.

2. Turnback

A turnback entry occurs when the lock must be turned back, empty, from a previous lockage to accept the next vessel which is traveling in the same direction as the first. A turnback exit is when the lock must again be turned back, empty, to receive the next vessel. For example, vessel A is proceeding upstream followed by vessel B. After vessel A is raised to the upper pool, the lock is emptied or "turned back" in order to be ready to receive vessel B. Also, tows that are too large to fit in the chamber are typically broken down so that the first group of barges, the "unpowered cut" can be locked through, followed by a turnback to lock through the powered cut.

3. Exchange

An exchange entry or exit occurs when a vessel outbound from the lock passes a vessel inbound to the lock. The outbound vessel is in an exchange exit and the inbound vessel is in an exchange entry.

D. SKILL OF CREW

The actions of those people on the tows and at the locks play a significant role in lock processing time. The master or pilot of a vessel must align the tow with the guidewall to enter the lock. The deckhands must uncouple any barges for reconfiguration and secure them to the guidewall or lock wall. The lock personnel may assist with the mooring lines of the tow and its barges. Once the vessel is secure, lock personnel must close the gates, empty or fill the chamber, and then open the gates at the opposite end. If extraction of an unpowered cut is required, tow haulage equipment must attached and operated as well. Deckhand will tend lines during exit and reconfiguration with assistance from lock personnel if required.

The skill of those involved in this process can have a substantial impact on the time it takes to accomplish it. An unskilled crew, be they either lock personnel or vessel personnel, may take up to three or four times as long to complete a double lockage than an experienced crew.

E. SOPHISTICATION OF COUPLING AND UNCOUPLING GEAR

The mechanical means by which the barges and towboats are fastened to each other affects the speed of reconfiguration. Modern equipment can decrease the time it takes to break-up and make-up, setover, knockout and double tow configurations.

F. DIRECTION OF TRAVEL

1. Upbound

Tows traveling against the river's current (upbound) make slower transits than those traveling with the river's current (downbound). Although an upbound vessel makes slower approaches and exits, it does maintain greater maneuverability because of the water flowing past the vessel's rudders.

2. Downbound

Vessels traveling downbound make faster transits, but loose maneuverability as they approach the lock structure because the relative speed of the water flowing past the rudder approaches zero.

G. VESSEL LOADING AND CARGO

A fully laden fleet of barges has less freeboard, greater draft and a lower center of gravity than a fleet of empty barges. These factors greatly affect vessel maneuverability and thus vessel speed on approach to the lock. A lower freeboard means the vessel is less susceptible to the forces of the wind, but the greater draft makes the vessel more susceptible to river currents, eddies, outdrafts, and tailwater currents. The increased draft also increases the turning radius of the vessel as the amount of water beneath the vessel decreases, particularly upon approach to the lock.

Towboats pushing a mixture of laden and unladen barges or an asymmetrical configuration must also account for the changes in vessel handling characteristics resulting from a horizontal shift of the center of gravity. A vessel hauling dangerous materials may also be subject to additional precautions and slower transits due to the nature of its cargo.

H. CURRENT CONDITION

Currents in the Upper Mississippi River and the Illinois Waterway are affected by the configuration of the river basin, the flow of tributaries into the river, the amount of rainfall in the contributing drainage basins, releases from hydropower plants and dams, and lock operation. Currents play a major role in the maneuvering of vessels, particularly when the vessel is approaching a lock.

I. WEATHER CONDITIONS

The weather plays an important role in the operation of vessels on the rivers. Rainfall not only affects currents and water levels, but it can also restrict visibility and make work on steel decks slippery. Snow and sleet have similar effects, and ice conditions can completely shut down traffic flow in the rivers. Locks filled with ice may require both gate and valve machinery to be heated. Decks and ladders become slippery and ice may accumulate on the rake end of the barge, increasing the danger of damage to the sill. Fog, haze, and smoke may also impair visibility, thereby slowing approaches to and exits from the lock.

J. WATER LEVEL DIFFERENTIAL BETWEEN POOLS

The water level differential between the upper and lower pools affects the amount of time it takes to fill or empty the lock chamber. The water level for all pools above Lock 27 is controlled by spillway releases from the dams. Locks in the study area are typically medium lift locks with pool differentials ranging from about 10 to 20 feet.

K. TIME OF DAY

The time of day also effects the speed of the locking process. Nighttime approaches to lock facilities are much more difficult than daytime approaches and, as a result, they tend to be slower.

L. VESSEL MANEUVERABILITY

There are a variety of towboats on the rivers today and they all have different characteristics that affect the speed with which they can accomplish an approach, exit or reconfiguration. These vessels characteristics include, but are not limited to, horsepower, screw and rudder configuration, the availability of a bow thruster (or bow boat), and the length, draft, beam and hull shape of the towboat.

Section IV

IV THE STUDY AREA

A. LOCKS UNDER STUDY

This study deals with locks on the Upper Mississippi River and Illinois Waterway. The majority of these locks were built in the first half of this century under a system-wide plan. Although technology evolved during the construction process, many of the locks retained similar features.

In order to simplify this study process, a "standard" lock was identified as the baseline facility against which improvements will be evaluated. The "standard" lock is defined as one with these characteristics;

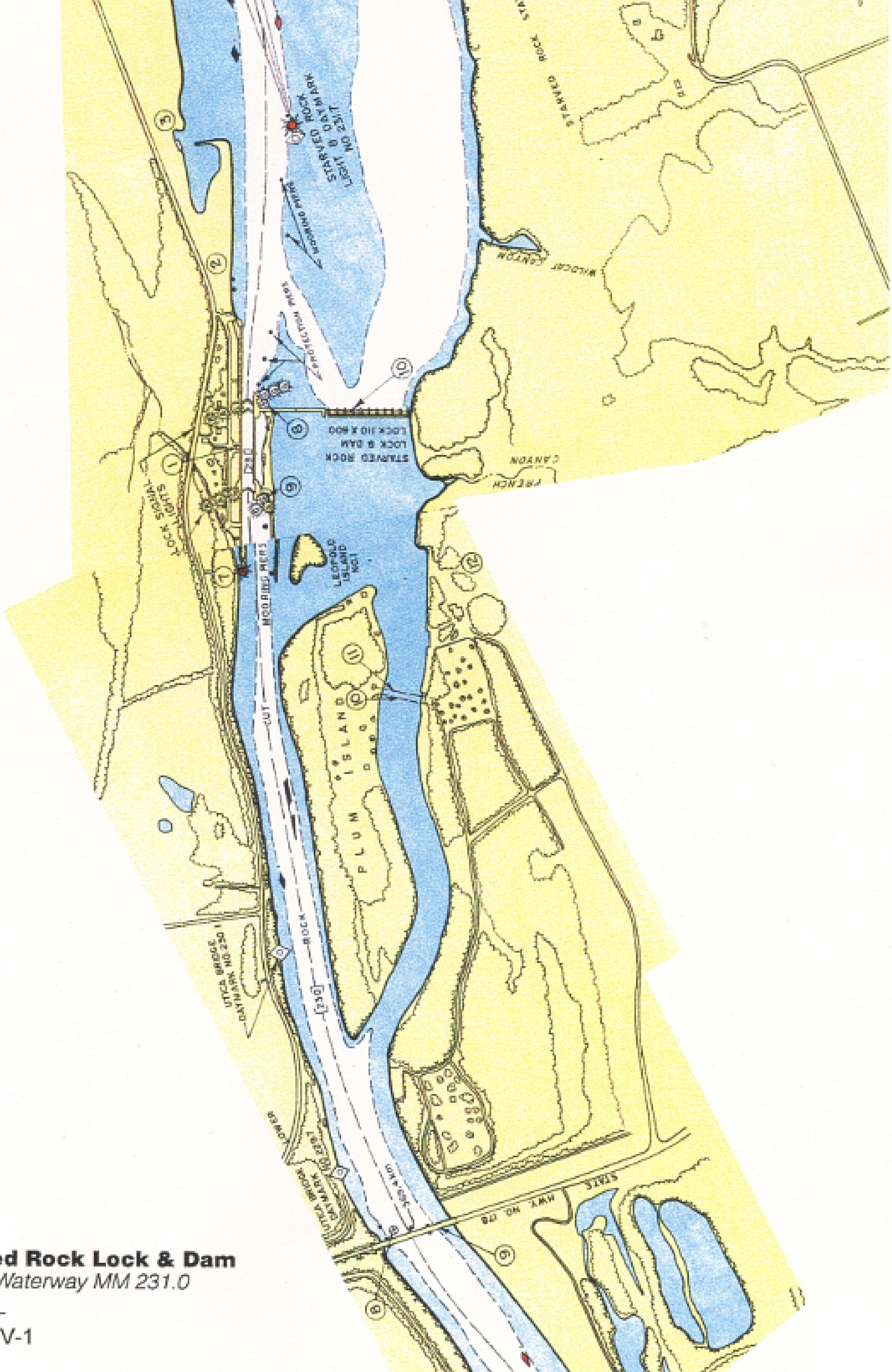
1. a single 600' x 110' chamber,
2. miter gates at each end,
3. a 600' upstream guidewall,
4. a 600' downstream guidewall,
5. cable and winch tow haulage equipment on both ends,
6. an unpowered traveling kevel on the upstream guidewall,
7. an interior monolithic culvert filling/emptying system,
8. an open river location with an adjacent dam,
9. medium lift (10'-20') ability,
10. control stations at both ends of the lock,
11. a two-person operating crew, and
12. run by the U.S. Army Corps of Engineers.

The two locks visited by the Consultant were chosen to represent this standard lock. They were Lock 24, on the Upper Mississippi River, and Starved Rock Lock, on the Illinois Waterway.

All of the proposed small scale improvement measures have been evaluated against this "standard" lock. Lock facilities that vary from this standard, such as those with two chambers or different dimensions, may have greater or less success with the proposed measures.

B. SITE VISIT - STARVED ROCK LOCK

On August 16th and 17th, 1994, the Consultant visited Starved Rock Lock and Dam at Milepost 231.0 on the right descending bank of the Illinois Waterway at Utica, Illinois. (See Figures IV-1 and IV-2) The Consultant met with and interviewed a



Starved Rock Lock & Dam

Illinois Waterway MM 231.0

Utica, IL

Figure IV-1

Figure IV-2 **Starved Rock Lock**

number of lock personnel including Larry Collins (Lockmaster), Mark Witalka (Assistant Lockmaster), Adrian Estes & George Swartz (Shift Chiefs), and Don Henke, Dennis Beedle, and Jay McNall (Lockmen). They were extremely helpful during the visit.

1. Site Information

Starved Rock Lock is located on the right descending bank of the Illinois River near Utica, Illinois, between Ottawa and LaSalle, across from Starved Rock State Park. Marseilles Lock and Dam is about 14 miles upstream and Peoria Lock and Dam is about 73 miles downstream. The modern Illinois Waterway was started by the State in 1920. Due to lack of funds, it was turned over to the Corps of Engineers in 1930 and completed in 1933. Starved Rock Lock and Dam was one of 8 lock & dam facilities completed during this time frame.

Starved Rock Lock has one 110' x 600' chamber and typically locks vessels across a 15'-19' head differential. It has a 600' landside guidewall at each end. The upstream approach has two guide cells on the landside, two guide cells on the riverside, and two mooring cells upstream on the river side of the approach. The downstream end has a 600' rock wall on the riverside of the bullnose to protect unpowered cuts from the discharge over the dam. A red buoy marks the confluence of the dam's discharge with the navigation channel. There are no mooring facilities on the downstream end.

The dam uses tainter gates that are controlled by electric motors from the walkway above. Gates 1 and 2 have protective covers that allow people to work inside them during the winter. The City of Peru is building a low head 7.6 MW hydroelectric plant between the lock and the dam. It is expected to be operational next year. The presence of the hydroelectric plant could alter the flow characteristics in the upstream and downstream approaches.

2. Conditions During Visit

Weather and water flow conditions at the site during those two days were roughly the same. The gates on the dam were opened a total of 5', flow conditions were normal, winds were light, temperatures were in the mid 70's during the day and mid 50's at night. Conditions were ideal for lockage.

3. Lock Users

ACBL (American Commercial Barge Line) and ART Co. (American River Transportation Company) are the two largest commercial users of this lock. Other major companies include Ingram and WKN (Western Kentucky Navigation). The lock sees a great deal of recreational boaters on the weekend because of nearby marinas and state parks.

4. High Flow Conditions

High flow conditions on the river create high outdraft conditions that pull towboats away from the upper end the lock towards the dam. This condition is particularly important for downbound towboats who get the front end of the tow between the guidewall and the bullnose, but allow the stern to drift towards the dam. Outdraft conditions, marked by a large orange circle on the upstream guidewall, are signalled to mariners when the gate opening on the dam is 15.5' or higher.

During outdraft conditions, towboats wait their turn to lock further away then usual. Downbound vessels either wait at the marina upstream or they back into an adjacent cove. Towboats can request a helper boat, but may have to wait several hours for one from Ottawa to arrive at the lock. Typically, downbound vessels are met at the end of the guidewall and the head of the barge is checked on buttons as it moves towards the gates. Six barges were lost to the dam last March under high outdraft conditions. Lock personnel felt that more traffic was being moved during high flow conditions than in previous years.

5. Winter Conditions

Ice conditions on the river have a significant impact on the lock and its users during the months of December, January, and February. Ice forms along the walls in sheets as the water in the chamber is emptied and filled. It also forms a ledge along the high water mark of the chamber that grows with each fill cycle. Ice that forms on the river flows downstream into the gate recesses or is pushed there by moving tows. Ice can sometimes be flushed over the dam or locked through, but it often is impeded by the ice that is downstream. The ice also builds up in layers as it is pushed on top of itself resulting in "ice gorges"; river conditions where there is so little water that towboat propellers are unable to get a "bite" on the water in order to move.

Ice is a particular problem when it gets into the gate recesses. It prevents the gates from opening fully and in some cases has caused the lock to impose a 70' width restriction (2 barges wide) on tows.

Lock personnel use a number of methods to keep the lock open, including pike poles, steam lines, an air bubbler system, and fanning the gates. Delays still result, and the lock must then impose policies such as "double tripping" (excess barges are pushed into the ice) and ice couplings (box to rake or rake to rake barges at the coupling). Tow companies cooperate with the locks in the winter by providing a RIAC (River Industry Action Committee) Emergency Officer to manage the traffic flow.

Tugs occasionally break up ice in front of the dam so that it can flow away from the approach. They will also back up to the gates and use their propwash to clear away the ice. Even if the ice is broken, it may still have no place to go if the downstream side is frozen over as well.

The air bubbler system is operated from a rented diesel compressor in the winter. The lock is scheduled to receive a permanent electric compressor before next winter. The compressor provides air to 3 installed lines in the forebay; along each of the upstream recesses and directly across the forebay. The air bubbles create open water by disturbing it from below.

Starved Rocks Lock frequently acts as a "test bed" for new projects developed by the Army's Cold Regions Research Engineering Lab (CRREL). Some of their experiments include a 3' x 8' x 0.5" heat panel installed in a lower gate recess at the high water line. This thin plate reportedly kept the ice ledge from building up in this location last winter. The panel is made from commercially available parts, including industrial grade heat tape, and is still in place.

The heated water jet is another CRREL experiment that did not receive good reviews at the lock. This device looks like a small electric trolling motor on a long pole. The small propeller sends water through a heated coil to melt ice with the resulting warm water. The lockmen stated that it was difficult to work with, slow, and not very effective.

6. Trash Problems

Lock personnel felt that trash significantly slowed their filling time because it accumulated on the intake screens. When a screen is removed and brought to the surface after years of use, it is a fused mess of tires, trees, and rope. The trash is packed in so tight that it must be burned off. Trash also floats free when barges are uncoupled. Debris that includes 40'-50' trees is not uncommon. Floating trash is usually moved out of the way with pike poles.

7. Emptying/Filling System

It takes about two minutes to open or close a valve. The intakes, located in the upper miter gate recesses, create a significant vortex just above the upstream sill. Recreational vessels are required to keep clear, but ice and trash are pulled down into the intakes. Valves are sometimes opened in increments so as to avoid pulling the trash and ice down as well as to avoid putting strain on an unpowered cut at the upstream guidewall.

The intake screens were last cleaned in 1987, and there is no scheduled maintenance program for them. The lockmaster would like to see the screens inspected and cleaned every 2 years. Replacement screens could be installed as soon as the old ones were removed in order to minimize the lock's down-time.

There are 10 3'x5' ports in the chamber from the 12' diameter culvert. Vessels in the chamber must be tied off to the wall or "push up" against it (under power) because of the turbulence created during filling. Vessels will surge on their lines as the chamber is filled or emptied. When a chamber holds a cut that extends the full length, the water flow during filling will cause the vessel to surge downstream and then back upstream. This is probably due to the upstream ports filling the chamber before the downstream ones are fully utilized.

The discharges are all located just below the sill in the guidewall and bullnose. Emptying the chamber with fully opened valves and a 15' head causes significant turbulence in this area. The turbulent water continues to move downstream for about 200-300 feet before visually dissipating. When an unpowered cut is just below the bullnose, it is especially susceptible to the full force of the discharge. Lock operators will therefore open the valves partially until the head is reduced. They will also open the landside valves more than the river side so as to divert the flow of turbulent water away from the guidewall and out the opening between the bullnose and the aft end of the unpowered cut. Upbound towboats waiting on the guidewall during the turnback of the lock are also subject to these forces. The flow from the discharge actually pulls barges at the lower end towards the lower miter gates.

Another important aspect of the filling/emptying system is the need to leave valves open as cuts are extracted at the downstream end. When an unpowered cut is pulled from the chamber, water must be allowed to flow back into the chamber through the discharges to fill the water void left behind by the moving vessel. The discharges, therefore, also act as intakes.

8. Tow Haulage Equipment

Starved Rock Lock is equipped with two cable winch tow haulage units and one unpowered traveling kevel (on the upstream guidewall). While the chamber is being emptied or filled, the eye of the wire rope is led by hand from the sheave (located just outside the chamber on the wall) over the miter gates (while they are closed) and looped over small metal posts on the railing to keep it out of the water. It is then pulled with an electric cart to the quarter kevel on the first barge. As the gates are opened, the wire rope is tended so as not to be caught in the recesses. Once the gates are fully open, the cable is cast off the railing and into the water.

The tow haulage unit is then engaged and the slack is taken up. The unit takes a strain on the barges and pulls them out with a constant tension force. The cable is only led about 120', so when the quarter kevel is abeam of the sheave, the wire rope is removed and the momentum of the barges normally carries the full cut out of the chamber. If the unpowered cut slows or stops, then the wire rope is led back to another kevel and the tow haulage unit gives the cut another tug.

If the unpowered cut is going upstream, its head is made off to the unpowered traveling kevel. The stern of the cut is checked on one of the buttons on the guidewall once it is clear of the chamber. The stern of the cut does not travel past the first upstream guidecell. At this lock, the guidecell is used to allow recreational boaters access to the lock between the bullnose and the guidecell so they can lock through during the turnback of a double cut (commercial vessel) lockage.

9. Gate Operating System

It takes about 2 minutes to open or close a gate. The operator can easily see when the gates are in their recesses (open position), but can not readily see (from their position on the lock wall) if there is a tree, ice, or other form of debris caught in the miter (closed position). For this reason, they will walk out onto the gates when they are in the closed position to make sure that there is a clean seal before the valves are opened or closed.

10. Mooring Cells

Two mooring cells are provided on the riverside of the upstream approach channel. Towboats will often tie up here while awaiting lockage, but they will not break their coupling here. There are no mooring cells downstream of the lock, so barges must either push into the bank or idle in the river.

11. Other adverse weather conditions

Tows will typically stop running in fog or snow because the low visibility prevents them from seeing the wing dams along the shoreline. They are not allowed to "hang on the lock wall" during low visibility. If they begin a lockage, then they must complete it.

Wind can be a significant problem for towboats with empty barges and for recreational vessels. Pilots and Masters will typically call ahead to check on the wind conditions and a wind sock is provided at the lock. Winter winds are out of the NW and are usually the strongest. Windbreaks are not considered desirable because of the resulting decrease in visibility.

12. Lighting

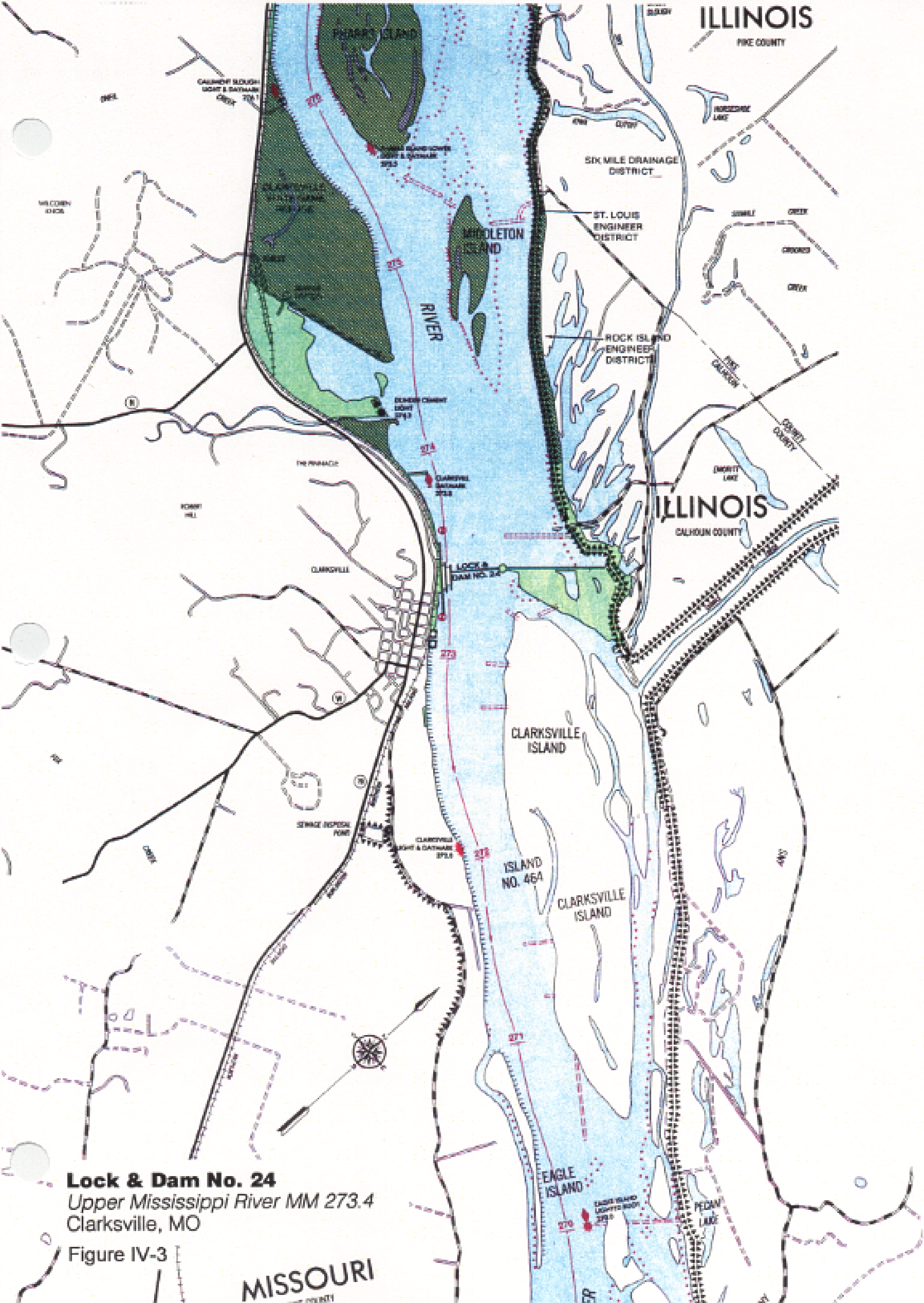
The current lighting at Starved Rock Lock creates a number of dark spots. Lock operators complained of the inability to see well because of the lighting.

C. SITE VISIT - LOCK 24

On August 18th and 19th, 1994, the Consultant visited Lock and Dam 24 at Milepost 273.4 on the Upper Mississippi River. The Consultant met with and interviewed a number of lock personnel including Chris Morgan (Lockmaster), Cindy Zimmerman (Administrative Assistant), Charles Marshall and Garry Vetter (Shift Chiefs) and Bob Blankenship and Mike Reynolds (Lockmen). Everyone was very helpful during the visit.

1. Site Information

Lock and Dam 24 is located on the right descending bank of the Upper Mississippi River at Clarksville, Missouri. Lock and Dam 22 is located about 28 miles upstream and Lock and Dam 25 is located 32 miles downstream. (There is no Lock and Dam 23.) Lock and Dam 24 was part of the navigation project to provide a 9-foot deep channel on the Upper Mississippi River and was built between 1936 and 1940. (See Figures IV-3 and IV-4)



Lock & Dam No. 24
Upper Mississippi River MM 273.4
Clarksville, MO

Figure IV-3

Figure IV-4 LOCK & DAM 24

The facility consists of a main lock and upper gate bay for an auxiliary lock (for future use). In 1982, a closure dike was constructed just above the auxiliary gates as a temporary measure until the deteriorating gates could be replaced. The gravity dam's 15 80-foot wide by 25-foot high tainter gates are used to regulate the upper pool and are not navigable. (See Figure IV-5)

Lock 24's 600-foot long by 110-foot wide reinforced concrete structure is made up of two independent monolithic wall structures founded on bedrock (shale) at 416.5 NGVD. The floor of the lock is natural shale at approximate elevation 421.5 NGVD. The top of the lock wall is at elevation 457 NGVD. The filling and emptying system contained within each lock wall consists of an interior, ported intake manifold upstream of the upper gate recesses, a 12.5' wide by 14' high internal culvert with 20 filling and emptying ports in each wall, and a ported discharge manifold downstream. The upstream gate sill elevation is 430 NGVD and the downstream sill elevation is 422 NGVD. Maximum lift is designed to be 15'. The auxiliary gate bay is similar in all respects to the upper gate bay of the main lock except that the sill elevation is 425 NGVD.

Both the upstream and downstream guidewall are 600' and are founded on bedrock. Base widths range from 14.5' to 16.5 feet with top widths of 5'. The elevation of the top of the upper wall is 457 (same as the lock walls). The elevation of the lower wall is 455 NGVD. A riverside guardwall is located on the upstream end of the auxiliary chamber and is flared to approaching traffic. It is a solid wall above the water surface, but is supported on sheet pile cells below the water surface. A single trash chute provides an outlet for debris accumulated in the forebay.

The minimum upper pool water elevation is 445.5 and the maximum regulated upper pool elevation is 449 NGVD. During the flood of '93, the upper pool reached 460.02 NGVD. The lowest tailwater elevation for lockage is 434 NGVD.

2. Conditions During Visit

Weather and water flow conditions at the site during the two day visit were roughly the same. The gates on the dam were opened a total of 30', winds were light, temperatures were in the 90's during the day and 60's at night. Outdraft conditions are considered to exist when the dam has 25' or more open. Thus, the outdraft warning was displayed at the upper guidewall. The pool differential was 10'.

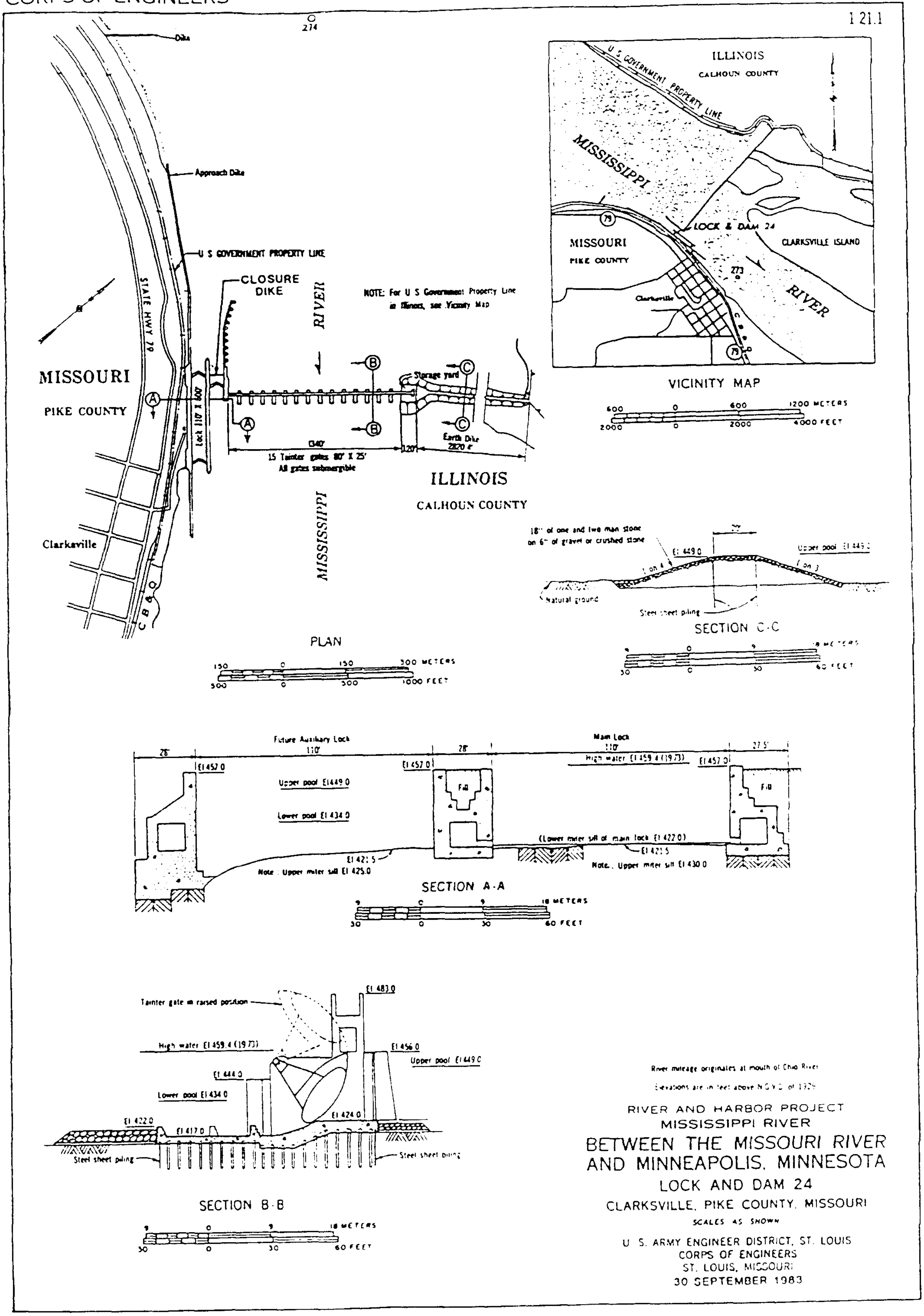

1 21.1
Dike
Approach Dike
U S GOVERNMENT PROPERTY LINE
CLOSURE DIKE
RIVER
MISSISSIPPI
NOTE: For U S Government Property Line in Illinois, see Vicinity Map
MISSOURI
PIKE COUNTY
STATE HWY 79
Lock 110' X 600'
Storage yard
1340'
15 Tainter gates 80' X 25'
All gates submergible
120'
Earth Dike 2820 ft
ILLINOIS
CALHOUN COUNTY
Clarksville
C B & Q
PLAN
150 0 150 300 METERS
500 0 500 1000 FEET
ILLINOIS
CALHOUN COUNTY
U S GOVERNMENT PROPERTY LINE
MISSISSIPPI
LOCK & DAM 24
MISSOURI
PIKE COUNTY
CLARKSVILLE ISLAND
Clarksville
RIVER
VICINITY MAP
600 0 600 1200 METERS
2000 0 2000 4000 FEET
18" of one and two man stone on 6" of gravel or crushed stone
El 449.0
Upper pool El 449.0
Natural ground
Steel sheet piling
SECTION C-C
Future Auxiliary Lock 110'
Main Lock 110'
High water El 459.4 (1973)
El 452.0
Upper pool El 449.0
Lower pool El 434.0
Fill
(Lower miter sill of main lock El 422.0)
El 421.5
Note: Upper miter sill El 425.0
Note: Upper miter sill El 430.0
SECTION A-A
9 0 9 18 METERS
30 0 30 60 FEET
Tainter gate in raised position
High water El 459.4 (1973)
El 483.0
El 456.0
Upper pool El 449.0
El 444.0
Lower pool El 434.0
El 422.0
El 417.0
El 424.0
Steel sheet piling
SECTION B-B
9 0 9 18 METERS
30 0 30 60 FEET
River mileage originates at mouth of Ohio River
Elevations are in feet above N.G.V.D. of 1929
RIVER AND HARBOR PROJECT
MISSISSIPPI RIVER
BETWEEN THE MISSOURI RIVER AND MINNEAPOLIS, MINNESOTA
LOCK AND DAM 24
CLARKSVILLE, PIKE COUNTY, MISSOURI
SCALES AS SHOWN
U. S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI
30 SEPTEMBER 1983

Figure IV-5

3. Lock Users

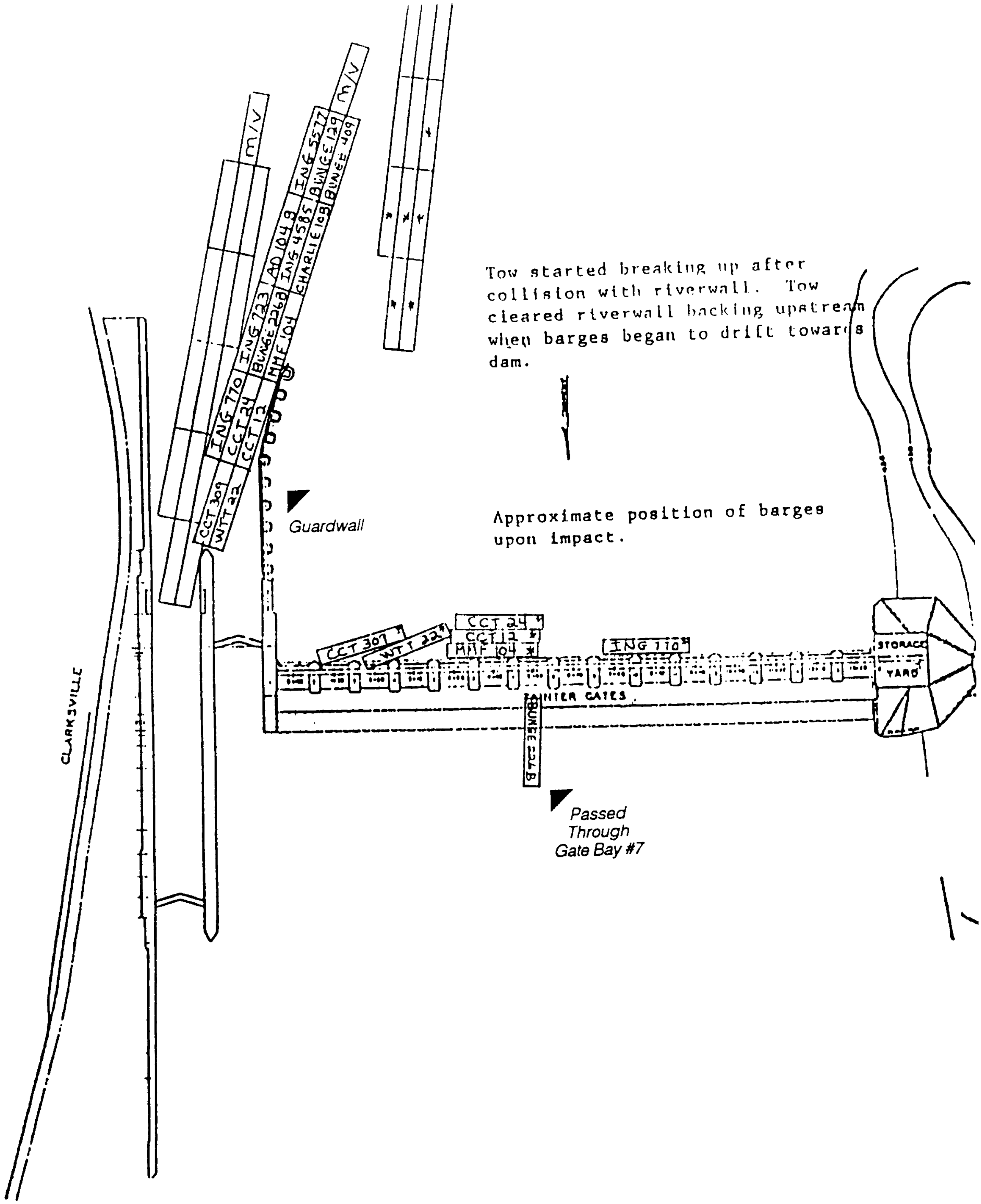
There are a wide variety of towboat companies using this lock. Unlike the Illinois Waterway, which serves a few major towboat companies, locks on the Mississippi see a wide spectrum of commercial vessels. The lock will occasionally serve a 16 barge tow; the towboat will carry the extra barge "on the hip", meaning alongside. It can take an extra 5-10 minutes to lock through a 16 barges tow because of the need to ensure that the second cut is fully inside the chamber before closing the gates. Recreational vessels are also heavy users of the lock, particularly on the weekends.

4. High Flow Conditions

High outdraft conditions exist during high flow conditions on the river. The volume of flow is measured in cfs (cubic feet per second) but is more easily referred to by the total amount of opening on the dam. Outdraft warnings used to be given when the dam had 30' of gate open. Due to the high number of accidents attributed to outdraft when the gates were at 27-28', the Corps of Engineers decided to give outdraft warnings to mariners when the dam was at 25' of gate opening or more.

The "Polly Jo", a commercial helper boat, moors in the forebay of the auxiliary chamber of the lock. It is manned around the clock and is a private commercial enterprise. The helper boat and the lock provide mutual support for each other in the form of icebreaking for the lock and electrical services for the boat. The helper boat is available to all vessels using the lock and is frequently used in keep the head of downbound barges in next to the guidewall during the approach. The helper boat pushes on the head of cut, perpendicular to the direction of the towboats movement. With the head of the cut held into the wall, the master or pilot can maneuver to put the stern of the towboat on the guidewall as well. Use of the helper boat does not always provide insurance against barges being pulled into the dam. If the towboat is not successful in keeping its stern on the wall, it may get caught against the riverside guidewall and break off barges. (See Figure IV-6)

The helper boat charges the towboat's parent company $150/hr with a minimum of 1 hour charged. Use of the boat is at the discretion of the master or pilot. Lock personnel may not require the towboat to use the helper boat, though they consider its use to contribute to a safer and faster lockage. The lockmaster suggested that tow companies be charged a flat (annual) rate for the helper boat in order to separate the master/pilot's safety decisions from economic ones.



Tow started breaking up after collision with riverwall. Tow cleared riverwall backing upstream when barges began to drift towards dam.
Approximate position of barges upon impact.
Guardwall
Passed Through Gate Bay #7
CLARKSVILLE
STORAGE YARD
TAINTER GATES
M/V
ING 770
CCT 24
CCT 12
ING 723
BUNGE 226B
MMF 104
AD 1049
ING 4585
CHARLIE 108
ING 5577
BUNGE 129
BUNGE 109
CCT 309
WTT 22
CCT 307
CCT 12
ING 770
BUNGE 226B

Figure IV-6

5. Winter Conditions

Ice conditions are a factor in winter operations of the lock. Ice accumulates at the upstream approach, but there is usually clear water downstream. Ice accumulates on the lock walls and may form a ledge at the high water elevation. Covers are placed over the gate gears to keep the snow and ice out. The lock has no steam lines (like Starved Rock), but it does have an installed air bubbler system. Ice conditions occasionally cause the lock to implement a 70' wide restriction on tows.

Downbound vessels may push so much ice ahead of them that they may have to wait for two ice lockage before proceeding into the lock themselves. When a downbound tow recouples on the guidewall, lock personnel may have to move the first cut past the bullnose in order to allow accumulated ice to flush out into the river.

The installed air bubbler system provides air across the forebay, along the upper gate recesses, and along the upstream side of the upper gates. Although the system is not designed to keep ice from forming, it is reportedly very effective in creating open water to move ice.

6. Trash Problems

Debris, particularly trees and branches, is a problem at Lock 24. The flared guardwall has one small opening along the surface of the water for the removal of trash. The lock's major rehabilitation calls for more trash openings and this should relieve some of the problem. This guardwall is open below the surface and supported on piles which tend to accumulate submerged trash as well.

7. Emptying/Filling System

There are 6 intakes on the landside upstream guidewall, and 3 on either side of the upstream bullnose. Unlike Starved Rock, where the intakes are in the gate recesses, these intakes are in the guidewall monolith. There was no apparent vortex of water above the gates during filling. Unless the vessel in the chamber is three barges wide, the intakes are not opened fully until the head is reduced to minimize turbulence in the chamber.

The discharge arrangement includes a small basin on the landside of the downstream guidewall. The discharge from the landside culvert emptied through 8 ports on the river side of the guardwall and 2 ports into the basin on the opposite side of the guidewall. The bullnose has three discharge ports on each side. This diversion of water away from the navigation channel was seen by lock personnel as a time saver and a safety measure. They would like to have more of the discharge diverted outside of the guidewall/bullnose.

The lockmaster stated that it took approximately 9-11 minutes to empty a 10' head differential if there was a vessel or cut on the lower guidewall, and about 6 minutes if there were no vessels on the lower guidewall. The slower emptying time is because the valves are opened at a slower rate so as not to place an excessive strain on lines holding an unpowered cut on the lower guidewall.

The opening of intake valves to "flush out" a downbound cut when the lower gates are open is prohibited, except when the lower pool is so low that a tow can not exit over the sill.

8. Tow Haulage Equipment

Lock 24 is equipped with two cable winch tow haulage units (one at each end of the lock chamber) and one unpowered traveling kevel (on the upstream guidewall). Once the gates are opened, the cable is hauled to the barge kevel with the electric cart. It is then attached to the cut and the winch is engaged. (Note: Starved Rock led the cable by hand while the gates were closed, then slipped it off the wall when the gates were opened.) Lock 24's procedure delayed the extraction of the cut slightly, but required less physical effort). The configuration of the lock's handrails and machinery prevents the cable from being hauled by cart before the gates are opened.

Upbound cuts are hauled from the half kevel when the dam is at 30' of gate and from the head kevel when the dam is at 60' of gate. The reason for pulling from the head kevel in high flow conditions is to provide a more lateral pull during extraction. Downbound cuts are extracted with care because they tend to pick up speed (from the dam's discharge) when they still have 200' left in the chamber. This condition has become worse since the Flood of '93 because a newly created sandbar diverts the dam's discharge more towards the lower guidewall than before.

9. Gate Operating System

The gates required about 2 minutes to fully open or close. Lock personnel did not walk out onto the gates to check the miter before emptying or filling the chamber.

10. Mooring Cells

The only mooring facility downstream is a mooring buoy that sits out in the middle of the river (away from the approach). During the Flood of '93, there were as many as 5 towboats with barges attached in a line off of this buoy.

Vessels upstream of the lock use the right descending bank to wait their turn to lock. They typically snag a tree with a line or cable from the stern of the towboat. This practice has damaged a number of trees and eroded some of the shoreline. Lock personnel have placed a ship's anchor on the shore with a length of heavy duty chain marked by a white milk jug for towboats to tie off to. Erosion still occurs because of the towboats propwash, but the trees are not damaged.

Some towboats will wait in the calm water just below the rock dike on the Missouri bank of the river just upstream of the lock. The lockmaster has sounded the area upstream of the rock dike and found a natural rock ledge that he feels would be a good setting for mooring facility. In the meantime, he is pursuing the additional of timber mooring posts along the treeline upstream of the current mooring chain location.

11. Other adverse weather conditions

Wind causes a problem at the lock, particularly for empty barges. The existing high ground at Clarksville disrupts the natural wind flow, causing the wind to generally parallel the lock structure.

12. Lighting

Lock personnel felt that the lighting was poor and created difficult working conditions because of their low intensity and placement on the walls. They would like to see brighter, fewer lights that are not obstacles on the lock or guidewalls.

D. STOPWATCH DATA ANALYSIS

The following data analysis is meant for informational purposes only. The minimal number of data points are not statistically significant to allow a more detailed analysis.

The time elements of locking that are dependent upon the lock itself include the opening and closing of gates, as well as the filling and emptying time required. The gate operating time is a function of the design speed of the machinery. The fill/empty time is a function of the head differential (which affects volume and flow) and, to a lesser extent, the culvert system that transmits the flow. During the Consultant's visits, Starved Rock Lock had a head differential of 16' and Lock 24 had a head differential of 10'. The average time for these processes are as follows;

	Starved Rock Lock	**Lock 24**	**Average**
Open/Close Gates	2	2	2
Empty Chamber	13	7	10
Fill Chamber	12.5	6.5	9.5

The difference in filling/emptying time between the two locks can be attributed to the difference in head differential. The half-minute difference in time between emptying or filling at each lock may be attributed to the culvert design and hydraulics involved. It takes less time to fill the chamber than to empty it.

The approach and exit phases of lockage are subject to a great deal of variation in time. This time is a function of the tow configuration, size, horsepower, and speed, as well as the channel configuration. In addition, lock operators record a start of lockage (SOL) and end of lockage (EOL) based on the previous and follow-up lockage. SOL and EOL do not necessarily represent the time a vessel arrives at a certain spot, but rather when the lock is able to transfer its tows form one customer to the next. A lock operator does not have a "bird's eye" view of the process either. He or she must estimate some of the time elements based on a low-level visual picture of the channel. These estimates become even less accurate at night or when a vessel is around a bend in a channel.

The following tabular data is based on a very small number of observations and under a variety of conditions that include single, double, and setover configurations as well as turnback, fly, and exchange entries/exits. It is merely meant to give the reader a sense of the time elements of a lockage. Actual times varied from 2 to 55 minutes.

	Starved Rock Lock	**Lock 24**	**Average**
Approach	29	19	24
Exit	26	14	19

The approach times are averaged from SOL to when the gates first start to close. The exit times are averaged from the last time the gates are fully opened until EOL. These times are extremely variable.

Therefore, the average time for a single lockage for a vessel going downstream would be;

	Starved Rock Lock	**Lock 24**	**Average**
Approach	29	19	24
Gate (Close)	2	2	2
Empty	13	7	10
Gate (Open)	2	2	2
Exit	26	14	19
TOTAL	72	44	57

This time series can also be represented graphically. (See Figure IV-7)

A double lockage, however, includes many more time elements. In general, there are two additional time series elements to add to the overall process along with multiple gate and chamber elements. After the first (unpowered) cut is raised or lowered, it must be pulled out of the chamber before the lock is turned back for the second cut. The first cut is usually 6 (3 long and 2 wide) to 9 (3 long and 3 wide) barges. Its removal is a function of the power of tow haulage unit, whether or not it is being pulled upstream (against the current) or downstream (with the current), and the ability of the deckhands to stop and moor the cut.

Once the lock is turned back and ready for the second cut, the towboat must push its barges in and be secured to the lock wall. The timing of this element (the second cut entering the lock) is primarily a function of the number of barges it is pushing. This may range form 0 (towboat only) to 6 (2 long and 3 wide) and may even include an extra barge on each "hip" of the towboat. The site visit data, however, only includes second cuts with barges from 0 to 6.

	Starved Rock Lock	**Lock 24**	**Average**
First Cut (Removed)	18	16	17
Second Cut (Enter)	10	6	8

Therefore, the total average times for a double lockage of a vessel going downstream would be

	Starved Rock Lock	Lock 24	Average
Approach	29	19	24
Gate (Close)	2	2	2
Empty	13	7	10
Gate (Open)	2	2	2
First Cut (Remove)	18	16	17
Gate (Close)	2	2	2
Fill	12.5	6.5	9.5
Gate (Open)	2	2	2
Second Cut (Enter)	10	6	8
Gate (Close)	2	2	2
Empty	13	7	10
Gate (Open)	2	2	2
Exit	26	14	19
TOTAL (min)	133.5 min	87.5 min	109.5 min
(hours/min)	2 hr 14 min	1 hr 28 min	1 hr 50 min

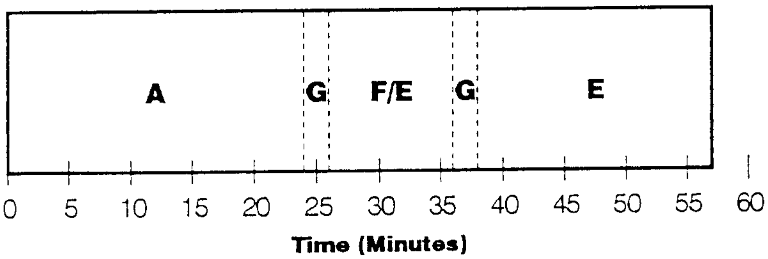
This time series can also be represented graphically. (See Figure IV-8)

Again, these numbers are rough estimates from limited data under varying conditions. They are intended to give the reader a feel for how long it takes to lock through a single (about an hour) and a double (about 2 hours).

Proposed small scale improvements can now be compared to the time table shown. For example, doubling the speed of the gates (1 minute to operate instead of 2) would eliminate about 6 minutes from a double lockage. A 5% increase in filling speed, however, would decrease the total filling time by a minute, thereby only saving 1-2 minutes in the overall time sequences.

Time Elements of Single Lockage (Average)

Figure IV-7

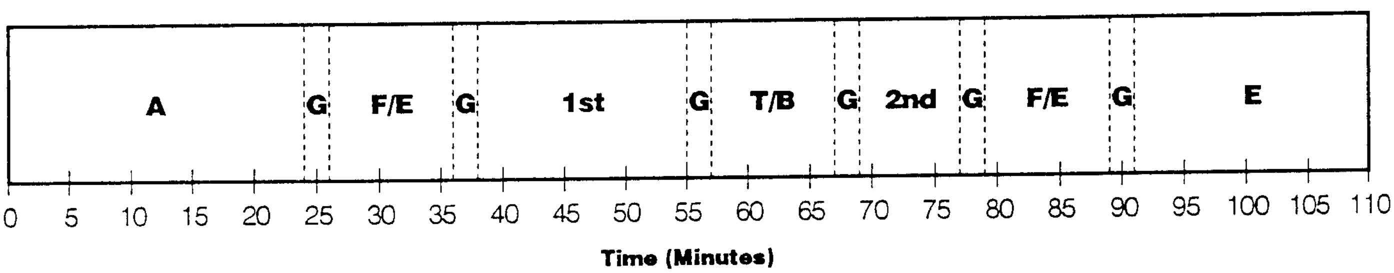


11-1817-025-1

A = Approach
G = Gate Operation
F/E = Fill/Empty
E = Exit

Time Elements of Double Lockage (Average)

Figure IV-8



11-1817-025-2

A = Approach
G = Gate Operation
F/E = Fill/Empty
1st = Extract Unpowered (1st) Cut
T/B = Turnback Chamber
2nd = 2nd Cut Enters
E = Exit

Extended guidewalls are another proposed small scale improvement. A separate time series analysis of the site visit data (Appendix III) shows that this measure would eliminate the time between "Cuts Bump Together" and "Tow Starts Exit" for a double lockage. Extended guidewalls allow the tow to complete a continuous exit without stopping to remake the tow while the stern is still in the chamber. For 10 to 15 barge tows, this results in an average time savings of 12.5 minutes. This savings only occurs, however, when there is equipment on hand to extract the first cut out to 1200' (as opposed to 600') and the next vessel to be locked is traveling in the same direction as the first (not an exchange entry/exit).

With these time elements in mind, the proposed small scale improvements can be evaluated for their ability to save time as well as their cost effectiveness in this regard.

Extended guidewalls are another proposed small scale improvement. A separate time series analysis of the site visit data (Appendix III) shows that this measure would eliminate the time between "Cuts Bump Together" and "Tow Starts Exit" for a double lockage. Extended guidewalls allow the tow to complete a continuous exit without stopping to remake the tow while the stern is still in the chamber. For 10 to 15 barge tows, this results in an average time savings of 12.5 minutes. This savings only occurs, however, when there is equipment on hand to extract the first cut out to 1200' (as opposed to 600') and the next vessel to be locked is traveling in the same direction as the first (not an exchange entry/exit).

With these time elements in mind, the proposed small scale improvements can be evaluated for their ability to save time as well as their cost effectiveness in this regard.

Section V

V POTENTIAL SMALL SCALE MEASURES

A. INTRODUCTION

The primary purpose of this study is to generate a list of potential lock improvements and, from this list, identify those measures with the greatest potential for further study. In order to accomplish this task, the study team compiled a list of possible actions from previous reports as well as from informational meetings with agencies and industry. This effort produced a 92 item list covering the "known universe" of potential small-scale measures. These items are listed in Table V-1 and described in the following pages.

TABLE V-1
POTENTIAL SMALL-SCALE MEASURES

1. **SCHEDULING OF LOCK OPERATIONS**
   - 1a. N-Up/N-Down
   - 1b. Ready to Serve Policy
   - 1c. Self Help Policy
   - 1d. Scheduling Program

2. **ASSISTANCE TO LOCKAGES**
   - 2a. Helper Boats
   - 2b. Switchboats
   - 2c. Endless Cable System
   - 2d. Unpowered Traveling Kevel
   - 2e. Powered Traveling Kevel
   - 2f. Hydraulic Assistance

3. **IMPROVEMENTS TO APPROACH CHANNELS**
   - 3a. Approach Channel Widening/Realignment
   - 3b. Adjacent Mooring Facilities
   - 3c. Funnel-Shaped Guidewalls
   - 3d. Wind Deflectors
   - 3e. Extend Guidewalls
   - 3f. Add Guide Cells
   - 3g. Reconfigure Bullnose
   - 3h. Radar Reflectors
   - 3i. Electronic Guidance System

4. **AREA-WIDE CHANNEL IMPROVEMENTS**
   - 4a. Remove/Adjust Bends, One-way Reaches, Bridges
   - 4b. Improve Navigation Aids and Channel Markings
   - 4c. Innovative Dredging Strategies
   - 4d. Water Flow Management Policies
   - 4e. Increase Channel Width
   - 4f. Isolate Recreational Facilities & Marinas Away from Channel
   - 4h. Dual Channel at Restrictive Bridges

5. **TOW CONFIGURATION AND OPERATIONS**
   - 5a. Mandate Use of Bow Thrusters
   - 5b. Mandate Use of Prototype Bow Thrusters
   - 5c. Tow Size Standardization
   - 5d. Cooperative Equipment sharing/Scheduling

- 5e. Institute Waterway Traffic Management
- 5f. Increase Number and Size of Fleeting Areas
- 5g. Fuel Monitoring & Management
- 5h. Use of Heavy Fuels
- 5i. New Barge and Boat Bottom Treatments
- 5j. Improved Barge and Boat Hull Designs
- 5k. Barge Stacking for Backhauls
- 5l. Container Movement
- 5m. New Backhaul Opportunities
- 5n. Universal Couplers/Hand Winches
- 5o. Increase Speed Limits in Restricted Reaches
- 5p. Reduce Liability of Tow Operators for Damage
- 5q. Require Minimum Crew Size and Training
- 5r. Mandate Minimum Horsepower

6. LOCK OPERATING EQUIPMENT/PROCEDURES

- 6a. Modify Intake Structures
- 6b. Modify Discharge Structures
- 6c. Modify Wall Ports
- 6d. Install Self-Cleaning Trash Racks
- 6e. Centralize Controls
- 6f. Portable Controls
- 6g. Automate Controls
- 6h. Install Floating Mooring Bits
- 6i. Upgrade Valve Operating Equipment
- 6j. Upgrade Gate Operating Equipment
- 6k. Install Gate Wickets in Miter Gates
- 6l. Provide Explicit Operating Guides
- 6m. Fenders, energy Absorbers
- 6n. Require Vessels to Stay Clear of Emptying/Filling System
- 6o. Operate Dam Gates Based on Lockage
- 6p. Lift Gates at Lock

7. ICE CONDITIONS

- 7a. Mechanical Ice Cutting Device
- 7b. Skin Plates
- 7c. Air Bubbler System
- 7d. Heat Plates
- 7e. Heated Water Jet
- 7f. Clear Ice from Barges
- 7g. Ice Chutes

8. **RECREATIONAL VESSELS**

- 8a. Recreational Vessel Bypass Lifts
- 8b. Scheduling of Recreational Vessel Usage
- 8c. License Recreational Craft Operators
- 8d. Recreational Craft Landing Above and Below lock

9. **COST ALLOCATION**

- 9a. Apply Congestion Tolls
- 9b. Allocation of Operations and Maintenance Costs
- 9c. Low Head Hydroelectric Units
- 9d. Privatization of Lock Operations
- 9e. Excess Lockage Time Charges
- 9f. Lockage Time Charges

10. **OTHER**

- 10a. Increase Lock Staffing
- 10b. Automate Dam Controls
- 10c. Radar at Lock
- 10d. Real-Time Channel Depth and Weather Monitoring
- 10e. Improved Lighting
- 10f. Publish Lockage Times by User
- 10g. Create Indraft
- 10h. Operational Philosophy/Industry Attitude
- 10i. Deepen River Upstream of Gates
- 10j. Pilot Communication (Bulletin Board)
- 10k. Closed Circuit Television (CCTV) at Lock
- 10l. Wicket Gates in Dam
- 10m. Automated Lockage System from Queue Point
- 10n. Specified Navigation Season

B. DESCRIPTIONS OF POTENTIAL MEASURES

1. SCHEDULING OF LOCK OPERATIONS

1a. N-UP/N-DOWN

Under this measure, the lock operator locks through "N" vessels (1, 2, 3, etc.) in one direction before locking "N" vessels in the other direction when congestion is such that it takes less time to turn back the lock than to allow for an exchange. The measure improves efficiency at locks where the total of exchange approach and exit time exceeds that of the combination of turnback approach and exit time plus a chamber turnback.

1b. READY TO SERVE POLICY

Towboats are required to arrive ready for lockage. Splitting the tow, rearranging the barges, and other time consuming configuration changes would not be authorized within the approaches or in the chamber. This measure eliminates the time consuming process of locking through unpowered cuts as well as that of reconfiguring tows within the lock.

1c. SELF HELP POLICY

In this measure, the towing industry is required to extract unpowered cuts without the assistance of lock personnel or equipment. It often requires coordination and cooperation between the various towboat companies to schedule additional towboats to pull unpowered cuts out of the lock. These additional towboats act like helper and switch boats, but are provided by the industry. They eliminate the need for tow haulage equipment and provide for faster extraction.

1d. SCHEDULING PROGRAM

This measure could achieve some time savings by optimizing a mix of scheduling sequences using a PC-based scheduling program. The program would be based on mathematical modeling of various types and configurations of queues.

2. ASSISTANCE TO LOCKAGES

2a. HELPER BOATS

Helper boats guide large tows into the upstream ends of the lock during high flow conditions. Helper boats save time by countering the effects of outdraft on the upstream approach, thereby allowing a more controlled and efficient (quicker) entry into the chamber. Helper boats can also save time by pushing ice and debris out of the way.

2b. SWITCHBOATS

Switchboats are more powerful than helper boats. They can remove an unpowered cut from the chamber and move it out of the approach path to a remote mooring facility in cases where the wall is shorter than the full tow length. This allows other vessels to use the chamber while the first towboat is making-up. Switchboats can also save time by pushing ice and debris out of the way.

2c. ENDLESS CABLE SYSTEM

Endless cable systems extract unpowered cuts from the chamber by attaching the unpowered cut of barges to a fitting on the cable. This cable is already in place and is powered to remove the cut. Endless cable systems save time by eliminating the need to haul the cable off of the drum in the current tow haulage systems. The unpowered cut is therefore removed faster.

2d. UNPOWERED TRAVELING KEVEL

An unpowered traveling kevel holds the head of an unpowered cut in close to the upper guidewall during extraction. It could also be used to slow cuts (if it is equipped with a braking system) or to counter the effects of outdraft (if it is built to withstand the lateral forces).

2e. POWERED TRAVELING KEVEL

A powered traveling kevel provides power to extract the cut as well as the ability to hold the cut in close to the guidewall. This measure saves time by incorporating the tow haulage system and kevel into one unit. The current winch system and length of cable are eliminated. The guidewall can be lengthened and the unpowered cut of barges pulled a greater distance from the lock chamber.

2f. HYDRAULIC ASSISTANCE

After the lower gates are opened, water is released from the upstream side of the lock to assist the unpowered cut in moving downstream. This measure could result in minor time savings for downbound vessels. If not done correctly, hydraulic forces can pull a vessel back into the gates, causing damage to the gates.

3. IMPROVEMENTS TO APPROACH CHANNELS

3a. APPROACH CHANNEL WIDENING/REALIGNMENT

This measure includes widening or realignment of the channel, installation of river training structures or submerged dikes, and the reduction of the effects of powerhouse operations.

3b. ADJACENT MOORING FACILITIES

New mooring facilities above or below the lock could consist of mooring cells or buoys/wires attached to a ship's anchor. This measure may create minor time savings by allowing vessels to be staged closer to the lock than if they had to wait in the river or push into a bank. Unpowered cuts could also be moved to these facilities, thus clearing the approach.

3c. FUNNEL-SHAPED GUIDEWALLS

Guidewalls could be built in such a way that traffic is funneled into the chamber by reducing the neck of the approach path between the walls. Although this measure is used in canals, concern was expressed in discussion regarding its appropriateness for an open river and dam configuration because of outdraft and debris considerations.

3d. WIND DEFLECTORS

Wind breaks made of wood fencing or natural shrubbery could be built along the approaches to shield vessels from the wind.

3e. EXTEND GUIDEWALLS

Extending 600' guidewalls to 1200' allows the powered cut to make up with the unpowered cut completely outside of a 600' lock chamber. The lock is therefore free to turn back for the next vessel and is not impeded by the tow make-up on the guidewall. This measure would save time by allowing double lockage tows to reconfigure on the guidewall rather than in the chamber. This measure may work best when combined with other small scale improvements such as powered kevels, etc.

3f. ADD GUIDE CELLS

The installation of guide cells on the riverside of the lock would allow the unpowered cut to be extracted beyond the bullnose, leaving space for small boats to enter the chamber on the turnback, as well as protect the bullnose and end monoliths from damage. However, this measure shortens the effective length of the guidewall for approach purposes and may lead to slower approaches.

3g. RECONFIGURE BULLNOSE

The blunt bullnose on locks on the Illinois Waterway could be reconfigured such that glancing blows would be directed into the chamber. When such an event occurs, the towboat would sustain less damage.

3h. RADAR REFLECTORS

Radar reflectors could be added to the lock facility so that the lock is more visible (on radar) in poor weather and at night. However, this measure would have little affect on the lockage process itself.

3i. ELECTRONIC GUIDANCE SYSTEM

An electronic guidance system, similar to that found at airports, could be used to assist the master of the towboat in guiding the vessel into the lock. The technology necessary for this measure does not exist for maritime applications.

4. AREA-WIDE CHANNEL IMPROVEMENTS

4a. REMOVE/ADJUST BENDS, ONE-WAY REACHES, BRIDGES

This measure calls for the removal of such navigation hazards as bends, one-way reaches, narrow bridge clearances, and obsolete dock structures. This could permit an increase in tow size and a reduction in transit time. Although this measure saves transit time between locks, it does not improve the time with which a tow passes through the lock itself.

4b. IMPROVE NAVIGATION AIDS AND CHANNEL MARKINGS

Additional navigation aids, as well as the timely replacement and repair of missing aids, would greatly assist mariners by marking the channel more clearly. Although this measure saves transit time between locks, it does not improve the time with which a tow passes through the lock itself.

4c. INNOVATIVE DREDGING STRATEGIES

Innovative dredging techniques such as river disposal, sediment traps, wing dam removal, river training structures, and air dredging could increase operating efficiency of towboats. Although this measure saves transit time between locks, it does not improve the time with which a tow passes through the lock itself.

4d. WATER FLOW MANAGEMENT POLICIES

Water flow management techniques seek to redirect the natural flow of the river to enhance channel scouring or regulate adverse currents. Water flow management uses wing dams for this purpose. In some cases, wing dams may have to be removed or relocated because they are now sediment laden and may be hazardous. Although this measure saves transit time between locks, it does not improve the time with which a tow passes through the lock itself.

4e. INCREASE CHANNEL WIDTHS

Increasing channel width would allow tows to transit the river between locks faster. Although this measure saves transit time between locks, it does not improve the time with which a tow passes through the lock itself.

4f. ISOLATE RECREATIONAL FACILITIES AND MARINAS AWAY FROM CHANNEL

Isolating recreational facilities and marinas away from the commercial channel allows towboats to proceed faster because they are not required to slow down to avoid swamping small boats, breaking mooring lines, or causing wake damage. Although this measure saves transit time between locks, it does not improve the time with which a tow passes through the lock itself.

4g. IMPROVE BRIDGE OPERATIONS AND MAINTENANCE

Bridge operations could be modified to better handle auto/rail/towboat congestion. Movable bridge machinery could be improved to the extent that it results in less time delays for river traffic. Although this measure saves transit time between locks, it does not improve the time with which a tow passes through the lock itself.

4h. DUAL CHANNEL AT RESTRICTIVE BRIDGES

An alternate passage under a secondary bridge span would eliminate restrictions at bridges. Although this measure saves transit time between locks, it does not improve the time with which a tow passes through the lock itself.

5. TOW CONFIGURATION AND OPERATIONS

5a. MANDATE USE OF BOW THRUSTERS

Use of Bow Thrusters, either in the form of Bow Boats or by installing one on the barge directly, can increase the maneuverability of tows in tight reaches and difficult current conditions (such as outdraft). However, this equipment displaces some of the cargo and is not considered to be cost effective by many in the industry participating in coordination efforts.

5b. MANDATE USE OF PROTOTYPE BOW THRUSTERS

Prototype Bow Thrusters, either in the form of Bow Boats or direct mounted units, use a water jet system to propel the water rather than a standard conventional propeller (which might be shielded by a fully laden vessel). This equipment also takes the place of some of the cargo and is not considered to be cost effective by many in the industry participating in coordination efforts.

5c. TOW SIZE STANDARDIZATION

Tows that completely fill the chamber have better space utilization than those that only partially fill the chamber. Therefore, the optimal size tow for a 110' x 600' chamber is 8+ towboat, or, if double lockage is necessary, the 16 + towboat is optimum.

5d. COOPERATIVE EQUIPMENT SHARING/SCHEDULING

Empty barges travel in both directions on the waterways. Cooperative equipment utilization between companies would provide more efficient use of equipment and reduce the number of empty barge lockages.

5e. INSTITUTE WATERWAY TRAFFIC MANAGEMENT

A Vessel Traffic System (VTS) could manage and coordinate the flow of traffic on the river. The level of involvement could range from two-way radio communications to on-board transceivers and GPS equipment to pinpoint locations. Its purpose would be to collect information in order to direct traffic and therefore optimize the use of lock facilities.

5f. INCREASE NUMBER AND SIZE OF FLEETING AREAS

Towboats require fleeting areas to reconfigure their tows at points where waterway dimensions change (i.e., at Locks 2, 26, 27 and LaGrange). These fleeting areas are not considered adequate by industry. This measure does not save time during the locking process.

5g. FUEL MONITORING AND MANAGEMENT

Fuel consumption changes at a variable rate depending on river conditions and operating speeds. Increases in overall system capacity could be gained with a dynamic system to monitor and take advantage of fuel consumption information. This measure does not save time during the locking process.

5h. USE OF HEAVY FUELS

Heavy fuels, if proven to be cheaper, could increase system capacity by decreasing costs. This measure does not save time during the locking process.

5i. NEW BARGE AND BOAT BOTTOM TREATMENTS

Barge and towboat bottom treatments are designed to extend equipment life and improve fuel efficiency.

5j. IMPROVED BARGE AND BOAT HULL DESIGNS

The design dimensions and surface characteristics of the individual barge and towboat units determine the tow resistance and fuel consumption rate. New designs can improve these aspects.

5k. BARGE STACKING FOR BACKHAULS

Grain barges usually return upriver empty. They could conceivably be stacked to reduce the area they occupy in the chamber on the return upstream. ACBL studied this measure and reported it to be not cost effective on the Upper Mississippi and Illinois Waterway.

5l. CONTAINER MOVEMENTS

Empty grain barges returning upriver could be reconfigured to carry containers. This measure does not save time during the locking process.

5m. NEW BACKHAUL OPPORTUNITIES

New cargoes such as forest products, refuse derived fuel (RDF), reclaimed topsoil, and military cargoes could be promoted for shipment by barge. This measure does not save time during the locking process.

5n. UNIVERSAL COUPLERS/HAND WINCHES

The development of a simple, quick-operating, and universally adaptable coupler for joining barges could save considerable time in breaking and remaking tows.

5o. INCREASE SPEED LIMITS IN RESTRICTED REACHES

Increasing the allowable speed of barges in constrained areas would allow for faster transit times between locks. This measure does not save time during the locking process.

5p. REDUCE LIABILITY OF TOW OPERATORS FOR DAMAGE

Increased speeds can cause increased wake damage to shore facilities. Reducing the liability of two operators would allow towboats to transit at a higher speed.

5q. REQUIRE MINIMUM CREW SIZE AND TRAINING

An experienced crew that is large enough to handle a lockage can save time in the breaking and remaking of tows.

5r. MANDATE MINIMUM HORSEPOWER

The Corps of Engineers could mandate minimum horsepower towboats necessary to push barges of a given capacity through the lock.

6. LOCK OPERATING EQUIPMENT/PROCEDURES

6a. MODIFY INTAKE STRUCTURES

Intakes can be modified to reduce air entrainment, increase their hydraulic efficiency, and decrease vibration. This improvement would allow the chamber to fill/empty faster.

6b. MODIFY DISCHARGE STRUCTURES

Outlets can be modified to divert the discharge water away from a waiting vessel, reducing the turbulence in that area. This may make emptying faster.

6c. MODIFY WALL PORTS

Wall ports could be modified to improve the diffusion and hydraulic efficiency of flow into the lock chamber. This improvement would allow the chamber to fill/empty faster.

6d. INSTALL SELF-CLEANING TRASH RACKS

Mechanical rakes could be installed to remove accumulated debris from the intakes.

6e. CENTRALIZE CONTROLS

Centralized controls would allow the lock operator to conduct the lockage from a single location.

6f. PORTABLE CONTROLS

Controls for all lock machinery and ancillary operating elements such as lights, signals and horns, could be operated from a battery powered chest pack carried by lock operating personnel.

6g. AUTOMATE CONTROLS

Automated Controls could allow for faster lockage by quickly sequencing the events in an orderly manner. This eliminates the delays such as the lock operator judging when the chamber is in balance with the outside water level.

6h. INSTALL FLOATING MOORING BITS

Floating Mooring Bits provide a place for deckhands to secure the barges during the emptying and filling of the chamber. Once the lines are secured, they need only be monitored rather than manually tended.

6i. UPGRADE VALVE OPERATING EQUIPMENT

Old valve equipment could be replaced with modern equipment. This improvement would allow the chamber to fill/empty faster.

6j UPGRADE GATE OPERATING EQUIPMENT

Old gate equipment could be replaced with modern equipment. This may make the gates open/close faster and reduce down time for repairs.

6k. INSTALL SLUICE VALVES IN MITER GATES

Sluice valves could be installed in the miter gates to allow for end filling and emptying operations similar to those used by sector gates.

6l. PROVIDE EXPLICIT OPERATING GUIDES

Signs posted near lock controls would indicate the sequencing of valves/gates for lock operators as well as provide instructions for emergencies. This measure would save little time in the overall locking process.

6m. FENDERS/ENERGY ABSORBERS

Replaceable fenders and energy absorbers could be installed in locks and at critical approach points to ease entry into the chamber for vessels traveling too fast or are not properly aligned.

6n. REQUIRE VESSELS TO STAY CLEAR OF EMPTYING/FILLING SYSTEM

Signs could be posted to warn mariners of the danger of approaching emptying/filling systems due to the turbulent water flow in these locations. This measure would save little time in the overall locking process.

6o. OPERATE DAM GATES BASED ON LOCKAGE

A method of reducing the effects of outdraft on downbound vessels might be to shut down certain dam gates as the towboat approaches the lock.

6p. LIFT GATES AT LOCK

Miter gates could be replaced with lift gates to allow for the passage of ice as well as open navigation (at some locks) during high water conditions.

7. ICE CONDITIONS

7a. MECHANICAL ICE CUTTING DEVICE

Mechanical devices similar to backhoes could be used to remove the ice collar from the lock walls.

7b. SKIN PLATES

Skin plates could be placed over lock gate structural niches to keep ice from floating in there as well as from forming there. These plates could be sprayed with a polymer coating that inhibits ice formation by reducing the adhesion of ice to the gate.

7c. AIR BUBBLER SYSTEM

High flow air screens can be used to create an ice barrier in front of or along the gates. It is also usd to create an area of "open water" for ice to be moved into.

7d. HEAT PLATES

Heat plates are thin panels placed in the gate recesses that are heated electrically. They prevent the formation of ice.

7e. HEATED WATER JET

A heated water jet is a hand operated device that pulls water in at one end, heats it with an electric coil, and sends it out the other end. It can be used to melt ice off the lock walls.

7f. CLEAR ICE FROM BARGES

This measure requires towboat operators to remove ice that has accumulated on the bow of the first line of barges before entering the chamber. This could allow more barges in the chamber. However, the technology to adequately accomplish this task does not yet exist.

7g. ICE CHUTES

Ice chutes are areas in the dam or spillway that can be opened to let accumulated ice flow downriver. This reduces the number of ice lockages in the winter.

8. RECREATIONAL VESSELS

8a. RECREATIONAL VESSEL BYPASS LIFTS

Lockage facilities for up to 12 recreational craft could be developed to bypass the regular lock. This measure would use a mechanical lifting device to transport the vessels over or around the lock facility.

8b. SCHEDULING OF RECREATIONAL VESSEL USAGE

In this measure, recreational vessels would be locked through only at certain times of the day.

8c. LICENSE RECREATIONAL CRAFT OPERATORS

A program could be developed to train and license recreational vessel operators. (Commercial vessel operators are licensed by the U.S. Coast Guard.)

8d. RECREATIONAL CRAFT LANDING ABOVE AND BELOW LOCK

This measure calls for adding a boat ramp facility at both ends of the lock.

9. COST ALLOCATION

9a. APPLY CONGESTION TOLLS

Tolls could be collected to force the distribution of towboat traffic.

9b. ALLOCATION OF OPERATIONS AND MAINTENANCE COSTS

Operations and maintenance costs at the lock could be offset by the allocation of the costs to the users. This measure does not save time in the lockage process.

9c. LOW HEAD HYDROELECTRIC GENERATORS

Operational costs of maintaining the lock could be offset by using the lock culverts as a source of hydroelectric power generation. This measure does not save time in the lockage process.

9d. PRIVATIZATION OF LOCK OPERATIONS

Lock operations may be more efficient and effective when operated by a commercial entity. This measure does not save time in the lockage process.

9e. EXCESS LOCKAGE TIME CHARGES

This measure seeks to charge users who take longer than the "average" to lock through.

9f. LOCKAGE TIME CHARGES

This measure seeks to charge all vessels based on the length of time the lock is in use.

10. OTHER

10a. INCREASE LOCK STAFFING

Lockages could possibly be made more quickly if the number of personnel staffing the lock was increased. This measure does not save time in the lockage process.

10b. AUTOMATE DAM CONTROLS

Lock operators could spend more of their time conducting lock operations if the controls for the dam were easier to reach and monitor. This measure does not save time in the lockage process.

10c. RADAR AT LOCK

Lock operators would have a better traffic picture if they could see where the towboats are in relation to the lock rather than relying on a radio call from the towboat. This measure does not save time in the lockage process.

10d. REAL-TIME CHANNEL DEPTH AND WEATHER MONITORING

Towboats could make faster transits with better information on the conditions they will experience throughout their trip. This measure does not save time in the lockage process.

10e. IMPROVED LIGHTING

Current lighting conditions at locks may include a number of "blind spots" at night. Night lock operations could be made safer with improved lighting. This measure does not save time in the lockage process.

10f. PUBLISH LOCKAGE TIMES BY USER

This measure seeks to point out those towboat and towboat companies that take too long to lock.

10g. CREATE INDRAFT

This measure proposes to reroute the river flow towards the upstream guidewall rather than away from it.

10h. OPERATIONAL PHILOSOPHY/INDUSTRY ATTITUDE

In this measure, lock masters would be given more authority to readjust traffic queuing based on a vessel's lock performance history.

10i. DEEPEN RIVER UPSTREAM OF DAM GATES

This measure calls for a deeper pool just upstream of the dam in order to alleviate outdraft.

10j. PILOT COMMUNICATION (BULLETIN BOARD)

This measure involves the sharing of information between vessels via telecommunications networks (via electronic bulletin boards).

10k. CLOSED CIRCUIT TELEVISION (CCTV) AT LOCK

CCTV could be installed at the lock so that operators could view the approaches or other portions of their operations from a central location.

10l. WICKET GATES IN DAM

Tainter and roller gates in the dam could be replaced with wicket gates to allow for navigable passage of towboats during high water conditions. Bays in the dam would require widening as well.

10m. AUTOMATED LOCKAGE SYSTEM FROM QUEUE POINT

This measure uses a system much like an automatic car wash to handle and move tows through each stage of the process.

10n. SPECIFIED NAVIGATION SEASON

This measure would require the Government to impose a specified navigation season to reduce O&M costs during winter conditions.

Section VI

VI SMALL-SCALE MEASURE SCREENING

A. INTRODUCTION

Small-scale measures are potential navigation improvements other than replacement or addition of lock chambers. The large capital outlays required for construction of a new chamber, contrasted with the cost of other measures, lead to the term "small". The inclusion of these measures in the Upper Mississippi River - Illinois Waterway Systems Navigation Study recognizes their potential for increasing economic efficiency. Further, small-scale measures will take on additional importance in an investment future constrained by limited budgets.

The fundamental purpose of the navigation study is to provide the necessary information and analysis needed to make informed investment decisions for the waterways. Like any endeavor, this study must be completed within constraints of manpower, funding, and time. Producing a successful product calls for the wise application of study resources. In light of these constraints, the following analytical process for evaluating the potential of small-scale measures was adopted.

B. THE ANALYTICAL PROCESS

The process began by identifying the "known universe" of potential small-scale measures that might have an impact on system efficiency. These measures were obtained from previous studies, discussions with Corps personnel, members of private industry, and other governmental organizations. In all, 92 measures were identified. The next step of the process selected those measure most suitable for further detailed analysis. The method used to perform this screening of candidate measures is a qualitative analysis which is described at length later in this section. The list of measures remaining, after qualitative screening, will then be subjected to an analysis which will quantify the costs and impacts of the measures. Finally, those measures which are still found worthwhile, will be incorporated into the systemic analysis for final evaluation of their costs and impacts.

The value of this analytical process is that, while no measure is eliminated, study resources are continually concentrated on those items showing greatest promise. The critical reasoning underlying the screening process is fully documented. The remainder of this chapter addresses the second step of the study process – the qualitative analysis.

C. WHY A QUALITATIVE ANALYSIS?

A qualitative analysis was accomplished to provide a framework for screening potential small-scale measures. Under this framework, all measures can be analyzed with a reasonable expenditure of resources. This permits focusing scarce study resources on those measures showing the greatest potential for achieving beneficial impacts relative to the costs of implementation. Qualitative analysis has the added advantage in that it addresses the subjective nature of the problem.

A common misconception is that "qualitative" is synonymous with subjective. This is not the case. Objective analysis requires actual observations and measurements of the objects of study, while subjective analysis relies on the "perception" of the object in the mind of the analyst. Qualitative analysis involves identifying certain qualities (properties, characteristics, attributes) present or absent in the subjects of study. Identifying the color of an object or the foundation conditions of a dam site are qualitative observations, but certainly objective. On the other hand, qualitative judgments can be subjective. For example, a person living in St. Paul may determine that winter weather in St. Louis is warm, while a resident of Florida may conclude the opposite.

While qualitative analysis is concerned with identifying the properties of an object, quantitative analysis is concerned with measuring or "quantifying" these properties. This may also be done either objectively or subjectively. A common problem, however, is that it may not be readily apparent when a quantitative analysis is subjective.

The fact that many of the 92 small-scale measures we are analyzing exist only as concepts, requires that this analysis is to some extent subjective. This subjectivity exists due to the nature of the problem.

D. THE QUALITATIVE SCREENING CRITERIA – GENERAL

Corps of Engineers' planning guidance (ER 1105-2-100, 28 December 1990) defines four broad decision criteria which are applicable to the evaluation of all projects. These criteria are: Completeness; Effectiveness; Efficiency; and Acceptability. Completeness is the extent to which given alternative plan provides and accounts for all necessary investments or other actions to ensure the realization of the planned effects.

Effectiveness is the extent to which an alternative plan alleviates the specified problems and achieves the specified opportunities. Efficiency is the extent to which an alternative plan is the most cost-effective means of alleviating the specified problems and realizing the specified opportunities, consistent with protecting the nation's environment. Acceptability is the workability and viability of the alternative plan with respect to acceptance by state and local entities and the public and compatibility with existing laws, regulations, and public policies.

While the above are an excellent set of general criteria for evaluating an overall investment plan, they are unwieldy when used to screen individual small-scale measures. For this reason, another set of criteria, consistent with the general criteria, was developed. These criteria serve as the "qualities" to be evaluated in the qualitative analysis. These specific criteria are presented in the next section.

E. THE QUALITATIVE SCREENING CRITERIA – SPECIFIC

A set of eight qualitative screening criteria were developed for use by the study team in determining those measures most appropriate for further analysis within the scope of the navigation study. Figure VI-1 below lists these criteria and illustrates their relationship with the general criteria described above.

Figure VI-1

Measure Exclusion Criteria	Planning Guidance Criteria
1. No Potential to Reduce Lock Delay	Effectiveness/Completeness
2. Not Technically Feasible	Effectiveness
3. Not Safe	Acceptability
4. Not Environmentally Acceptable	Acceptability
5. Is Economically Inefficient	Efficiency
6. Is Not Cost Effective	Efficiency
7. Industry Cooperation	Acceptability
8. Addressed in O&M Program	Completeness

The dotted line indicates that, while the first seven criteria address the merits of the small-scale measure itself, the eighth criterion determines if the measure has already been implemented or could be implemented through the Corps' Operations and Maintenance Program.

The analysis was accomplished by sequentially applying each criterion to all measures not eliminated by a previous criteria. That is, all 92 potential small-scale improvements were examined subject to the first criterion. The measures not screened based on the first criterion were then formally examined subject to the second criterion and so forth. Figure VI-2 summarizes the applicability of the criteria to all of the 92 individual small-scale measures. As the figure shows, 17 of the original 92 measures survived this screening process.

In this formal analysis measures are eliminated based on a single criterion. It is possible that several criteria may apply to a single measure and, in the text, many illustrations of this are provided. Each criterion is discussed below.

Criterion 1

Eliminate measures which have no potential to reduce delay at locks.

It is often noted that a chain is only as strong as its weakest link. On the river navigation system, these "weak links" are the navigation locks. The capability of a lock to pass traffic depends on the particular characteristics of the lock, the characteristics of the traffic, the operating policies in effect, and exogenous variables such as river flows and weather conditions. For the purposes of this discussion, consider that a typical 600 foot lock on the Mississippi River or Illinois Waterway can service about 16 tows per day. Other types of navigation constraints, such as bridges or difficult reaches of channel, can pass tows far in excess of this number. Therefore, in a situation of increasing traffic demands, the first system constraints to traffic growth will occur at the navigation locks. As traffic levels approach the limits of locks to process traffic, the result will be increased queue lengths and associated delays to traffic. Moreover, the navigation locks are the only constraints which are likely to place real physical limitations on traffic growth over the 50-year planning horizon. Further, if historic rates of growth in traffic demand continue over this planning horizon, and the throughput constraints imposed by some critical system locks remain, we risk not only the potential future benefits associated with traffic growth, but existing benefits will decline as systemic congestion grows. Therefore, in the interest of "completeness" we must focus on measures designed to address lock congestion whenever it may occur over the planning horizon.

FIGURE VI-2
SMALL SCALE MEASURE SCREENING

No.	Description	No Delay Reduction	Not Technically Feasible	Not Safe	Not Environ. Acceptable	Economically Inefficient	Not Cost Effective	Industry Cooperation	Corps O&M Program	Recommended
1a.	N-up/N-Down								✘	
1b.	Ready to Serve Policy						✘			
1c.	Self Help Policy									✔
1d.	Scheduling Program									✔
2a.	Helper Boats									✔
2b.	Switchboats									✔
2c.	Endless Cable System w/Extended Guidewalls									✔
2d.	Unpowered Traveling Kevel								✘	
2e.	Powered Traveling Kevel w/Extended Guidewalls									✔
2f.	Hydraulic Assistance								✘	
3a.	Approach Channel Widening/Realignment						✘			
3b.	Adjacent Mooring Facilities									✔
3c.	Funnel-Shaped Guidewalls					✘				
3d.	Wind Deflectors					✘				
3e.	Extend Guidewalls									✔
3f.	Add Guide Cells	✘								
3g.	Reconfigure Bullnose	✘								
3h.	Radar Reflectors	✘								
3i.	Electronic Guidance System					✘				
4a.	Remove/Adjust Bends, One-way Reaches, Bridges	✘								
4b.	Improve Navigation Aids and Channel Markings	✘								
4c.	Innovative Dredging Strategies	✘								
4d.	Water Flow Management Policies	✘								
4e.	Increase Channel Width	✘								
4f.	Isolate Recreational Facilities & Marinas Away from Channel	✘								
4g.	Improve Bridge Operations & Maintenance	✘								
4h.	Dual Channel at Restrictive Bridges	✘								
5a.	Mandate Use of Bow Thrusters						✘			
5b.	Mandate Use of Prototype Bow Thrusters						✘			
5c.	Tow Size Standardization							✘		

No.	Description	No Delay Reduction	Not Technically Feasible	Not Safe	Not Environ. Acceptable	Economically Inefficient	Not Cost Effective	Industry Cooperation	Corps O&M Program	Recommended
5d.	Cooperative Equipment Sharing/Scheduling							✘		
5e.	Institute Waterway Traffic Management							✘		
5f.	Increase Number and Size of Fleeting Areas	✘								
5g.	Fuel Monitoring & Management	✘								
5h.	Use of Heavy Fuels	✘								
5i.	New Barge and Boat Bottom Treatments	✘								
5j.	Improved Barge and Boat Hull Designs	✘								
5k.	Barge Stacking for Backhauls							✘		
5l.	Container Movement	✘								
5m.	New Backhaul Opportunities	✘								
5n.	Universal Couplers/Hand Winches									✔
5o.	Increase Speed Limits in Restricted Reaches	✘								
5p.	Reduce Liability of Tow Operators for Damage	✘								
5q.	Require Minimum Crew Size and Training									✔
5r.	Mandate Minimum Horsepower							✘		
6a.	Modify Intake Structures					✘				
6b.	Modify Discharge Structures					✘				
6c.	Modify Wall Ports					✘				
6d.	Install Self-Cleaning Trash Racks								✘	
6e.	Centralize Controls								✘	
6f.	Portable Controls								✘	
6g.	Automate Controls								✘	
6h.	Install Floating Mooring Bits	✘								
6i.	Upgrade Valve Operating Equipment								✘	
6j.	Upgrade Gate Operating Equipment								✘	
6k.	Install Gate Wickets in Miter Gates			✘						
6l.	Provide Explicit Operating Guides								✘	
6m.	Fenders, Energy Absorbers	✘								
6n.	Require Vessels to Stay Clear of Emptying/Filling System	✘								
6o.	Operate Dam Gates Based on Lockage								✘	
6p.	Lift Gates at Lock					✘				
7a.	Mechanical Ice Cutting Device								✘	

No.	Description	No Delay Reduction	Not Technically Feasible	Not Safe	Not Environ. Acceptable	Economically Inefficient	Not Cost Effective	Industry Cooperation	Corps O&M Program	Recommended
7b.	Skin Plates								✘	
7c.	Air Bubbler System								✘	
7d.	Heat Plates								✘	
7e.	Heated Water Jet								✘	
7f.	Clear Ice from Barges		✘							
7g.	Ice Chutes					✘				
8a.	Recreational Vessel Bypass Lifts					✘				
8b.	Scheduling of Recreational Vessel Usage									✔
8c.	License Recreational Craft Operators	✘								
8d.	Recreational Craft Landing Above and Below Lock									✔
9a.	Apply Congestion Tolls									✔
9b.	Allocation of Operations and Maintenance Costs	✘								
9c.	Low Head Hydroelectric Units	✘								
9d.	Privatization of Lock Operations	✘								
9e.	Excess Lockage Time Charges									✔
9f.	Lockage Time Charges									✔
10a.	Increase Lock Staffing	✘								
10b.	Automate Dam Controls	✘								
10c.	Radar at Lock	✘								
10d.	Real-Time Channel Depth and Weather Monitoring	✘								
10e.	Improved Lighting								✘	
10f.	Publish Lockage Times by User									✔
10g.	Create Indraft		✘							
10h.	Operational Philosophy / Industry Attitude							✘		
10i.	Deepen River Upstream of Gates				✘					
10j.	Pilot Communication (Bulletin Board)	✘								
10k.	Closed Circuit Television (CCTV) at Lock	✘								
10l.	Wicket Gates in Dam									✔ Included in Large Scale Assessment
10m.	Automated Lockage System from Queue		✘							
10n.	Specified Navigation Season	✘								

Other impediments to traffic on the system, such as bridges or difficult channel reaches, will not impose real systemic constraints to traffic over the planning horizon. Therefore, we do not compromise the completeness of the systemic analysis by not considering these constraints at this time.

We are not stating here that transportation costs incurred in the channel are any less important than transportation costs incurred by lock delay. In fact, on an hourly basis, due to great fuel consumption, channel delay is probably more costly. Further, we are not saying that the opportunity for economically justified projects involving reduction of channel delays will not exist over the planning horizon. We are arguing that these potential channel related investments are not required to realize the benefits of improvements to system locks and hence, these are best evaluated on a case-by-case basis.

Some potential small-scale measures deal with neither channel delay nor lock delay. They may be meritorious ideas and deserve consideration, but not within the frame work of this study. An example is the measure "Low Head Hydroelectric Units". While this measure may produce benefits in excess of costs, it is not an "effective" solution to the real problem of increasing system congestion. Including such measures within the scope of this study will not serve the ultimate purpose of providing relevant information regarding the potential solutions for reducing system congestion.

One might ask why we included measures without the potential to reduce lock delays in the original "known universe" of measures. The answer is twofold. First, it permits the study the opportunity to examine these measures and determine if there might be some compelling reason to include any of them for further detailed analysis. Second, even without further study, their inclusion provides a valuable reference for the future.

Important exceptions to Criterion 1 are measures addressing site specific channel constraints that exist in conjunction with navigation locks. Examples of these constraints are the bridge immediately downstream of Lock 15 on the Upper Mississippi River and the narrow upstream channel at Marseilles Lock on the Illinois River. These items exacerbate lock delay and will be examined during site specific feasibility studies.

For application of this criterion, it is important to discuss what types of measures can reduce lock congestion. Generally, delay at a lock depends on the relationship of the arrival process to the service process. Measures which increase the service rate, decrease the arrival rate, or decrease the variability of the service or the arrival rate, will decrease expected lock delay. In other words, delays can be decreased by processing boats faster or promoting consistency in processing time. Delays can also be decreased by decreasing traffic arrival rates or promoting more regular traffic patterns. Most of the small-scale measures proposed deal with reducing processing time.

Applying this criterion to the 92 potential measures eliminates 34 leaving 58 measures. In most cases, applying this criterion to the measures was fairly straightforward. Most measures either clearly did, or did not, possess potential for reducing lock delay. A few notable exceptions were: "Addition of Guide Cells"; "Reduce Liability of Tow Operators for Damage"; and "Increase Lock Staffing". After discussion, the study team concluded that these measures would provide no improvement or perhaps even prove to have a negative impact. Comments from carriers indicated that, in difficult approach conditions, guide cells were as likely as not to be an obstacle to navigation traffic. Reducing the liability of tow operators was rejected because, on average, the time saved by encouraging quicker approaches would be overridden by the potential for increase downtime due to accidents. Finally, the study team concluded that, at sites involved in this system analysis, staffing is sufficient to achieve efficient lockage and hence this measure did not have the potential for beneficial impacts.

Criterion 2

Measures which are not technically feasible are eliminated.

Clearly measures which are not technically feasible are not "effective" in achieving planned effects. Two conditions determined that a small-scale measure was not technically feasible. First, the technology does not currently exist to implement the measure. Second, it would be prohibitively expensive to develop the necessary new technology. Three measures: "Clear Ice from Barges", "Automated Lockage System from Queue", and "Create Indraft", were eliminated under application of this criterion.

Criterion 3

Measures considered unsafe are eliminated.

This criterion is directly related tot he "acceptability" of a plan. The purpose of this criterion is to eliminate measures which would lead to increased probability of injury or loss of life. One measure, "Install Gate Wickets in Miter Gates" was eliminated under this criterion. This measure was intended to decrease chambering time by allowing water to pass through valves in the gates. This proposed measure was deemed dangerous due to the turbulence this measure would create inside the lock chamber.

There are safety issues associated with other proposed small-scale measures as well. In particular, the measures of "Hydraulic Assistance", "Barge Stacking", and "Reducing Tow Operator Liability" were all considered to have potential safety problems. These three measures, however, were screened from detailed consideration based on other criteria.

Criterion 4
Eliminate measures with disproportionately adverse environmental consequences.

Environmental considerations fall under the "acceptability" category as described above. During the initial coordination for this screening process, the original 92 small-scale measures were primarily given positive or neutral ratings with respect to potential environmental effects. Eighteen of the 92 measures were considered environmentally negative in regards to potential environmental concern primarily associated with site-specific locations. These ratings were not based on specific ranking factors, but rather on the professional judgment of Corps and agency personnel who participated in an initial meeting or later submitted comments on the list of measures. Of the 17 selected measures, only one, "Extended Guidewalls", carried with it a negative environmental rating. Comments received indicated that this rating may be qualified, in that the prospect of construction related impacts may be outweighed by potential overall benefits to environmental resources. During the ensuing quantitative analysis and plan formulation process, potential siting and impact analyses of guidewalls will be conducted if such a measure is recommended at a given lock and dam site. In fact, this habitat-based analysis will include the entire array of measures recommended at a given site.

Resource agency comments recommended further study of some measures which did not make the final list of selected measures. These measures include:

a. Add Guide Cells
b. Improve Navigation aids and channel markings
c. Innovative Dredging Strategies
d. Water Flow Management Policies
e. Mandate Use of Bow Thrusters

f. Mandate Use of Prototype Bow Thrusters

g. Institute Waterway Traffic Management

h. Reduce Liability of Tow Operators for Damage

As shown in Figure VI-2, measures a, b, c, d, and h were considered to have little or no potential to reduce delays at locks, which is the main focus of this effort. The benefits of guide cells were mentioned frequently during site visits associated with the Objective 4b (large-scale enhancements), and they will be recommended for consideration under the Avoid & Minimize program. Innovative dredging strategies, which are not well defined at this time, would be better addressed under existing long and short-term dredging programs. Water flow management is being considered in separate initiatives by other agencies, and opportunities for beneficial flow alternatives will be included in the large-scale assessments. Measures e, f, and g were thought to be better addressed by the towing industry. Measures e and f were also found not cost effective in terms of reducing delay at locks. Industry comments on the use of bow thrusters did indicate some safety concerns. Some transportation agency comments did endorse some means of traffic management, but it is unclear where such measures would be addressed. One measure "Deepen River Upstream of Gates" was eliminated from further consideration under the environmental acceptability criterion.

Criterion 5

Measures which are too costly relative to impacts are eliminated.

The total costs of measures are comprised of construction costs, operations and maintenance costs, and costs imposed on system traffic from disturbances during construction. Measures which produce small impacts to lockage times but carry a significant cost will not be economically justified.

Some proposed measures are simply too costly, relative to their impacts, to be reasonably considered for inclusion in an "efficient" plan. Some of these measures, such as "Wind Deflectors" produce little impact because they are only applicable to a small percentage of the lockages taking place.

Another way to state this is that the level of congestion which must exist to justify these measures is high and hence the benefits obtained will erode quickly as traffic demand increases. This concept is explained more fully later in this section.

Nine measures are screened out based on this criterion. Three of these measures involve modifications to intake structures, discharge structures and wall ports. While major modifications to these structures is prohibitively expensive, minor modifications may occur during lock rehabilitation under authority of the Operations and Maintenance Program (O&M).

Criterion 6

Measures which are not cost effective are eliminated.

As this criterion applies to our qualitative analysis, two measures both impacting the same component of the lockage process (e.g., approach time, chambering time) would generally be considered mutually exclusive. If one provides the same or greater impact at less cost than the second, the second measure is eliminated.

Some might argue that this determination is not possible within the frame work of a qualitative analysis. However, a good analogy is that one could observe two light bulbs and, if the difference is sufficient, determine which is brighter without resorting to a quantitative measurement.

Viewed in this perspective, "Self Help" is superior to the measure "Ready to Serve Policy", as it provides essentially the same benefit at a much lower cost. Using helper boats and switch boats, possible through self help, is more cost effective than bow thrusters. Finally, it was concluded that the use of helper boats would provide as fast or faster approach times, at less cost, than modifying the approach channel. In all, four measures were eliminated under application of this criterion.

Criterion 7

Eliminate measures which should be pursued through industry cooperation rather than Corps of Engineers' requirements.

This criterion addresses the issue of "acceptability" of planned actions and the degree to which the Corps should mandate practices to industry. In general, market discipline provides carriers a strong incentive to operate in an individually economically efficient manner. They do not, however, need to consider in their profit calculus the economic consequences of their actions on other system users. For example, a tow using a lock does not bear the cost of the delay it imposes on other tows waiting in queue.

This leads to a situation where the level of system usage may not be at the "socially optimum" level.

The mechanics of locking are a shared process between the vessel operators and the Corps. Therefore, any analysis which ignores the impact of tow operators on this process would be incomplete. On the other hand, measures which interfere with the efficiency imposed on industry by the marketplace should not be pursued, unless there is a real demonstrable social reason to interfere.

In this light, the measures of "Industry Self Help", "Universal Coupler", and "Require Minimum Crew Training" are included for further study as they are directly related to the joint effort of locking. Further, the costs and impacts of these measures can be well measured in a quantitative analysis.

Six measures are judged to be not worthy of further detailed analysis using this criterion. The most interesting of these is the measure proposing empty barge stacking. This measure, if practical, would certainly have an impact on lock delay. It would, however, require a substantial investment in the necessary infrastructure to stack and unstack barges. Further, problems could arise if the barge stacker itself creates delays, and the question of where and under what conditions bargestacking would be implemented remains. Finally, concern exists regarding the safety of this measure, especially in windy conditions. In all, it would lead to a situation where, while the benefits would be apparent, many of the costs would be hidden and not readily measurable. It should be noted that despite the apparent efficiencies, industry has never adopted this practice.

At this point, it is important to note that other measures exist to promote system efficiency which do not involve mandating practices to industry. These involve charging users differing types of lockage fees. Three have been proposed for further analysis: "A Congestion Fee", "A Lockage Time Fee", and an "Excess Lockage Time Fee". Certainly, assessment of this type of institutional arrangement measure might yield other related measures in the future and beyond this study effort.

A lockage time fee gives added incentive to industry to expedite lockages, while an excess lockage time fee theoretically reduces the number of exceptionally long lockage times thus reducing variability in service rates and consequently delay times. In addition, these fees could reduce traffic levels thereby further decreasing delay.

The congestion fee is a lockage charge based on the level of congestion at a lock. It reduces delay by discouraging traffic which is not willing to bear the cost of the delay it is imposing on other lock users.

Criterion 8

Measures that are addressed through the Corps of Engineers Operations and Maintenance Program (O&M).

At this point in the qualitative analysis, 34 of the original 92 measures had survived the screening process, and shown some potential for implementation. This final criterion does not directly address the desirability of implementing individual measures, but seeks to focus resources on those measures for which the Corps may require new authority to implement or has a history of not being implemented in consideration of budget constraints.

Some measures identified under this criterion are commonly in place at some or all system lock sites (e.g., air bubbler systems, unpowered traveling kevels). Others, if warranted, could be implemented through the Corps' Operation and Maintenance Program (e.g., self-cleaning trash racks). Two measures, "Upgrade Valve Operating Equipment" and "Upgrade Gate Operating Equipment" address improving the aging lock components which reduce lock reliability and performance. Five measures deal with the problems associated with ice interference during winter lockage. A total of 17 measures fall into this category.

These 17 measures will be incorporated, as appropriate, into the baseline or future without-project conditions. While measures such as guidewall extensions and adjacent mooring facilities might be implemented under the Operation and Maintenance Program it is not reasonable to assume the certainty of their implementation under this program. The uncertainty is due in part to prioritization in view of constrained budgets. In view of this realization and potential benefits, the guidewalls and adjacent mooring facilities are being further considered.

The measure "N-up, N-down" is one of the measures identified under this criterion because it is already commonly used when congested conditions exists. This measure is a policy which calls for making multiple lockages of boats in the same direction. It reduces lockage time, and hence delay, at sites where the short approach associated with a turnback lockage combined with the time needed to turn back the chamber is less than the long approach required for an exchange lockage. Because this measure is commonly used, and can be implemented under the authority of the lockmaster, it will be considered as part of the baseline future in the system study. It should be noted that other small-scale measures, such as "Extended Guidewalls with

Powered Traveling Kevels" may provide much greater benefits when used in conjunction with an N-up, N-down lockage policy. This impact will be examined for those measures chosen for further analysis. Finally, other queuing disciplines, which are not currently used but have potential for beneficial impacts, will be examined in further detail.

F. SUMMARY

The analysis described above yielded 17 measures deemed appropriate for further investigation as small-scale investments. The study team decided that, due to the large capital cost, one of these measures, "Wicket Gates in Dams" was more appropriately studies as a large scale measure. The remaining 16 measures can be usefully grouped into categories as follows:

1. **Optimizing Decisions (Scheduling Program)**

2. **Towboat Power**
    a. Helper Boats
    b. Switchboats
    c. Self Help

3. **Tow Haulage Equipment**
    a. Powered Traveling Kevel
    b. Endless Cable
    c. Extended guidewall

4. Mooring Facilities (Adjacent to Lock Approach)

5. **Crew Elements**
    a. Universal Couplers/Hand Winches
    b. Standard Training for Crews

6. **Tolls and Reports**
    a. Congestion Tolls
    b. Excess Lockage Time Charges
    c. Lockage Time Charges

d. Publish Lockage Times

7. Recreational Vessels

a. Scheduling of Recreational Vessel Usage

b. Recreational Craft Landing Above and Below Deck

G. DISCUSSION OF THE EFFECTIVENESS OF SMALL-SCALE IMPROVEMENTS

At low traffic levels, small reductions in service time have little impact on delay, and hence, little benefit is obtained from the implementation of small (or large) scale improvements. As traffic levels and congestion increase, small improvements can decrease delay time significantly. However, if traffic demand increases to the point where there is a large unmet demand for lockage, small improvements are again likely to result in small delay reductions as this previously unmet demand moves onto the system. This is illustrated in Figure VI-3.

This leads to a situation where, to be effective, a set of necessary conditions must exist to implement a small-scale measure. If congestion levels are too low, they do not produce sufficient benefits to be justified, while if congestion levels are too high, the implementation of small-scale measures is likely to just lead to slightly increased traffic at a very similar level of delay. The more expensive a measure or the smaller its impact on lockage time, the narrower the "window of effectiveness" for implementation of the measure. Less expensive or greater impact lead to a wider "window of effectiveness".

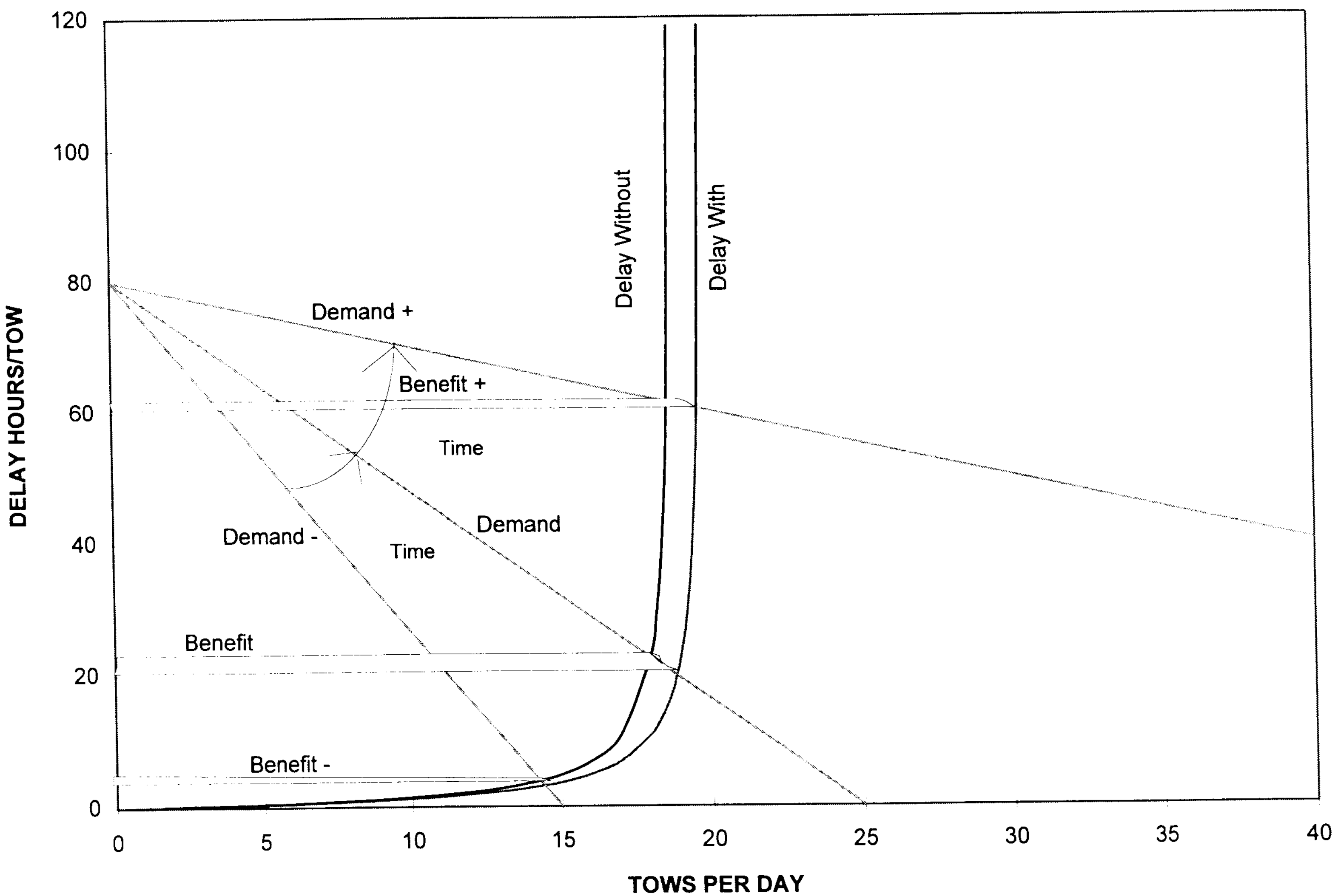
It is possible, since traffic growth is not smooth, that the conditions needed to make a particular small-scale measure desirable will never be realized. This matter will be addressed during the risk process phase of the UMR-IWW System Navigation Study.

H. CONCLUSION

This chapter describes the reasons for, and the analytical process of, the qualitative evaluation of small-scale measures. We have highlighted difficult decisions. Our intent is to demonstrate our rationale and allow the readers to follow the process and conclude that the criteria developed were reasonable and that each measure was given full and fair consideration subject to these criteria. Finally, we have shown that this process is compliant with Corps' guidance, is a wise use of resources, and ultimately contributes to the overall study goal of providing relevant information and analysis.

Figure VI -3

EFFECTIVENESS OF SMALE SCALE ALTERNATIVES



Appendix I

GLOSSARY OF TERMS

ACBL - American Commercial Barge Line (part of CSX), a major towboat company with vessels on the Upper Mississippi River and the Illinois Waterway

Aft - In, near, or towards the rear or stern of a vessel

Air Entrainment - the capture of air in a fluid system; air entrainment typically reduces the performance of the fluid performing the work because the fluid is not compressible, but air is compressible

Approach - the area leading to the entrance of a lock

ART Co. - American River Transportation Company; a major towboat company with vessels on the Upper Mississippi River, the Illinois Waterway, and others

Baffles - devices used to dissipate the energy of flowing water; they may be in the form of wooden posts or concrete blocks

Bit - a metal fixture on a barge or lock wall used to secure a line

Bow - the front end of a vessel or barge

Bow Boat - a small boat with a propeller that is attached to the front end of a series of barges and used to help guide the bow

Bow Thruster - an internal device that provide lateral propulsion to the forward end of a vessel

Box End - the end of a barge which is squared for the full depth and width of the hull

Bulkhead - a vertical panel on a ship or barge; a wall; a series of flat pieces that slide down into slots to form a wall in front of a valve or dam

Bulkhead Slot - the casing or guide that bulkheads are slid into to position them correctly for their function

Bullgear - the large, toothed gear that operates the miter gates

Bullnose - the end section of the short wall or river-side guidewall on either end of a lock

Buoy - a hollow metal object that floats in the river to mark the limits of a channel, obstruction, or other important waterway feature

Button - a metal fitting that lines are looped over or around to hold a vessel onto a lock wall; found on lock walls and on barges

Cast Off - the act of removing the lines holding a vessel or barge to a lock wall, guide cell, or mooring cell

Sheet Pile - long vertical interlocking metal pieces that, when fitted together, can form a wall; often driven down into the bottom and placed in a circular shape to form a guide or mooring cell

Chamber - the area of a lock between the upstream and downstream miter gates that is emptied and filled to lower or raise vessels

COE - U.S. Army Corps of Engineers; the engineering branch of the United States Army and the United States "engineer" for the operation and maintenance of the Inland Waterway Navigation System of the U.S.

Coupling - the manner in which two barges or a barge and a vessel are joined together

CRREL - Cold Regions Research and Engineering Laboratory, operated by the U.S. Army Corps of Engineers; located in Hanover, NH

Culvert - the large tunnel inside the lock wall monoliths that carries the filling/ emptying water into and out of the lock chamber

Current - the horizontal movement of water

Cut - a group of barges that is only a portion of the towboats full load; the unpowered cut is the section of barges that is locked through without the towboat attached; the powered cut is that section of barges that still has the towboat attached

Deckhand - a person who works as a crew member on a towboat charged with the handling of lines and lashings

DeLong Pier - a temporary pier made up of a barge that is anchored to the bottom with "spuds", or piling that is driven down into the ground

Dike - a wall or windrow of material, usually rock, used to train or align the flow of water in a particular direction; a dike may be submerged

Discharge - the water that flows out of the culverts into the lower pool area of a lock; the port through which this water flows

Double Tripping - the process of a barge leaving some of its barges temporarily behind while it powers the rest through the lock process; it towboat takes one set of barges through the locks, places then in a safe spot, and then returns to pick up the remaining set of barges and locks them through; this process requires cuts of barges to have power to them at all times during the locking process

Downbound - traveling with the flow of the river

Elastic Deformation - the process by a which a material is deformed or deflected from its original shape, but returns to that original shape after some period of time (like a diving board)

Eye - a loop formed in the end of a line either by doubling it over or by splicing the end back into itself

Exchange Entry - a vessel enters the lock after passing a vessel departing the lock

Exchange Exit - a vessel departing the lock passes a vessel entering the lock

Fender - a device made of rubber, foam, plastic, or wood, used to dissipate the energy of an object striking it

Fly Entry - a vessel enters a lock that is already set-up to receive it in the direction it is traveling; the vessel does not have to wait for another vessel to lock through, nor does it pass a vessel that has just exited the lock or for the status of the lock to change (turn back)

Fly Exit - a vessel departs a lock and no other vessels are ready to enter it from either side

Forebay - the area just upstream of the upper miter gates of the lock chamber

Guide Cell - a large, round "island", approximately 20' in diameter, consisting of a sheetpile cell filled with earth or concrete

Guidewall - the long wall of a lock approach, generally on the landside of the approach channel; used to guide towboats into the lock chamber

Hair Pin - a metal rod, bent up at 90 degrees, mounted in lock wall or guidewall; used to secure a vessel to a wall with lines; also called a hook

Hawser - a large diameter line

Head - the front end, or bow of a barge or cut of barges; also, the energy of elevated water

Head Differential - a difference in water levels

Head Kevel - the device used to secure a line on the front end of a barge

Helper Boat - a low-power towboat used to assist tows in entering or exiting a lock chamber

Hip Towing - a method of towing whereby the vessel being towed is secured alongside the towboat

Hook - see "Hair Pin"

Ice Coupling - a barge to barge connecting configuration used in winter conditions which consists of either a box-to-rake connection or a rake-to-rake connection (prohibiting box-to-box connections)

Ice Gorge - a river condition where the ice has become so thick and deep that there is not enough water for a towboats propeller to bite into

Illinois Waterway - the commercial water route including the Illinois River, the Calumet Sag Channel, the Chicago Sanitary and Ship Canal, and a portion of the Des Plaines and Chicago Rivers

Intakes - the entrance to the filling/emptying culvert

Kevel - a heavy, metal deck fitting having two horn-shaped arms projecting outward around which lines may be made fast for towing or mooring a vessel

Knockout Tow - a tow configuration whereby the towboat uncouples from its traveling position and moves into an empty space in the barge configuration

Lift Gate - a type of lock gate that rises straight up from the bottom the lock as one leaf or a series of leaves

Line - natural fiber, synthetic rope or wire cable used in the maritime industry

LMS - Lower Mississippi, St. Louis; the Corps of Engineers District Office in St. Louis, Missouri, in the Lower Mississippi Valley Division

Lockage - the process of passing floating objects from one pool water level to the next through a type of "water elevator"

Lockman - a person who works at a lock and dam facility

Lockmaster - the person in charge of a single lock and dam facility

Lower Pool - the water at the downstream side of a lock

LPMS - Lock Performance Monitoring System; used by the Corps of Engineers to track elements of lock operations

Master - the person in charge of a towboat and its crew

Mate - a member of the towboat crew who typically has responsibility for deck operations during lockage; the mate is usually in direct communications contact with the master

Miter - the seam that seals two miter gates together

Miter Gate - a type of gate used in locks; it has two doors that open upstream and close to a slight angle at the miter

Mooring Cell - typically a sheet pile cell of about 20' in diameter and filled with earth or concrete. Towboats tie off to them while awaiting lockage

Mule Training - the practice of pulling barges rather than pushing them; used in ice conditions when the towboat needs to break the ice ahead and the barges trail in the broken ice path

NCR - North Central, Rock Island; the Corps of Engineers District Office in Rock Island, IL in the North Central Division

NCS - North Central, St. Paul; the Corps of Engineers District Office in St. Paul, Minnesota, in the North Central Division

N-up/N-down - a locking policy whereby a certain number of vessels are locked through in one direction before the same number are locked through in the other direction; for example, a 3-up/3-down policy would require three vessels to be locked in each direction before reversing the sequence

Outdraft - the current along the upstream guidewall that tends to pull a towboat away from the guidewall and towards the dam; the greater the amount of water flowing through the dam, the greater the outdraft will be

Part - the act of stretching a line until it breaks; a parting synthetic line can kill people in its recoil path

Pelican Hook - a quick release mechanism used in barge couplings

Pike Pole - a long pole with a metal spike on the end; used by lock operators to move trash and ice in the lock chamber and approaches

Pilot - a licensed mariner who directs the operations of a towboat

PMS - Performance Monitoring System (See LPMS)

Propwash - the turbulence produced by a vessel's propeller

Quarter Kevel - the kevel that is one-quarter of the way aft from the head of a barge

Rake - the flared end of a barge

Recess - the indentation that the miter gates move in to in order to become flush with the lock walls, or that house other appurtenances that must not protrude from the lock wall into the lock chamber clear width

RIAC - River Industry Action Committee; an maritime industry organization

Sector Arm - the mechanical arm that opens and closes a miter gate

Sector Gate - a type of lock gate shaped like a section of a circle; the curved ends come together at the middle of the lock; the sector gates allow filling and emptying of a lock at the ends and eliminates the need for a culvert and valve operating system

Setover Tow - a tow configuration whereby a towboat pushes barges into the chamber, then uncouples itself and a portion of its barges, and moves into a configuration that fits the lock chamber

Sheave - a grooved wheel in a block over which a rope passes

Shift Chief - the person in charge of a lock operation during a typical 8 hour shift

Shoaling - the river's natural process of creating shallow areas by moving sand and earth

Sill - the floor of the lock where the miter gates seal

Smoke - placing too much strain on a line will cause it to physically smoke; this is an early warning sign of parting a line if the load is not removed

Spool - the drum that holds the wire rope on a tow haulage unit

Steamboat Ratchet - a device used to take up the slack in a coupling

Stern - the rear of a barge or vessel

Straight Single - a tow configuration that requires no reconfiguration prior to lockage

Switch Boat - a large horsepower towboat that can remove unpowered cuts from a chamber and take them to an area where the towboat can recouple the cuts

Tainter Gate - a type of dam gate that uses a curved face of a pie-shaped wedge to control the flow of water

Tainter Valve - a valve that uses the same principle of design as the tainter gate to control the flow of water into and out of a lock chamber

Timber Head - a metal fixture on towboats, barges or on the top of a lock wall used to secure a line to; it has two large round metal cylinders

Timber Pile - a mooring attachment created by driving heavy timber poles into the ground and tieing them together at the top to make a sturdy "post"

Towboat - a vessel that pushes barges on the inland river system

Tow Haulage Equipment - a land-based powered system that removes unpowered cuts from lock chambers

Trash Rack - a screen on the filling port intakes that prevents debris from entering the culvert and clogging the emptying/filling system

Traveling Kevel - a kevel that is mounted on a rail on the top of the guidewall and is used to hold the head of an unpowered cut close to the upper guidewall while it is being extracted from the chamber

Turnback - the process of locking through one vessel and then "turning back" the lock (empty) to lock through another vessel traveling in the same direction

UMR - Upper Mississippi River

Upper Mississippi River - that part of the Mississippi River from Cairo, IL (about 185 miles south of St. Louis, MO) to the rivers headwaters in Minnesota

Upbound - traveling against the flow of the river

Upper Pool - the water at the upstream side of a lock and/or dam

Winch - a hand or power-driven machine having one or more drums or barrels on which to wind a chain or rope and used for hoisting or hauling

Wing Dams - rock "walls" that extend from the shoreline into the river and are used to maintain a deep channel for vessel traffic; rock dikes may be either exposed or submerged

WKN - Western Kentucky Navigation; a major towboat company operating on the Illinois Waterway

Appendix II

LPMS DATA

STARVED ROCK LOCK

16 & 17 August 1994

LIST: 01 of *RPTS/NCRODP06/LRPT ON DISK04 09:00:43

Action: +

HOme GO REturn COmnd FIrst LAst SEQ COL + - (Press SPCFY for Help)

RPT03 AT - 08/17/94 09:00:42

RIVER-IL LOCK-061 DAILY DETAIL LOCKAGE REPORT FOR 08/16/1994

VESSEL NUMBER	VESSEL NAME	ORIGIN	DESTINATION	SOL TIME	EOL TIME	D I	CU TS	L T	V T	EE NX	BA RG	COMDTY TONAGE
0577329	LEVITICUS	LEMONT	CAIRO	0007	0128	D	01	K	T	EE	7	6000
0572403	RALPH E.PLAGGE	CAIRO	LEMONT	0128	0417	U	02	S	T	EE	14	19500
0503329	FLOYD H. BLASKE	LEMONT	ST.LOUIS	0417	0710	D	02	S	T	EE	10	8900
0651985	S/R ST.LOUIS	BATON ROUGE	JOLIET	0710	0805	U	01	K	T	EE	2	4000
9999999	RECREATION	RECREATION	RECREATION	0805	0827	D	01	S	R	EE	0	0
0245401	ALICE E	HAVANA	JOLIET	0827	0921	U	01	V	T	EE	3	0
9999999	RECREATION	RECREATION	RECREATION	0921	0944	D	01	S	R	EF	0	0
0534298	SEBRING	WOOD RIVER,	JOLIET, IL	1205	1253	U	01	S	T	FF	2	6000
0598151	BOB KOCH	ST LOUIS,MO	LEMONT,IL	1305	1600	U	02	S	T	FE	15	22500
0290399	VICKSBURG	LEMONT,ILLI	ST.LOUIS,MI	1600	1810	D	02	S	T	EE	9	4200
0578744	KAREN RENEE	CHILLOCHITE	LEMONT	1810	1940	U	01	K	T	EE	6	9000

Window MLIST/1 at NCRA5

LIST: 18 of *RPTS/NCRODP06/LRPT ON DISK04 09:01:08

Action: REturn

HOme GO REturn COmnd FIrst LAst SEQ COL + - (Press SPCFY for Help)

0599016	NANCY S	OTTAWA	LASALLE	1940	2038	D	01	K	T	EE	5	7500
0556629	LOIS ANN	NEW ORLEANS	LEMONT,IL.	2038	2321	U	02	S	T	EE	10	13500
0646311	HARVEST RUN	LEMONT,ILLI	PEORIA,ILLI	2321	0200	D	02	M	T	EE	12	12000

LOCKAGE RECORDS: CMRCL = 12 REC = 2 OTHER = 0 TOTAL-TONS = 113100

Window MLIST/1 at NCRA5

```
=============================== RID OMNI SYSTEM ==================================
==============================    LOCKAGE LOG    =================================
LCKMOX                                08/17/94
   VESL NO          VESSEL NAME              LOCK  CHMBR RIVER   REC NO   SOL YR
 0534298  SEBRING                         06    1    IL    0245    1994

       LCKG  LCKG  VESL    LT     RECN  ENTRY EXIT   ARR DT  ARR TIME
 DIRN   CUTS  TYPE  TYPE   CMCL    VESL  TYPE  TYPE  (MMDD)   (HHMM)
  U   01    S    T              F    F   0816    1205

          SOL-FC-DT   SOL-FC  BOS-FC  EOE-FC  SOE-FC  EOL-FC
            (MMDD)     (HHMN)  (HHMN)  (HHMN)  (HHMN)  (HHMN)
            0816     1205  1213   1228   1241   1253

                      SOL-LC  BOS-LC  EOE-LC  SOE-LC  BYE-LC  EOL-LC
                      (HHMN)  (HHMN)  (HHMN)  (HHMN)  (HHMN)  (HHMN)

                                             ORIGIN  WOOD RIVER, IL
 SCHED   BEGIN STALL     END STALL    STALL  DESTN  JOLIET, IL
 STALL (MMDD)  (HHMN)  (MMDD)  (HHMN) CODE

                                             ENTER OPTION   NEXT

              Window PMS/1 at NCRA5
=============================== RID OMNI SYSTEM ==================================
==============================    VESSEL LOG    ==================================
VSLMOX                                08/17/94
               LOCK   CHMBR  RIVER   REC NO   LCKG DATE   LCKG TIME
               06     1     IL    0245   08161994     1205

    VSL NO         VESSEL NAME            ASTG VSL NO   ASSISTING VESSEL NAME
  0534298   SEBRING

  FLT LNGTH  FLT WIDTH    DRAFT      BARGES  BARGES  TOW    NO OF   VSSL ASSISTS
    (FEET)     (FEET)    (FT)  (IN)   LOADED  EMPTY   STOP   PSGRS   (MAX OF 2)
    0675      052     09   00     02     00     N           0

 _____ BARGE ____  NO OF   CMDTY   TONS   : _____ BARGE ____  NO OF   CMDTY   TONS
 TYPE  WID  LEN  BARGES  CODE    CARGO  : TYPE  WID  LEN  BARGES  CODE    CARGO
  H  C  G   02    32    06000 :
                              :
                              :
                              :
                              :

                                             ENTER OPTION   NEXT

              Window PMS/1 at NCRA5
```

```
=============================== RID OMNI SYSTEM =================================
===============================   LOCKAGE LOG    =================================
LCKMOX                               08/17/94
   VESL NO          VESSEL NAME                 LOCK  CHMBR RIVER   REC NO   SOL YR
 0598151   BOB KOCH                          06    1    IL    0246    1994

         LCKG   LCKG   VESL     LT     RECN   ENTRY EXIT    ARR DT   ARR TIME
 DIRN    CUTS   TYPE   TYPE    CMCL    VESL   TYPE  TYPE    (MMDD)    (HHMM)
  U    02    S    T               F    E    0816    1305

            SOL-FC-DT   SOL-FC   BOS-FC   EOE-FC   SOE-FC   EOL-FC
              (MMDD)    (HHMN)   (HHMN)   (HHMN)   (HHMN)   (HHMN)
               0816     1305   1331   1355   1405   1425

                        SOL-LC   BOS-LC   EOE-LC   SOE-LC   BYE-LC   EOL-LC
                        (HHMN)   (HHMN)   (HHMN)   (HHMN)   (HHMN)   (HHMN)
                        1443   1445   1500   1516   1545   1600

                                                  ORIGIN   ST LOUIS,MO
 SCHED    BEGIN STALL      END STALL     STALL   DESTN    LEMONT,IL
 STALL (MMDD)   (HHMN)   (MMDD)   (HHMN)  CODE

                                                  ENTER OPTION   NEXT

                 Window PMS/1 at NCRA5
=============================== RID OMNI SYSTEM =================================
===============================   VESSEL LOG     =================================
VSLMOX                               08/17/94
                 LOCK   CHMBR  RIVER   REC NO   LCKG DATE   LCKG TIME
                 06     1      IL     0246    08161994      1305

     VSL NO         VESSEL NAME               ASTG VSL NO   ASSISTING VESSEL NAME
  0598151   BOB KOCH

  FLT LNGTH   FLT WIDTH     DRAFT       BARGES   BARGES   TOW      NO OF   VSSL ASSISTS
   (FEET)      (FEET)     (FT)  (IN)    LOADED   EMPTY    STOP     PSGRS    (MAX OF 2)
   1135       105      09   00      15      00     N             J

 _____ BARGE ____   NO OF   CMDTY    TONS    | _____ BARGE ____   NO OF   CMDTY    TONS
 TYPE   WID   LEN   BARGES  CODE     CARGO   | TYPE   WID   LEN   BARGES  CODE     CARGO
  C   C   E    06     10    09000 |   H   C   E    01    30    01500
  C   C   D    08     10    12000 |
                                  |
                                  |
                                  |

                                                  ENTER OPTION   NEXT

                 Window PMS/1 at NCRA5
```

================================ RID OMNI SYSTEM ==================================
================================ LOCKAGE LOG ==================================

LCKMOX 08/17/94

VESL NO	VESSEL NAME	LOCK	CHMBR	RIVER	REC NO	SOL YR
0290399	VICKSBURG	06	1	IL	0247	1994

DIRN	LCKG CUTS	LCKG TYPE	VESL TYPE	LT CMCL	RECN VESL	ENTRY TYPE	EXIT TYPE	ARR DT (MMDD)	ARR TIME (HHMM)
D	02	S	T			E	E	0816	1535

SOL-FC-DT (MMDD)	SOL-FC (HHMN)	BOS-FC (HHMN)	EOE-FC (HHMN)	SOE-FC (HHMN)	EOL-FC (HHMN)
0816	1600	1615	1630	1643	1656

SOL-LC (HHMN)	BOS-LC (HHMN)	EOE-LC (HHMN)	SOE-LC (HHMN)	BYE-LC (HHMN)	EOL-LC (HHMN)
1714	1718	1722	1737	1800	1810

ORIGIN LEMONT,ILLINOIS
DESTN ST.LOUIS,MISSOURI

SCHED STALL	BEGIN STALL (MMDD)	(HHMN)	END STALL (MMDD)	(HHMN)	STALL CODE

ENTER OPTION NEXT

Window PMS/1 at NCRA5

================================ RID OMNI SYSTEM ==================================
================================ VESSEL LOG ==================================

VSLMOX 08/17/94

LOCK	CHMBR	RIVER	REC NO	LCKG DATE	LCKG TIME
06	1	IL	0247	08161994	1600

VSL NO	VESSEL NAME	ASTG VSL NO	ASSISTING VESSEL NAME
0290399	VICKSBURG		

FLT LNGTH (FEET)	FLT WIDTH (FEET)	DRAFT (FT)	(IN)	BARGES LOADED	BARGES EMPTY	TOW STOP	NO OF PSGRS	VSSL ASSISTS (MAX OF 2)
0920	105	09	00	03	06	N		J

BARGE TYPE	WID	LEN	NO OF BARGES	CMDTY CODE	TONS CARGO	¦	BARGE TYPE	WID	LEN	NO OF BARGES	CMDTY CODE	TONS CARGO
C	C	D	05	01	00000	¦	C	C	E	01	01	00000
C	C	D	01	63	01400	¦	C	C	D	01	10	01400
H	C	D	01	20	01400	¦						

ENTER OPTION NEXT

Window PMS/1 at NCRA5

```
================================ RID OMNI SYSTEM ====================================
================================  LOCKAGE LOG    ====================================
LCKMOX                             08/17/94
   VESL NO          VESSEL NAME                  LOCK  CHMBR RIVER   REC NO   SOL YR
  0578744  KAREN RENEE                      06    1    IL    0248    1994

        LCKG  LCKG  VESL    LT     RECN  ENTRY EXIT    ARR DT   ARR TIME
 DIRN   CUTS  TYPE  TYPE   CMCL    VESL  TYPE  TYPE    (MMDD)    (HHMM)
  U   01    K     T           E    E    0816    1540

         SOL-FC-DT   SOL-FC  BOS-FC  EOE-FC  SOE-FC  EOL-FC
           (MMDD)    (HHMN)  (HHMN)  (HHMN)  (HHMN)  (HHMN)
           0816     1810   1851   1910   1925   1940

                     SOL-LC  BOS-LC  EOE-LC  SOE-LC  BYE-LC  EOL-LC
                     (HHMN)  (HHMN)  (HHMN)  (HHMN)  (HHMN)  (HHMN)


                                              ORIGIN  CHILLOCHITE
 SCHED   BEGIN STALL      END STALL      STALL  DESTN  LEMONT
 STALL (MMDD)  (HHMN)  (MMDD)   (HHMN)  CODE

                                              ENTER OPTION    NEXT

                 Window PMS/1 at NCRA5
================================ RID OMNI SYSTEM ====================================
================================   VESSEL LOG    ====================================
VSLMOX                             08/17/94
                LOCK   CHMBR  RIVER   REC NO   LCKG DATE   LCKG TIME
                06      1      IL    0248    08161994     1810

   VSL NO          VESSEL NAME              ASTG VSL NO   ASSISTING VESSEL NAME
  0578744  KAREN RENEE

 FLT LNGTH  FLT WIDTH    DRAFT       BARGES  BARGES  TOW    NO OF   VSSL ASSISTS
   (FEET)    (FEET)    (FT)  (IN)    LOADED  EMPTY   STOP   PSGRS    (MAX OF 2)
   0650      070     09  00     06     00     Y            0


 _____ BARGE ____   NO OF   CMDTY    TONS    | _____ BARGE ____   NO OF   CMDTY    TONS
 TYPE   WID   LEN  BARGES   CODE     CARGO   | TYPE   WID   LEN  BARGES   CODE     CARGO
  O   C   D    04    43    06000 |  O   C   E    02    43    03000
                                 |
                                 |
                                 |
                                 |

                                              ENTER OPTION    NEXT

                 Window PMS/1 at NCRA5
```

================================ RID OMNI SYSTEM ==================================
================================ LOCKAGE LOG ==================================

LCKMOX 08/17/94

VESL NO	VESSEL NAME	LOCK	CHMBR	RIVER	REC NO	SOL YR
0599016	NANCY S	06	1	IL	0249	1994

DIRN	LCKG CUTS	LCKG TYPE	VESL TYPE	LT CMCL	RECN VESL	ENTRY TYPE	EXIT TYPE	ARR DT (MMDD)	ARR TIME (HHMM)
D	01	K	T			E	E	0816	1915

SOL-FC-DT (MMDD)	SOL-FC (HHMN)	BOS-FC (HHMN)	EOE-FC (HHMN)	SOE-FC (HHMN)	EOL-FC (HHMN)
0816	1940	1950	2004	2017	2038

SOL-LC (HHMN)	BOS-LC (HHMN)	EOE-LC (HHMN)	SOE-LC (HHMN)	BYE-LC (HHMN)	EOL-LC (HHMN)

SCHED STALL	BEGIN STALL (MMDD)	(HHMN)	END STALL (MMDD)	(HHMN)	STALL CODE	ORIGIN DESTN	OTTAWA LASALLE

ENTER OPTION NEXT

Window PMS/1 at NCRA5

================================ RID OMNI SYSTEM ==================================
================================ VESSEL LOG ==================================

VSLMOX 08/17/94

LOCK	CHMBR	RIVER	REC NO	LCKG DATE	LCKG TIME
06	1	IL	0249	08161994	1940

VSL NO	VESSEL NAME	ASTG VSL NO	ASSISTING VESSEL NAME
0599016	NANCY S		

FLT LNGTH (FEET)	FLT WIDTH (FEET)	DRAFT (FT)	(IN)	BARGES LOADED	BARGES EMPTY	TOW STOP	NO OF PSGRS	VSSL ASSISTS (MAX OF 2)
0660	070	09	00	05	00	Y		0

BARGE TYPE	BARGE WID	BARGE LEN	NO OF BARGES	CMDTY CODE	TONS CARGO	BARGE TYPE	BARGE WID	BARGE LEN	NO OF BARGES	CMDTY CODE	TONS CARGO
C	C	D	04	65	06000	C	C	E	01	63	01500

ENTER OPTION NEXT

Window PMS/1 at NCRA5

================================ RID OMNI SYSTEM ==================================
================================ LOCKAGE LOG ==================================

LCKMOX 08/17/94

VESL NO	VESSEL NAME	LOCK	CHMBR	RIVER	REC NO	SOL YR
0556629	LOIS ANN	06	1	IL	0250	1994

DIRN	LCKG CUTS	LCKG TYPE	VESL TYPE	LT CMCL	RECN VESL	ENTRY TYPE	EXIT TYPE	ARR DT (MMDD)	ARR TIME (HHMM)
U	02	S	T		E	E	0816	1640	

SOL-FC-DT (MMDD)	SOL-FC (HHMN)	BOS-FC (HHMN)	EOE-FC (HHMN)	SOE-FC (HHMN)	EOL-FC (HHMN)
0816	2038	2100	2123	2136	2155

SOL-LC (HHMN)	BOS-LC (HHMN)	EOE-LC (HHMN)	SOE-LC (HHMN)	BYE-LC (HHMN)	EOL-LC (HHMN)
2211	2215	2236	2250	2310	2321

ORIGIN NEW ORLEANS,LA.
DESTN LEMONT,IL.

SCHED STALL	BEGIN STALL (MMDD)	(HHMN)	END STALL (MMDD)	(HHMN)	STALL CODE

ENTER OPTION NEXT

Window PMS/1 at NCRA5

================================ RID OMNI SYSTEM ==================================
================================ VESSEL LOG ==================================

VSLMOX 08/17/94

LOCK	CHMBR	RIVER	REC NO	LCKG DATE	LCKG TIME
06	1	IL	0250	08161994	2038

VSL NO	VESSEL NAME	ASTG VSL NO	ASSISTING VESSEL NAME
0556629	LOIS ANN		

FLT LNGTH (FEET)	FLT WIDTH (FEET)	DRAFT (FT)	(IN)	BARGES LOADED	BARGES EMPTY	TOW STOP	NO OF PSGRS	VSSL ASSISTS (MAX OF 2)
1140	070	09	00	09	01	Y		J

BARGE TYPE	WID	LEN	NO OF BARGES	CMDTY CODE	TONS CARGO	BARGE TYPE	WID	LEN	NO OF BARGES	CMDTY CODE	TONS CARGO
C	C	D	01	01	00000	C	C	D	03	32	04500
C	C	D	01	30	01500	C	C	D	05	10	07500

ENTER OPTION NEXT

Window PMS/1 at NCRA5

```
=============================== RID OMNI SYSTEM ==================================
==============================    LOCKAGE LOG    =================================
EDITLL                                   08/17/94
   VESL NO          VESSEL NAME                   LOCK  CHMBR RIVER   REC NO   SOL YR
                                              06    1    IL    0257    1994

        LCKG  LCKG  VESL    LT     RECN  ENTRY EXIT    ARR DT   ARR TIME
 DIRN   CUTS  TYPE  TYPE   CMCL    VESL  TYPE  TYPE    (MMDD)    (HHMM)
                             F

         SOL-FC-DT   SOL-FC  BOS-FC  EOE-FC  SOE-FC  EOL-FC
           (MMDD)    (HHMN)  (HHMN)  (HHMN)  (HHMN)  (HHMN)

                     SOL-LC  BOS-LC  EOE-LC  SOE-LC  BYE-LC  EOL-LC
                     (HHMN)  (HHMN)  (HHMN)  (HHMN)  (HHMN)  (HHMN)

                                                    ORIGIN
 SCHED   BEGIN STALL      END STALL      STALL  DESTN
 STALL (MMDD)  (HHMN)  (MMDD)   (HHMN) CODE

                                                       ENTER OPTION

                Window PMS/1 at NCRA5
```

```
================================ RID OMNI SYSTEM ==================================
================================  LOCKAGE LOG    ==================================
LCKMOX                              08/17/94
   VESL NO          VESSEL NAME                LOCK  CHMBR RIVER   REC NO   SOL YR
 0561281  RAMBLER                           06    1    IL    0257    1994

        LCKG   LCKG   VESL     LT     RECN  ENTRY EXIT    ARR DT   ARR TIME
 DIRN   CUTS   TYPE   TYPE    CMCL    VESL  TYPE  TYPE    (MMDD)    (HHMM)
  U   02    M    T               F    F   0817    1055

          SOL-FC-DT   SOL-FC   BOS-FC   EOE-FC   SOE-FC   EOL-FC
            (MMDD)    (HHMN)   (HHMN)   (HHMN)   (HHMN)   (HHMN)
            0817     1055   1107   1121   1138   1201

                      SOL-LC   BOS-LC   EOE-LC   SOE-LC   BYE-LC   EOL-LC
                      (HHMN)   (HHMN)   (HHMN)   (HHMN)   (HHMN)   (HHMN)
                      1220   1222   1226   1241   1243   1247

                                                     ORIGIN   PEKIN
 SCHED    BEGIN STALL      END STALL      STALL   DESTN   LEMONT
 STALL  (MMDD)   (HHMN)   (MMDD)   (HHMN)  CODE

                                                 ENTER OPTION    NEXT

 13:57    8/17        <Alt>H for Help           5    4 PAGE   1 ADDR LU FORM RCV LTAI
================================ RID OMNI SYSTEM ==================================
================================   VESSEL LOG    ==================================
VSLMOX                              08/17/94
                LOCK    CHMBR  RIVER    REC NO    LCKG DATE    LCKG TIME
                06      1      IL     0257    08171994      1055

    VSL NO          VESSEL NAME               ASTG VSL NO   ASSISTING VESSEL NAME
  0561281   RAMBLER

  FLT LNGTH  FLT WIDTH     DRAFT        BARGES  BARGES  TOW     NO OF   VSSL ASSISTS
    (FEET)     (FEET)     (FT)   (IN)    LOADED  EMPTY   STOP    PSGRS    (MAX OF 2)
    0685       105      09   00      09      00      Y           J

 _____ BARGE ____   NO OF    CMDTY    TONS    | _____ BARGE ____   NO OF    CMDTY    TONS
 TYPE   WID   LEN   BARGES   CODE     CARGO   | TYPE   WID   LEN   BARGES   CODE     CARGO
  H   C   D    01     32     01500 |   O   C   E    06     53     09000
  O   C   D    02     43     03000 |
                                   |
                                   |
                                   |

                                                 ENTER OPTION    NEXT

 13:57    8/17        <Alt>H for Help           8   45 PAGE   1 ADDR LU FORM RCV LTAI
```

```
================================ RID OMNI SYSTEM ==================================
================================   LOCKAGE LOG   =================================
LCKMOX                                   08/17/94
   VESL NO          VESSEL NAME               LOCK  CHMBR RIVER   REC NO   SOL YR
  9999999  RECREATION                      06    1    IL    0258    1994

        LCKG  LCKG  VESL    LT     RECN  ENTRY EXIT    ARR DT   ARR TIME
 DIRN   CUTS  TYPE  TYPE   CMCL    VESL  TYPE  TYPE    (MMDD)    (HHMM)
  D    01    M    R        03    F    F    0817    1159

         SOL-FC-DT   SOL-FC  BOS-FC  EOE-FC  SOE-FC  EOL-FC
           (MMDD)    (HHMN)  (HHMN)  (HHMN)  (HHMN)  (HHMN)
           0817    1159  1200  1201  1219  1220

                             SOL-LC  BOS-LC  EOE-LC  SOE-LC  BYE-LC  EOL-LC
                             (HHMN)  (HHMN)  (HHMN)  (HHMN)  (HHMN)  (HHMN)


                                                  ORIGIN  RECREATION
 SCHED   BEGIN STALL      END STALL     STALL  DESTN  RECREATION
 STALL (MMDD)  (HHMN)  (MMDD)  (HHMN) CODE

                                                     ENTER OPTION   NEXT
                                LOCK MODIFIED
 13:58   8/17        <Alt>H for Help          5    4 PAGE  1 ADDR LU FORM RCV LTAI
```

```
================================ RID OMNI SYSTEM ==================================
================================   LOCKAGE LOG   =================================
LCKMOX                                   08/17/94
   VESL NO          VESSEL NAME               LOCK  CHMBR RIVER   REC NO   SOL YR
  9999999  RECREATION                      06    1    IL    0259    1994

        LCKG  LCKG  VESL    LT     RECN  ENTRY EXIT    ARR DT   ARR TIME
 DIRN   CUTS  TYPE  TYPE   CMCL    VESL  TYPE  TYPE    (MMDD)    (HHMM)
  D    01    S    R              F    F    0817    1315

         SOL-FC-DT   SOL-FC  BOS-FC  EOE-FC  SOE-FC  EOL-FC
           (MMDD)    (HHMN)  (HHMN)  (HHMN)  (HHMN)  (HHMN)
           0817    1315  1316  1317  1335  1336

                             SOL-LC  BOS-LC  EOE-LC  SOE-LC  BYE-LC  EOL-LC
                             (HHMN)  (HHMN)  (HHMN)  (HHMN)  (HHMN)  (HHMN)


                                                  ORIGIN  RECREATION
 SCHED   BEGIN STALL      END STALL     STALL  DESTN  RECREATION
 STALL (MMDD)  (HHMN)  (MMDD)  (HHMN) CODE

                                                     ENTER OPTION   NEXT

 13:58   8/17        <Alt>H for Help          5    4 PAGE  1 ADDR LU FORM RCV LTAI
```

LPMS DATA

LOCK 24

18 August 1994

LIST: 01 of *RPTS/LMSC024/LRPT ON DISK04 08:09:30
Action: +
HOme GO REturn COmnd FIrst LAst SEQ COL + - (Press SPCFY for Help

RPT03 AT - 08/19/94 08:09:13
RIVER-MI LOCK-241 DAILY DETAIL LOCKAGE REPORT FOR 08/18/1994

VESSEL NUMBER	VESSEL NAME	ORIGIN	DESTINATION	SOL TIME	EOL TIME	D I	CU TS	L T	V T	EE NX	BA RG	COMDT TONAG
0602136	JOHN PAUL ECKSTE	ST.LOUIS,MO	ST.PAUL,MN.	0205	0327	U	02	S	T	TE	15	1350
0501595	C.W.RUSHING	HANNIBAL	ST LOUIS	0327	0348	D	01	S	T	EF	1	250
0628776	CONTI NAN	ST.LOUIS,MO	ST.PAUL,MN	0730	0945	U	02	S	T	FE	16	1500
0602461	MARY H.MORRISON	ST PAUL,MN	ST LOUIS,MO	0945	1128	D	02	S	T	EE	15	2340
9999999	RECREATION	RECREATION	RECREATION	1128	1140	U	01	S	R	EE	0	
0527346	BILL O'DONLEY	LOUISIANA,	ST. LOUIS	1140	1159	D	01	S	T	ET	4	100
9999999	RECREATION	RECREATION	RECREATION	1208	1225	D	01	S	R	TE	0	
9999999	RECREATION	RECREATION	RECREATION	1225	1235	U	01	S	R	EF	0	
0564520	GORDON JONES	ST PAUL MN	ST LOUIS MO	1315	1517	D	02	S	T	FT	15	2250
9999999	RECREATION	RECREATION	RECREATION	1525	1538	D	01	S	R	TE	0	
0570927	ARDYCE RANDLE	ST.LOUIS,MO	CLINTON,IA	1538	1708	U	02	S	T	EF	15	750

Window MLIST/1 at NCRA5
LIST: 18 of *RPTS/LMSC024/LRPT ON DISK04 08:09:45
Action: REturn
HOme GO REturn COmnd FIrst LAst SEQ COL + - (Press SPCFY for Help

0643411	SIR ROBERT	KEOKUK	GLASCOE	1820	1855	D	01	S	T	FE	7	10
0240858	KAY D	WOOD RIVER,	CANTON,MO.	1855	1929	U	01	S	T	EF	2	400
0513017	AMERICAN BEAUTY	ST.LOUIS,MO	CLINTON,IA	2020	2217	D	02	S	T	FF	15	2250

LOCKAGE RECORDS: CMRCL = 10 REC = 4 OTHER = 0 TOTAL-TONS = 11200

Window MLIST/1 at NCRA5

RPT01 AT - 08/19/94 08:19:12

RIVER-MI LOCK-24 SUMMARY TONS AND HOURS REPORT FROM 08/18/1994 - 08/18/1994

DESCRIPTION	UPBOUND	DOWNBND	TOTAL
NO OF CUTS:			
CMRCL	07	09	16
RECREATIONAL	02	02	04
OTHER	00	00	00
COMM. LOCKAGES:	04	06	10
NO OF VESSELS:			
LIGHT BOATS	00	01	01
RECREATIONAL	02	04	06
OTHER	00	00	00
LOCK UTILIZATION:			
IN USE(HRS)	6.06	7.72	13.78
% IN USE	25	32	57
STALL(HRS)	.00	.00	.00
NO.OF STALLS	00	00	00
DELAY(HRS)	5.13	3.95	9.08
NO. OF DELAYS	03	03	06
NO. OF PASSENGERS:			
VESSEL	00	00	00

DESCRIPTION	UPBOUND	DOWNBND	TOTAL
BARGES:			
LOADED	26	49	75
EMPTY	22	08	30
TONNAGE:			
(10)COAL	6000	00	6000
(20)PETROLEUM	4000	00	4000
(30)CHEMICALS	9000	00	9000
(40)CRUDE MAT	21000	1500	22500
(50)MANUF GOOD	00	2500	2500
(60)FARM PROD	00	66900	66900
(70)MANUF MACH	00	1100	1100
(99)UNKNOWN	00	00	00
TOTALS:	40000	72000	112000
MISC:			
GRAIN	00	56400	56400
STEEL	00	00	00

ENTER OPTION

Window PMS/1 at NCRA5

```
==================================== RID OMNI SYSTEM ====================================
====================================   LOCKAGE LOG    ===================================
LOCKMOX                                  08/19/94
   VESL NO           VESSEL NAME                  LOCK  CHMBR RIVER   REC NO    SOL YR
  0628776  CONTI NAN                           24    1    MI    0251    1994

         LCKG   LCKG   VESL     LT      RECN   ENTRY  EXIT    ARR DT   ARR TIME
 DIRN    CUTS   TYPE   TYPE    CMCL     VESL   TYPE   TYPE    (MMDD)    (HHMM)
  U   02    S    T              F     E    0818    0730

          SOL-FC-DT   SOL-FC  BOS-FC  EOE-FC  SOE-FC  EOL-FC
            (MMDD)    (HHMN)  (HHMN)  (HHMN)  (HHMN)  (HHMN)
            0818      0730   0755   0812   0820   0838

                      SOL-LC  BOS-LC  EOE-LC  SOE-LC  BYE-LC  EOL-LC
                      (HHMN)  (HHMN)  (HHMN)  (HHMN)  (HHMN)  (HHMN)
                      0849   0851   0901   0911   0925   0945

                                                 ORIGIN  ST.LOUIS,MO
 SCHED    BEGIN STALL       END STALL      STALL   DESTN   ST.PAUL,MN
 STALL  (MMDD)   (HHMN)   (MMDD)   (HHMN)  CODE

                                                    ENTER OPTION    NEXT

                  Window PMS/1 at NCRA5
==================================== RID OMNI SYSTEM ====================================
====================================   VESSEL LOG     ===================================
VSLMOX                                   08/19/94
                  LOCK    CHMBR  RIVER    REC NO    LCKG DATE    LCKG TIME
                  24      1      MI     0251     08181994     0730

     VSL NO          VESSEL NAME                ASTG VSL NO    ASSISTING VESSEL NAME
   0628776   CONTI NAN

  FLT LNGTH   FLT WIDTH     DRAFT        BARGES   BARGES   TOW      NO OF   VSSL ASSISTS
    (FEET)     (FEET)     (FT)   (IN)    LOADED   EMPTY    STOP     PSGRS    (MAX OF 2)
    1190       105      09   00       10      06      N             J


 ____ BARGE ___   NO OF    CMDTY    TONS    ! ____ BARGE ___   NO OF    CMDTY    TONS
 TYPE  WID   LEN  BARGES   CODE      CARGO   ! TYPE  WID  LEN   BARGES   CODE     CARGO
  C   C   E    02    10     03000 !  C   C   D    02    10    03000
  C   C   D    03    47     04500 !  C   C   E    02    47    03000
  C   C   D    01    46     01500 !  C   C   D    03    01    00000
  C   C   E    03    01     00000 !
                                   !

                                                    ENTER OPTION    NEXT

                  Window PMS/1 at NCRA5
```

```
================================= RID OMNI SYSTEM ==================================
=================================   LOCKAGE LOG    =================================
LCKMOX                              08/19/94
   VESL NO           VESSEL NAME                LOCK  CHMBR RIVER   REC NO   SIL YR
 0602461  MARY H.MORRISON               24    1    MI    0252    1994

        LCKG  LCKG  VESL    LT     RECN  ENTRY EXIT   ARR DT   ARR TIME
 DIRN   CUTS  TYPE  TYPE   CMCL    VESL  TYPE  TYPE   (MMDD)    (HHMM)
  D     02    S     T              E     E    0818    0815

        SOL-FC-DT   SOL-FC  BOS-FC  EOE-FC  SOE-FD  EOL-FC
          (MMDD)    (HHMN)  (HHMN)  (HHMN)  (HHMN)  (HHMN)
           0818      0945    0955    1011    1020    1041

                    SOL-LC  BOS-LC  EOE-LC  SOE-LC  BYE-LC  EOL-LC
                    (HHMN)  (HHMN)  (HHMN)  (HHMN)  (HHMN)  (HHMN)
                     1049    1050    1057    1106    1122    1128

                                                 ORIGIN  ST PAUL,MN
 SCHED   BEGIN STALL     END STALL     STALL  DESTN  ST LOUIS,MO
 STALL (MMDD)   (HHMN)  (MMDD)   (HHMN) CODE

                                                   ENTER OPTION   NEXT

               Window PMS/1 at NCRA5
```

```
================================= RID OMNI SYSTEM ==================================
=================================   VESSEL LOG     =================================
VSLMOX                              08/19/94
               LOCK    CHMBR  RIVER    REC NO    LCKG DATE    LCKG TIME
               24      1      MI       0252      08181994     0945

    VSL NO          VESSEL NAME              ASTG VSL NO   ASSISTING VESSEL NAME
  0602461   MARY H.MORRISON

  FLT LNGTH  FLT WIDTH    DRAFT       BARGES  BARGES  TOW     NO OF   VSSL ASSISTS
   (FEET)     (FEET)     (FT)  (IN)   LOADED  EMPTY   STOP    PSGRS   (MAX OF 2)
   1145       105       09    00      15      00      N               J  H

 ____ BARGE ___  NO OF   CMDTY   TONS   ! ____ BARGE ___  NO OF   CMDTY   TONS
 TYPE  WID  LEN  BARGES  CODE    CARGO  ! TYPE  WID  LEN  BARGES  CODE    CARGO
  C    C    D    05      63     07500 !  C    C    E    09      63     14400
  C    C    D    01      44     01500 !
                                      !
                                      !
                                      !

                                                   ENTER OPTION   NEXT

               Window PMS/1 at NCRA5
```

```
======================================== RIC OMNI SYSTEM ========================================
========================================   LOCKAGE LOG    ========================================
LOCKMOX                                  08/19/94
   VESL NO           VESSEL NAME               LOCK  CHMBR RIVER    REC NO    SOL YR
  9999999  RECREATION                  24    1    MI    025I    1994

        LCKG  LCKG  VESL    LT     RECN  ENTRY EXIT    ARR DT   ARR TIME
 DIRN   CUTS  TYPE  TYPE   CMCL    VESL  TYPE  TYPE    (MMDD)    (HHMM)
  U   01    S    R               E    E   0818    1128

          SOL-FC-DT   SOL-FC  BOS-FC  EOE-FC  SOE-FC  EOL-FC
            (MMDD)    (HHMN)  (HHMN)  (HHMN)  (HHMN)  (HHMN)
           0818     1128   1129   1130   1139   1140

                      SOL-LC  BOS-LC  EOE-LC  SOE-LC  BYE-LC  EOL-LC
                      (HHMN)  (HHMN)  (HHMN)  (HHMN)  (HHMN)  (HHMN)

                                                 ORIGIN  RECREATION
 SCHED   BEGIN STALL     END STALL     STALL  DESTN   RECREATION
 STALL (MMDD)   (HHMN)   (MMDD)   (HHMN) CODE

                                                    ENTER OPTION   NEXT

            Window PMS/1 at NCRA5
```

```
================================== RID OMNI SYSTEM =================================
==================================   LOCKAGE LOG   =================================
LOKMOX                              08/19/94
   VESL NO          VESSEL NAME              LOCK  CHMBR RIVER   REC NO   SOL YR
 0527346  BILL O'DONLEY                       24    1    MI    0254    1994

       LCKG  LCKG  VESL    LT    RECN  ENTRY EXIT   ARR DT  ARR TIME
 DIRN  CUTS  TYPE  TYPE   CMCL   VESL  TYPE  TYPE   (MMDD)   (HHMM)
  D    01    S     T             E     T    0818    1000

        SOL-FC-DT   SOL-FC  BOS-FC  EOE-FC  SOE-FC  EOL-FC
         (MMDD)     (HHMN)  (HHMN)  (HHMN)  (HHMN)  (HHMN)
          0818      1140    1142    1147    1154    1159

                    SOL-LC  BOS-LC  EOE-LC  SOE-LC  BYE-LC  EOL-LC
                    (HHMN)  (HHMN)  (HHMN)  (HHMN)  (HHMN)  (HHMN)

                                           ORIGIN  LOUISIANA, MO
 SCHED    BEGIN STALL      END STALL    STALL  DESTN  ST. LOUIS
 STALL (MMDD)  (HHMN)  (MMDD)   (HHMN) CODE

                                             ENTER OPTION   NEXT

                Window PMS/1 at NCRA5
================================== RID OMNI SYSTEM =================================
==================================   VESSEL LOG    =================================
VSLMOX                              08/19/94
                LOCK   CHMBR  RIVER   REC NO   LCKG DATE   LCKG TIME
                24      1      MI    0254    08181994     1140

   VSL NO          VESSEL NAME              ASTG VSL NO   ASSISTING VESSEL NAME
  0527346  BILL O'DONLEY

 FLT LNGTH  FLT WIDTH    DRAFT       BARGES  BARGES  TOW     NO OF   VSSL ASSISTS
   (FEET)    (FEET)    (FT)  (IN)    LOADED  EMPTY   STOP    PSGRS   (MAX OF 2)
   0430      072       03   00      01      03      Y              0

____ BARGE ___  NO OF   CMDTY   TONS   | ____ BARGE ___  NO OF   CMDTY   TONS
TYPE  WID  LEN  BARGES  CODE    CARGO  | TYPE  WID  LEN  BARGES  CODE    CARGO
 F    C    C    03      01     00000 |  F    C    C    01      70     01000
                                       |
                                       |
                                       |
                                       |

                                             ENTER OPTION   NEXT

                Window PMS/1 at NCRA5
```

```
================================ RIS OMNI SYSTEM ================================
================================    LOCKAGE LOG   ================================
LOKMOX                                08/19/94
   VESL NO           VESSEL NAME                LOCK  CHMBR RIVER    REC NO    SOL YR
  9999999  RECREATION                       24    1    MI    0255    1994

       LOKG  LOKG  VESL    LT     RECN  ENTRY EXIT    ARR DT   ARR TIME
 DIRN  CUTS  TYPE  TYPE   CMCL    VESL  TYPE  TYPE    (MMDD)    (HHMM)
  D   01    S    R       01    T    E   0818   1208

        SOL-FC-DT   SOL-FC  BOS-FC  EOE-FC  SOE-FC  EOL-FC
          (MMDD)    (HHMN)  (HHMN)  (HHMN)  (HHMN)  (HHMN)
           0818     1208   1209   1210   1224   1225

                    SOL-LC  BOS-LC  EOE-LC  SOE-LC  BYE-LC  EOL-LC
                    (HHMN)  (HHMN)  (HHMN)  (HHMN)  (HHMN)  (HHMN)

                                                ORIGIN  RECREATION
 SCHED   BEGIN STALL      END STALL     STALL  DESTN  RECREATION
 STALL (MMDD)   (HHMN)   (MMDD)   (HHMN) CODE

                                                  ENTER OPTION   NEXT

             Window PMS/1 at NCRA5
```

```
=================================== RID OMNI SYSTEM ====================================
===================================   LOCKAGE LOG    ====================================
LOKMOX                                08/19/94
   VESL NO          VESSEL NAME                LOCK  CHMBR RIVER   REC NO    SOL YR
 9999999  RECREATION                            24     1    MI    0256    1994

        LCKG   LCKG   VESL     LT     RECN   ENTRY EXIT    ARR DT   ARR TIME
 DIRN   CUTS   TYPE   TYPE    CMCL    VESL   TYPE  TYPE    (MMDD)    (HHMM)
  U    01     S     R             E     F    0818    1225

          SOL-FC-DT    SOL-FC   BOS-FC   EOE-FC   SOE-FC   EOL-FC
            (MMDD)     (HHMN)   (HHMN)   (HHMN)   (HHMN)   (HHMN)
           0818     1225   1226   1227   1234   1235

                       SOL-LC   BOS-LC   EOE-LC   SOE-LC   BYE-LC   EOL-LC
                       (HHMN)   (HHMN)   (HHMN)   (HHMN)   (HHMN)   (HHMN)

                                                  ORIGIN  RECREATION
 SCHED    BEGIN STALL      END STALL      STALL   DESTN   RECREATION
 STALL  (MMDD)   (HHMN)   (MMDD)   (HHMN)  CODE

                                                    ENTER OPTION    NEXT

                Window PMS/1 at NCRA5
```

```
=================================== RID OMNI SYSTEM ===================================
===================================   LOCKAGE LOG   ===================================
LCKMOX                               08/19/94
  VESL NO          VESSEL NAME                   LOCK  CHMBR RIVER   REC NO    SOL YR
 0564520  GORDON JONES                          24     1    MI    0257    1994

          LCKG  LCKG  VESL     LT     RECN   ENTRY EXIT    ARR DT   ARR TIME
 DIRN     CUTS  TYPE  TYPE    CMCL    VESL   TYPE  TYPE    (MMDD)    (HHMM)
  D   02     S     T              F    T    0818    1315

          SOL-FC-DT   SOL-FC   BOS-FC   EOE-FC   SOE-FC   EOL-FC
           (MMDD)     (HHMN)   (HHMN)   (HHMN)   (HHMN)   (HHMN)
           0818     1315   1343   1404   1412   1432

                      SOL-LC   BOS-LC   EOE-LC   SOE-LC   BYE-LC   EOL-LC
                      (HHMN)   (HHMN)   (HHMN)   (HHMN)   (HHMN)   (HHMN)
                      1439   1440   1449   1459   1510   1517

                                                   ORIGIN   ST PAUL MN
 SCHED    BEGIN STALL      END STALL     STALL   DESTN    ST LOUIS MO
 STALL  (MMDD)   (HHMN)   (MMDD)   (HHMN)  CODE

                                                  ENTER OPTION    NEXT

              Window PMS/1 at NCRA5
=================================== RID OMNI SYSTEM ===================================
===================================    VESSEL LOG    ===================================
VSLMOX                               08/19/94
              LOCK    CHMBR  RIVER    REC NO    LCKG DATE    LCKG TIME
              24      1      MI     0257     08181994      1315

    VSL NO          VESSEL NAME               ASTG VSL NO    ASSISTING VESSEL NAME
  0564520   GORDON JONES

 FLT LNGTH  FLT WIDTH     DRAFT        BARGES  BARGES   TOW      NO OF   VSSL ASSISTS
  (FEET)     (FEET)     (FT)  (IN)    LOADED  EMPTY    STOP     PSGRS   (MAX OF 2)
  1145       105      09   00      15     00     N              H   J


 ____ BARGE ___   NO OF    CMDTY    TONS    ! ____ BARGE ___   NO OF    CMDTY    TONS
 TYPE   WID   LEN   BARGES   CODE     CARGO   ! TYPE   WID   LEN   BARGES   CODE     CARGO
  C   C   E    09    65    13500 !   C   C   D    03    65    04500
  C   C   E    02    63    03000 !   C   C   D    01    65    01500
                                 !
                                 !
                                 !

                                                  ENTER OPTION    NEXT

              Window PMS/1 at NCRA5
```

PMS STALL SYSTEM
LOCKAGE LOG
02/19/94
LOKMOK

VESL NO	VESSEL NAME	LOCK	CHMBR	FLEET	REC NO	SOL YR
0000099	RECREATION	DA	1	MI	0258	1994

DIRN	LOKG CUTS	LOKG TYPE	VESL TYPE	LT CMDL	RCDN VESL	ENTRY TYPE	EXIT TYPE	ARR DT (MMDD)	ARR TIME (HHMM)
D	01	E	R	01	T	E		0818	1525

SOL-FC-DT (MMDD)	SOL-FC (HHMN)	BOS-FC (HHMN)	EOE-FC (HHMN)	SOE-FC (HHMN)	EOL-FC (HHMN)
0818	1525	1526	1527	1537	1538

SOL-LC (HHMN)	BOS-LC (HHMN)	EOE-LC (HHMN)	SOE-LC (HHMN)	BYE-LC (HHMN)	EOL-LC (HHMN)

SCHED STALL	BEGIN STALL (MMDD)	(HHMN)	END STALL (MMDD)	(HHMN)	STALL CODE	ORIGIN DESTN	
						RECREATION	
						RECREATION	

ENTER OPTION NEXT

Window PMS/1 at NCRA5

```
==================================== RID OMNI SYSTEM ====================================
====================================   LOCKAGE LOG    ====================================
LCKMOX                                08/19/94
   VESL NO          VESSEL NAME                  LOCK  CHMBR RIVER   REC NO   SCL YR
 0570927  ARDYCE RANDLE                           24     1     MI    0259    1994

        LCKG   LCKG   VESL     LT      RECN  ENTRY EXIT    ARR DT   ARR TIME
 DIRN   CUTS   TYPE   TYPE    CMCL     VESL  TYPE  TYPE    (MMDD)    (HHMM)
  U     02     S      T                  E      F     0818    1320

          SOL-FC-DT   SOL-FC  BOS-FC  EOE-FC  SCE-FC  ECL-FC
            (MMDD)    (HHMN)  (HHMN)  (HHMN)  (HHMN)  (HHMN)
            0818       1538    1544    1558    1605    1619

                      SOL-LC  BOS-LC  EOE-LC  SOE-LC  BYE-LC  ECL-LC
                      (HHMN)  (HHMN)  (HHMN)  (HHMN)  (HHMN)  (HHMN)
                      1631    1632    1640    1647    1702    1708

                                                  ORIGIN  ST.LOUIS,MO
 SCHED   BEGIN STALL       END STALL      STALL   DESTN   CLINTON,IA
 STALL (MMDD)  (HHMN)   (MMDD)   (HHMN)  CODE

                                                       ENTER OPTION    NEXT

                  Window PMS/1 at NCRA5
=============================== RID OMNI SYSTEM ===================================
===============================   VESSEL LOG    ===================================
VSLMOX                                08/19/94
                  LOCK    CHMBR  RIVER    REC NO    LCKG DATE    LCKG TIME
                  24       1      MI     0259     08181994       1538

     VSL NO          VESSEL NAME                 ASTG VSL NO    ASSISTING VESSEL NAME
   0570927   ARDYCE RANDLE

 FLT LNGTH   FLT WIDTH     DRAFT         BARGES    BARGES    TOW      NO OF    VSSL ASSISTS
   (FEET)      (FEET)     (FT)   (IN)    LOADED    EMPTY     STOP     PSGRS     (MAX OF 2)
   1060        105      09   00     05      10       N                J

 ____ BARGE ___    NO OF    CMDTY    TONS     : ____ BARGE ___    NO OF    CMDTY    TONS
 TYPE   WID  LEN   BARGES   CODE     CARGO    : TYPE   WID  LEN   BARGES   CODE     CARGO
  C    C    D      02       31      03000  :  C    C    E      03       31      04500
  C    C    D      06       01      00000  :  C    C    E      04       01      00000
                                           :
                                           :
                                           :

                                                       ENTER OPTION    NEXT

                  Window PMS/1 at NCRA5
```

```
================================= RID OMNI SYSTEM ==================================
=================================   LOCKAGE LOG    ==================================
LCKMOX                                  08/19/94
   VESL NO           VESSEL NAME               LOCK  CHMBR RIVER   REC NO   SOL YR
 0643411  SIR ROBERT                           24     1     MI    0260    1994

         LCKG  LCKG  VESL    LT     RECN  ENTRY EXIT   ARR DT   ARR TIME
 DIRN    CUTS  TYPE  TYPE   CMDL    VESL  TYPE  TYPE   (MMDD)   (HHMM)
  D   01    S     T          F    E   0818   1820

          SOL-FC-DT   SOL-FC   BOS-FC   EOE-FC   SOE-FC   EOL-FC
           (MMDD)     (HHMN)   (HHMN)   (HHMN)   (HHMN)   (HHMN)
           0818      1820   1833   1841   1848   1855

                      SOL-LC   BOS-LC   EOE-LC   SOE-LC   BYE-LC   EOL-LC
                      (HHMN)   (HHMN)   (HHMN)   (HHMN)   (HHMN)   (HHMN)

                                                     ORIGIN   KEOKUK
 SCHED   BEGIN STALL      END STALL     STALL   DESTN   GLASCOE
 STALL  (MMDD)  (HHMN)   (MMDD)  (HHMN)  CODE

                                                 ENTER OPTION   NEXT

                  Window PMS/1 at NCRA5
================================= RID OMNI SYSTEM ==================================
=================================   VESSEL LOG     ==================================
VSLMOX                                  08/19/94
                  LOCK   CHMBR  RIVER   REC NO   LCKG DATE   LCKG TIME
                  24      1      MI    0260    08181994     1820

     VSL NO          VESSEL NAME              ASTG VSL NO   ASSISTING VESSEL NAME
   0643411   SIR ROBERT

  FLT LNGTH   FLT WIDTH     DRAFT         BARGES   BARGES   TOW      NO OF    VSSL ASSISTS
   (FEET)      (FEET)     (FT)   (IN)     LOADED   EMPTY    STOP     PSGRS    (MAX OF 2)
   0565       070      01   06      02      05      N                0

 ____ BARGE ___   NO OF    CMDTY    TONS    | ____ BARGE ___   NO OF    CMDTY    TONS
 TYPE   WID  LEN  BARGES   CODE     CARGO   | TYPE  WID  LEN   BARGES   CODE     CARGO
  F   B   B   02    70      00100 |  F   A   A    03     01     00000
  F   B   B   02    01      00000 |
                                  |
                                  |
                                  |

                                                 ENTER OPTION   NEXT

                  Window PMS/1 at NCRA5
```

RID OMNI SYSTEM

LOCKAGE LOG

LCKMOX 08/19/94

VESL NO VESSEL NAME LOCK CHMBR RIVER REC NO SOL YR

0240858 KAY D 24 1 MI 0261 1994

DIRN LCKG CUTS LCKG TYPE VESL TYPE LT CMCL RECN VESL ENTRY TYPE EXIT TYPE ARR DT (MMDD) ARR TIME (HHMM)

U 01 S T E F 0818 1835

SOL-FC-DT (MMDD) SOL-FC (HHMN) BOS-FC (HHMN) EOE-FC (HHMN) SOE-FC (HHMN) EOL-FC (HHMN)

0818 1855 1905 1912 1919 1929

SOL-LC (HHMN) BOS-LC (HHMN) EOE-LC (HHMN) SOE-LC (HHMN) BYE-LC (HHMN) EOL-LC (HHMN)

ORIGIN WOOD RIVER,IL.

SCHED STALL BEGIN STALL (MMDD) (HHMN) END STALL (MMDD) (HHMN) STALL CODE DESTN CANTON,MO.

ENTER OPTION NEXT

Window PMS/1 at NCRA5

RID OMNI SYSTEM

VESSEL LOG

VSLMOX 08/19/94

LOCK CHMBR RIVER REC NO LCKG DATE LCKG TIME

24 1 MI 0261 08181994 1855

VSL NO VESSEL NAME ASTG VSL NO ASSISTING VESSEL NAME

0240858 KAY D

FLT LNGTH (FEET) FLT WIDTH (FEET) DRAFT (FT) (IN) BARGES LOADED BARGES EMPTY TOW STOP NO OF PSGRS VSSL ASSISTS (MAX OF 2)

0545 045 08 06 02 00 N 0

____ BARGE ___ TYPE WID LEN NO OF BARGES CMDTY CODE TONS CARGO | ____ BARGE ___ TYPE WID LEN NO OF BARGES CMDTY CODE TONS CARGO

L C B 01 23 01800 | L C F 01 23 02200

ENTER OPTION NEXT

Window PMS/1 at NCRA5

```
==================================== RID OMNI SYSTEM ====================================
====================================  LOCKAGE LOG    ====================================
LCKMOX                                08/19/94
   VESL NO            VESSEL NAME                LOCK  CHMBR RIVER   REC NO    SOL YR
 0513017  AMERICAN BEAUTY                    24    1     MI    0262   1994

         LCKG  LCKG  VESL     LT     RECN  ENTRY EXIT    ARR DT   ARR TIME
 DIRN    CUTS  TYPE  TYPE    CMCL    VESL  TYPE  TYPE    (MMDD)    (HHMM)
  D    02    S     T     01          F     F    0818    2020

         SOL-FC-DT    SOL-FC   BOS-FC   EOE-FC   SOE-FC   EOL-FC
          (MMDD)      (HHMN)   (HHMN)   (HHMN)   (HHMN)   (HHMN)
          0818      2020   2041   2057   2105   2127

                      SOL-LC   BOS-LC   EOE-LC   SOE-LC   BYE-LC   EOL-LC
                      (HHMN)   (HHMN)   (HHMN)   (HHMN)   (HHMN)   (HHMN)
                      2134   2135   2144   2154   2209   2217

                                                ORIGIN   ST.LOUIS,MO
 SCHED    BEGIN STALL       END STALL     STALL  DESTN    CLINTON,IA
 STALL  (MMDD)   (HHMN)   (MMDD)    (HHMN)  CODE

                                                ENTER OPTION    NEXT

                Window PMS/1 at NCRA5
================================= RID OMNI SYSTEM =================================
=================================   VESSEL LOG    =================================
VSLMOX                                08/19/94
                LOCK    CHMBR   RIVER    REC NO    LCKG DATE    LCKG TIME
                24       1      MI     0262    08181994      2020

   VSL NO           VESSEL NAME                ASTG VSL NO    ASSISTING VESSEL NAME
 0513017   AMERICAN BEAUTY

 FLT LNGTH  FLT WIDTH     DRAFT        BARGES  BARGES  TOW     NO OF   VSSL ASSISTS
  (FEET)     (FEET)     (FT)   (IN)    LOADED  EMPTY   STOP    PSGRS    (MAX OF 2)
  1160       105      09   00      15      00      N        J

 ____ BARGE ___   NO OF    CMDTY    TONS   | ____ BARGE ___   NO OF   CMDTY    TONS
 TYPE  WID  LEN   BARGES   CODE     CARGO  | TYPE  WID  LEN   BARGES  CODE     CARGO
  C   C   D    07     67     10500 |  C   C   E    08     63     12000
                                          |
                                          |
                                          |
                                          |

                                                ENTER OPTION    NEXT

                Window PMS/1 at NCRA5
```

Appendix III

STOPWATCH DATA

STARVED ROCK LOCK

16 & 17 August 1994

Lock: Starved Rock **Date:** 16 Aug 94

ITEM	DESCRIPTION		Notes:
a.	Observation Number	1	Sebring
b.	Tow Type	Setover	
c.	Number of Barges	2	Fuel Barges
d.	Type of Entry	Fly	
e.	Upbound/Downbound	Upbound	

NO.	EVENT	CLOCK	ELAPSED	COMMENTS
1.	Bow Over Sill	12:13:10		
			00:01:20	
2.	First Cut In	12:14:30		
			00:08:00	tie off barges to wall
3.	Begin Reconfiguration	12:22:30		
			00:02:20	
4.	End Reconfiguration	12:24:50		
			00:00:02	
5.	Start Gate Closure	12:24:52		
			00:01:42	
6.	Gate Closed	12:26:34		
			00:11:41	
7.	End Fill/Empty	12:38:15		
			00:02:03	
8.	Gate Recessed	12:40:18		
			00:00:02	
9.	Begin Reconfiguration	12:40:20		
			00:05:40	reconfig during exit
10.	End Reconfiguration	12:46:00		
			00:02:20	
11.	Tow Stern Over Sill	12:48:20		

Lock: Starved Rock **Date:** 16 Aug 94

ITEM	DESCRIPTION		Notes:
a.	Observation Number	2	Bob Koch
b.	Tow Type	Double	
c.	Number of Barges	15	+2 Recreational Vessels
d.	Type of Entry	Fly	Exchange Exit
e.	Upbound/Downbound	Upbound	

NO.	EVENT	CLOCK	ELAPSED	COMMENTS
1.	Bow Over Sill	13:30:00		
			00:12:00	
2.	First Cut In	13:42:00		
			00:04:28	
3.	Second Cut Loose	13:46:28		
			00:02:52	
4.	Second Cut Clear of Gate	13:49:20		
			00:00:28	
5.	Start Gate Closure	13:49:48		
			00:01:44	
6.	Gate Closed	13:51:32		
			00:12:28	
7.	End Fill/Empty	14:04:00		
			00:02:20	
8.	Gate Recessed	14:06:20		
			00:01:50	
9.	First Cut Begins Exit	14:08:10		
			00:11:20	used tow haulage unit
10.	First Cut Stern Over Gate	14:19:30		
			00:01:30	moor cut prior to closure
11.	Start Gate Closure	14:21:00		
			00:01:56	
12.	Gate Closed	14:22:56		
			00:16:04	
13.	End Fill/Empty	14:39:00		
			00:02:12	
14.	Gate Recessed	14:41:12		
			00:03:48	
15.	Second Cut Bow Over Gate	14:45:00		
			00:08:00	
16.	Second Cut Clear of Gate	14:53:00		
			00:05:15	
17.	Start Gate Closure	14:58:15		
			00:01:55	
18.	Gate Closed	15:00:10		
			00:12:50	
19.	End Fill/Empty	15:13:00		
			00:03:09	
20.	Gate Recessed	15:16:09		
			00:00:51	
21.	Second Cut Begins Exit	15:17:00		
			00:03:00	
22.	Cuts Bump together	15:20:00		
			00:24:10	includes 10 min delay for exch. vsl
23.	Tow Starts Exit	15:44:10		to moor @ cell in approach
			00:05:20	
24.	Tow Stern Over Sill	15:49:30		

Lock: Starved Rock **Date:** 16 Aug 94

ITEM	DESCRIPTION		Notes:
a.	Observation Number	3	Vicksburg
b.	Tow Type	Double	
c.	Number of Barges	9	3x3 configuration
d.	Type of Entry	Exchange	Moored at cell in upstream approach
e.	Upbound/Downbound	Dwnbound	

NO.	EVENT	CLOCK	ELAPSED	COMMENTS
1.	Bow Over Sill	16:13:45		
			00:06:15	
2.	First Cut In	16:20:00		
			00:02:00	
3.	Second Cut Loose	16:22:00		
			00:02:14	
4.	Second Cut Clear of Gate	16:24:14		
			00:01:01	
5.	Start Gate Closure	16:25:15		
			00:01:55	
6.	Gate Closed	16:27:10		
			00:10:05	
7.	End Fill/Empty	16:37:15		
			00:02:01	
8.	Gate Recessed	16:39:16		
			00:01:39	
9.	First Cut Begins Exit	16:40:55		
			00:08:50	
10.	First Cut Stern Over Gate	16:49:45		
			00:07:05	wait on rec vsl to enter in exchange
11.	Start Gate Closure	16:56:50		
			00:02:05	
12.	Gate Closed	16:58:55		
			00:11:11	
13.	End Fill/Empty	17:10:06		
			00:01:57	
14.	Gate Recessed	17:12:03		
			00:04:13	
15.	Second Cut Bow Over Gate	17:16:16		
			00:00:27	2nd cut was towboat only
16.	Second Cut Clear of Gate	17:16:43		
			00:00:17	
17.	Start Gate Closure	17:17:00		
			00:01:45	
18.	Gate Closed	17:18:45		
			00:13:15	
19.	End Fill/Empty	17:32:00		
			00:02:08	
20.	Gate Recessed	17:34:08		
			00:00:12	
21.	Second Cut Begins Exit	17:34:20		
			00:01:35	
22.	Cuts Bump together	17:35:55		
			00:03:35	
23.	Tow Starts Exit	17:39:30		
			00:01:00	2nd cut was towboat only
24.	Tow Stern Over Sill	17:40:30		

Lock: Starved Rock **Date:** 16 Aug 94

ITEM	DESCRIPTION		Notes:
a.	Observation Number	4	Karen Renee
b.	Tow Type	Knockout	
c.	Number of Barges	6	
d.	Type of Entry	Fly	
e.	Upbound/Downbound	Upbound	

NO.	EVENT	CLOCK	ELAPSED	COMMENTS
1.	Bow Over Sill	18:49:00		
			00:12:00	
2.	First Cut In	19:01:00		
			00:01:00	
3.	Begin Reconfiguration	19:02:00		
			00:03:00	
4.	End Reconfiguration	19:05:00		
			00:00:05	
5.	Start Gate Closure	19:05:05		
			00:01:52	
6.	Gate Closed	19:06:57		
			00:12:33	
7.	End Fill/Empty	19:19:30		
			00:02:05	
8.	Gate Recessed	19:21:35		
			00:01:25	
9.	Begin Reconfiguration	19:23:00		
			00:03:00	reconfig during exit
10.	End Reconfiguration	19:26:00		
			00:04:25	
11.	Tow Stern Over Sill	19:30:25		

Lock: Starved Rock **Date:** 16 Aug 94

ITEM	DESCRIPTION		Notes:
a.	Observation Number	5	Nancy S
b.	Tow Type	Knockout	
c.	Number of Barges	5	
d.	Type of Entry	Fly	
e.	Upbound/Downbound	Dwnbound	

NO.	EVENT	CLOCK	ELAPSED	COMMENTS
1.	Bow Over Sill	19:50:00		
			00:07:58	
2.	First Cut In	19:57:58		
			00:00:20	
3.	Begin Reconfiguration	19:58:18		
			00:01:02	
4.	End Reconfiguration	19:59:20		
			00:00:15	
5.	Start Gate Closure	19:59:35		
			00:01:45	
6.	Gate Closed	20:01:20		
			00:09:38	
7.	End Fill/Empty	20:10:58		
			00:01:53	
8.	Gate Recessed	20:12:51		
			00:04:39	exiting
9.	Begin Reconfiguration	20:17:30		
			00:02:43	reconfig during exit
10.	End Reconfiguration	20:20:13		
			00:04:33	
11.	Tow Stern Over Sill	20:24:46		

Lock: Starved Rock **Date:** 16 Aug 94

ITEM	DESCRIPTION		Notes:
a.	Observation Number	6	Lois Ann
b.	Tow Type	Double	Inexperienced Deckhands
c.	Number of Barges	10	2x5 configuration
d.	Type of Entry	Exchange	
e.	Upbound/Downbound	Upbound	Night Lockage

NO.	EVENT	CLOCK	ELAPSED	COMMENTS
1.	Bow Over Sill	20:58:30		
			00:11:28	
2.	First Cut In	21:09:58		
			00:09:17	
3.	Second Cut Loose	21:19:15		
			00:01:45	
4.	Second Cut Clear of Gate	21:21:00		
			00:00:18	
5.	Start Gate Closure	21:21:18		
			00:02:05	
6.	Gate Closed	21:23:23		
			00:11:39	
7.	End Fill/Empty	21:35:02		
			00:02:04	
8.	Gate Recessed	21:37:06		
			00:01:54	
9.	First Cut Begins Exit	21:39:00		
			00:09:00	used tow haulage unit
10.	First Cut Stern Over Gate	21:48:00		
			00:02:12	moor cut prior to closure
11.	Start Gate Closure	21:50:12		
			00:02:05	
12.	Gate Closed	21:52:17		
			00:15:34	
13.	End Fill/Empty	22:07:51		
			00:02:19	
14.	Gate Recessed	22:10:10		
			00:02:35	
15.	Second Cut Bow Over Gate	22:12:45		
			00:07:53	
16.	Second Cut Clear of Gate	22:20:38		
			00:04:29	moor cut before closing gates
17.	Start Gate Closure	22:25:07		
			00:01:53	
18.	Gate Closed	22:27:00		
			00:11:45	
19.	End Fill/Empty	22:38:45		
			00:01:59	
20.	Gate Recessed	22:40:44		
			00:00:16	
21.	Second Cut Begins Exit	22:41:00		
			00:07:50	
22.	Cuts Bump together	22:48:50		
			00:14:10	
23.	Tow Starts Exit	23:03:00		
			00:08:00	
24.	Tow Stern Over Sill	23:11:00		

Lock: Starved Rock **Date:** 17Aug94

ITEM	DESCRIPTION		Notes:
a.	Observation Number	7	Rambler
b.	Tow Type	Double	second cut; tug only
c.	Number of Barges	9	3x3 configuration
d.	Type of Entry	Fly	3 rec vessels during turnback
e.	Upbound/Downbound	Upbound	

NO.	EVENT	CLOCK	ELAPSED	COMMENTS
1.	Bow Over Sill	11:04:47		
			00:13:13	
2.	First Cut In	11:18:00		
			00:00:43	
3.	Second Cut Loose	11:18:43		
			00:00:17	
4.	Second Cut Clear of Gate	11:19:00		
			00:00:15	
5.	Start Gate Closure	11:19:15		
			00:01:52	
6.	Gate Closed	11:21:07		
			00:13:28	
7.	End Fill/Empty	11:34:35		
			00:01:59	
8.	Gate Recessed	11:36:34		
			00:01:11	2 min delay for rec vsls
9.	First Cut Begins Exit	11:37:45		
			00:15:15	used tow haulage unit
10.	First Cut Stern Over Gate	11:53:00		
			00:07:57	5 min delay for rec vsls to enter
11.	Start Gate Closure	12:00:57		
			00:02:09	
12.	Gate Closed	12:03:06		
			00:13:14	
13.	End Fill/Empty	12:16:20		
			00:01:50	
14.	Gate Recessed	12:18:10		
			00:02:40	delay for rec vsls to depart
15.	Second Cut Bow Over Gate	12:20:50		
			00:00:25	tug only
16.	Second Cut Clear of Gate	12:21:15		
			00:00:10	
17.	Start Gate Closure	12:21:25		
			00:01:55	
18.	Gate Closed	12:23:20		
			00:14:36	
19.	End Fill/Empty	12:37:56		
			00:02:02	
20.	Gate Recessed	12:39:58		
			00:00:01	
21.	Second Cut Begins Exit	12:39:59		
			00:02:18	stern over sill prior to cuts together
22.	Cuts Bump together	12:42:17		
			N/A	
23.	Tow Starts Exit	N/A		
			N/A	
24.	Tow Stern Over Sill	N/A		

STOPWATCH DATA

LOCK 24

18 August 1994

Lock: 24 Date: 18Aug94

ITEM	DESCRIPTION		Notes:
a.	Observation Number	1	Mary H. Morrison
b.	Tow Type	Double	
c.	Number of Barges	15	3x5 configuration
d.	Type of Entry	Exchange	
e.	Upbound/Downbound	Dwnbound	

NO.	EVENT	CLOCK	ELAPSED	COMMENTS
1.	Bow Over Sill	09:53:56		
			00:08:25	
2.	First Cut In	10:02:21		
			00:01:50	
3.	Second Cut Loose	10:04:11		
			00:02:19	
4.	Second Cut Clear of Gate	10:06:30		
			00:00:30	
5.	Start Gate Closure	10:07:00		
			00:02:10	
6.	Gate Closed	10:09:10		
			00:06:40	
7.	End Fill/Empty	10:15:50		
			00:02:10	
8.	Gate Recessed	10:18:00		
			00:02:16	
9.	First Cut Begins Exit	10:20:16		
			00:16:17	used tow haulage unit
10.	First Cut Stern Over Gate	10:36:33		
			00:00:11	
11.	Start Gate Closure	10:36:44		
			00:01:56	
12.	Gate Closed	10:38:40		
			00:06:05	
13.	End Fill/Empty	10:44:45		
			00:01:55	
14.	Gate Recessed	10:46:40		
			00:00:15	
15.	Second Cut Bow Over Gate	10:46:55		
			00:05:15	
16.	Second Cut Clear of Gate	10:52:10		
			00:00:55	
17.	Start Gate Closure	10:53:05		
			00:02:10	
18.	Gate Closed	10:55:15		
			00:07:25	
19.	End Fill/Empty	11:02:40		
			00:01:50	
20.	Gate Recessed	11:04:30		
			00:02:30	delay for fouled mooring line
21.	Second Cut Begins Exit	11:07:00		
			00:04:00	
22.	Cuts Bump together	11:11:00		
			00:09:00	
23.	Tow Starts Exit	11:20:00		
			00:04:06	
24.	Tow Stern Over Sill	11:24:06		

Lock: 24 Date: 18Aug94

ITEM	DESCRIPTION		Notes:
a.	Observation Number	2	Bill O'Donley
b.	Tow Type	Single	
c.	Number of Barges	2	in line
d.	Type of Entry	Exchange	
e.	Upbound/Downbound	Dwnbound	

NO.	EVENT	CLOCK	ELAPSED	COMMENTS
1.	Bow Over Sill	11:40:30		
			00:01:50	
2.	Entry Complete	11:42:20		
			00:00:20	
3.	Start Gate Closure	11:42:40		
			00:01:50	
4.	Gate Closed	11:44:30		
			00:05:30	
5.	End Fill/Empty	11:50:00		
			00:01:55	
6.	Gate Recessed	11:51:55		
			00:00:05	
7.	Begin Exit	11:52:00		
			00:02:00	
8.	Tow Stern Over Sill	11:54:00		

Lock: 24 Date: 18Aug94

ITEM	DESCRIPTION		Notes:
a.	Observation Number	3	Ardyce Randall
b.	Tow Type	Double	
c.	Number of Barges	15	3x5 configuration
d.	Type of Entry	Exchange	
e.	Upbound/Downbound	Upbound	

NO.	EVENT	CLOCK	ELAPSED	COMMENTS
1.	Bow Over Sill	15:45:25		
			00:08:55	
2.	First Cut In	15:54:20		
			00:01:35	
3.	Second Cut Loose	15:55:55		
			00:01:20	
4.	Second Cut Clear of Gate	15:57:15		
			00:00:10	
5.	Start Gate Closure	15:57:25		
			00:02:01	
6.	Gate Closed	15:59:26		
			00:05:42	
7.	End Fill/Empty	16:05:08		
			00:01:57	
8.	Gate Recessed	16:07:05		
			00:02:15	drag cable for tow haul unit
9.	First Cut Begins Exit	16:09:20		
			00:08:10	used tow haulage unit
10.	First Cut Stern Over Gate	16:17:30		
			00:00:05	
11.	Start Gate Closure	16:17:35		
			00:01:55	
12.	Gate Closed	16:19:30		
			00:10:20	
13.	End Fill/Empty	16:29:50		
			00:02:01	
14.	Gate Recessed	16:31:51		
			00:00:24	
15.	Second Cut Bow Over Gate	16:32:15		
			00:06:11	
16.	Second Cut Clear of Gate	16:38:26		
			00:00:31	
17.	Start Gate Closure	16:38:57		
			00:02:01	
18.	Gate Closed	16:40:58		
			00:06:10	
19.	End Fill/Empty	16:47:08		
			00:01:55	
20.	Gate Recessed	16:49:03		
			00:00:07	
21.	Second Cut Begins Exit	16:49:10		
			00:02:55	
22.	Cuts Bump together	16:52:05		
			00:11:45	
23.	Tow Starts Exit	17:03:50		
			00:03:10	
24.	Tow Stern Over Sill	17:07:00		

Lock: 24 Date: 18Aug94

ITEM	DESCRIPTION		Notes:
a.	Observation Number	4	Sir Robert
b.	Tow Type	Single	
c.	Number of Barges	4	2x2 configuration
d.	Type of Entry	Fly	
e.	Upbound/Downbound	Dwnbound	

NO.	EVENT	CLOCK	ELAPSED	COMMENTS
1.	Bow Over Sill	18:33:20		
			00:04:25	
2.	Entry Complete	18:37:45		
			00:00:55	
3.	Start Gate Closure	18:38:40		
			00:02:00	
4.	Gate Closed	18:40:40		
			00:06:02	
5.	End Fill/Empty	18:46:42		
			00:02:04	
6.	Gate Recessed	18:48:46		
			00:00:29	
7.	Begin Exit	18:49:15		
			00:03:05	
8.	Tow Stern Over Sill	18:52:20		

Lock: 24 Date: 18Aug94

ITEM	DESCRIPTION		Notes:
a.	Observation Number	5	Kay D
b.	Tow Type	Single	
c.	Number of Barges	2	Fuel Barges
d.	Type of Entry	Exchange	
e.	Upbound/Downbound	Upbound	

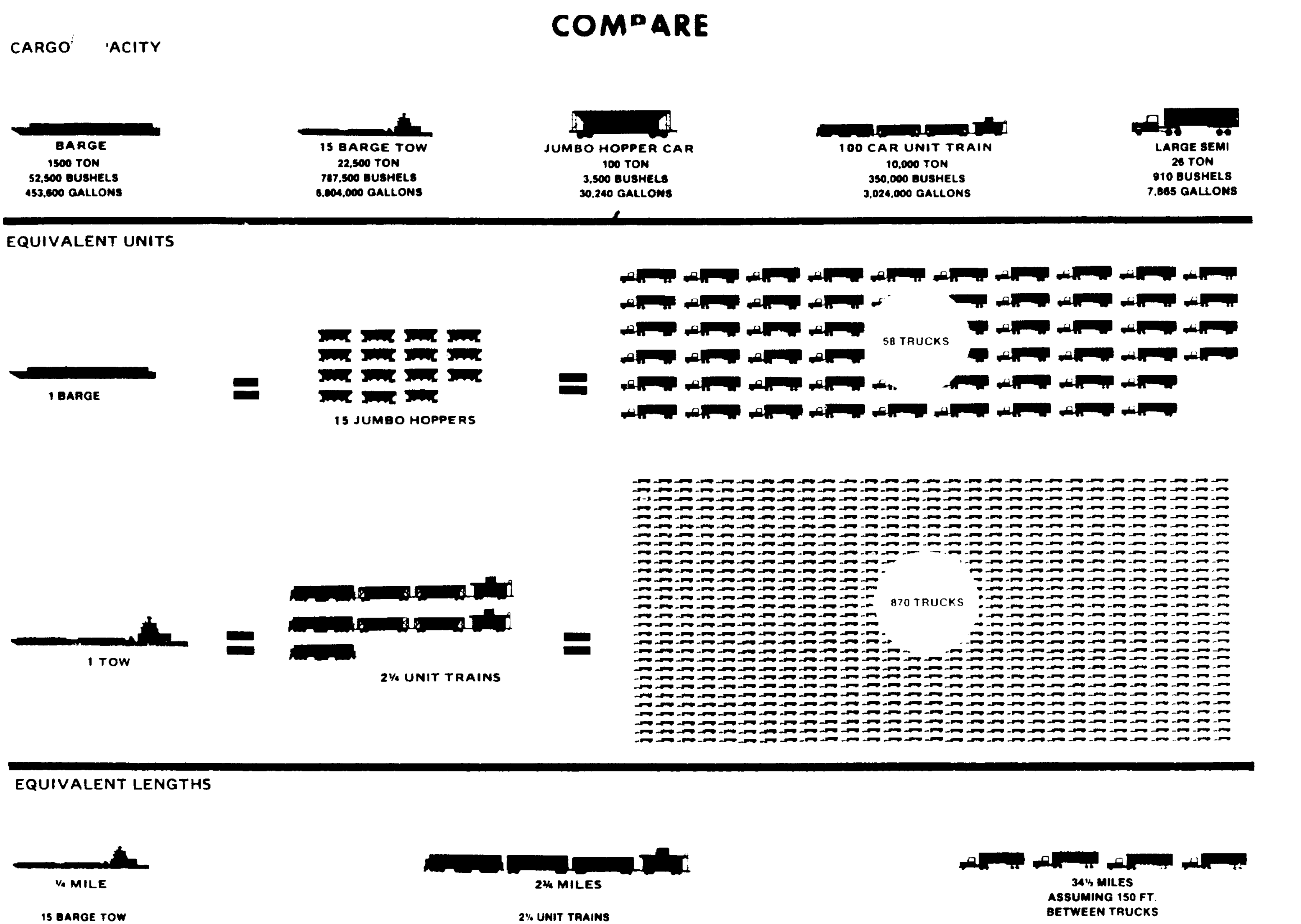
NO.	EVENT	CLOCK	ELAPSED	COMMENTS
1.	Bow Over Sill	19:05:50		
			00:04:20	
2.	Entry Complete	19:10:10		
			00:00:50	
3.	Start Gate Closure	19:11:00		
			00:02:00	
4.	Gate Closed	19:13:00		
			00:08:28	
5.	End Fill/Empty	19:21:28		
			00:01:59	
6.	Gate Recessed	19:23:27		
			00:00:03	
7.	Begin Exit	19:23:30		
			00:02:50	
8.	Tow Stern Over Sill	19:26:20		

Lock: 24 Date: 18Aug94

ITEM	DESCRIPTION		Notes:
a.	Observation Number	6	American Beauty
b.	Tow Type	Double	
c.	Number of Barges	15	3x5 configuration
d.	Type of Entry	Fly	
e.	Upbound/Downbound	Dwnbound	Night Lockage

NO.	EVENT	CLOCK	ELAPSED	COMMENTS
1.	Bow Over Sill	20:41:00		
			00:10:03	
2.	First Cut In	20:51:03		
			00:03:27	
3.	Second Cut Loose	20:54:30		
			00:01:10	
4.	Second Cut Clear of Gate	20:55:40		
			00:00:15	
5.	Start Gate Closure	20:55:55		
			00:02:25	
6.	Gate Closed	20:58:20		
			00:05:28	
7.	End Fill/Empty	21:03:48		
			00:01:57	
8.	Gate Recessed	21:05:45		
			00:02:15	drag cable for tow haul unit
9.	First Cut Begins Exit	21:08:00		
			00:16:17	used tow haulage unit
10.	First cut Stern Over Gate	21:24:17		
			00:01:08	moor cut before closing gates
11.	Start Gate Closure	21:25:25		
			00:02:02	
12.	Gate Closed	21:27:27		
			00:06:00	
13.	End Fill/Empty	21:33:27		
			00:01:58	
14.	Gate Recessed	21:35:25		
			00:01:25	
15.	Second Cut Bow Over Gate	21:36:50		
			00:03:40	
16.	Second Cut Clear of Gate	21:40:30		
			00:01:20	
17.	Start Gate Closure	21:41:50		
			00:02:00	
18.	Gate Closed	21:43:50		
			00:07:25	
19.	End Fill/Empty	21:51:15		
			00:01:51	
20.	Gate Recessed	21:53:06		
			00:00:01	
21.	Second Cut Begins Exit	21:53:07		
			00:03:53	
22.	Cuts Bump together	21:57:00		
			00:13:05	
23.	Tow Starts Exit	22:10:05		
			00:04:32	
24.	Tow Stern Over Sill	22:14:37		

Appendix IV



RAIL AND WATER
800 Lincoln Way
Ames, Iowa 50010
515-239-1367

Gra 432
0410 1 7 92

Iowa Department of Transportation

Prepared by:
Planning and Research Division

29 JUNE 1988
AS PER OD-I

LOCK AND DAM DATA

All Elevations refer to Mean Sea Level (MSL), 1929 Adjusted

LOCK NAME ELEVATION LOCATION	OBRIEN	LOCKPORT	BRANDON ROAD	DRESDEN ISLAND	MARSEILLES	STARVED ROCK	PEORIA	LAGRANGE
1. RIVER MILE	326.5R	291.0L	285.9R	271.4L	244.6R	231.0R	157.7L	80.2R
2. COMPLETE	1960	1933	1933	1933	1933	1933	1938	1939
3. COST+	6,954,700	2,153,867	4,434,748	3,915,964	3,079,372	4,462,734	3,381,030	2,744,592
4. FLAT POOL								
a. Upper	579.5	577.6	538.6	504.5	482.8	458.5	440.0	429.0
b. Lower	577.5	538.6	504.6	482.8	458.5	440.3	429.0	419.0
5. HIGH WATER								
a. Year	1986	1947	1982	1982	1982*	1982	1943	1943
b. Upper	584.62	N/A	540.50	509.10	485.75	466.10	456.07	447.25
c. Lower	584.62	544.90	513.30	505.29	474.15	464.72	455.90	447.10
6. LOCK								
a. Size	110'x1000'	110'x600'	110'x600'	110'x600'	110'x600'	110'x600'	110'x600'	110'x600'
b. Lift (Nominal)	0-4.5'	39 ft.	34 ft.	21.7 ft.	24.3 ft.	18.2 ft.	11 ft.	10 ft.
c. Ave. Fill Time	5 min.	20 min.	19 min.	14 min.	15 min.	12 min.	5 min.	5 min.
d. Ave. Empty Time	Variable	16 min.	15 min.	12 min.	10 min.	9 min.	5min.	5min.
e. Lock Wall Elev.	586.5	584.6	542.6	509.5	486.0	463.5	445.0	434.0
f. Sill Elev.								
(1) Upper	561.0	557.6	520.7	487.7	464.2	441.7	424.5	413.5
(2) Lower	561.0	523.6	490.7	470.5	444.5	426.0	417.0	406.0
g. Guide Wall								
(1) Upper Elev.	586.5	584.6	542.6	509.5	486.0	463.5	445.0	434.0
(2) Upper Length	1000'	3 miles	610'	580'	600'	598.5'	500'	~~500~~ 550'
(3) Lower Elev.	584.5	546.6	513.6	496.5	466.7	458.5	440.0	430.0
(4) Lower Length	1000'	350'	600'	594'	550'	594'	500'	~~550~~' 500
h. Upper Gates								
(1) Type	Sector	Vert. Lift	Miter	Miter	Miter	Miter	Miter	Miter
(2) Height	24'	24'	20'	20'	20'	20'	17.5'	17.5'
(3) Length	138'x35'	118'	65'	65'	65'	65'	65'	65'
(4) Weight	216 ton	190 ton	90 ton	90 ton	90 ton	90 ton	63 ton	62 ton
i. Lower Gates								
(1) Type	Sector	Miter	Miter	Miter	Miter	Miter	Miter	Miter
(2) Height	24'	59'	50'	39'	39'	36'	25.5'	25.5'
(3) Length	138'x35'	65'	65'	65'	65'	65'	65'	65'
(4) Weight	216 ton	240 ton	270 ton	162 ton	170 ton	150 ton	76 ton	75 ton

PHYSICAL DATA
UPPER MISSISSIPPI RIVER AND KASKASKIA RIVER

LOCKS AND DAM NOS. 24, 25, LOCKS NO. 27, MELVIN PRICE AND KASKASKIA LOCK AND DAM

GENERAL	KASKASKIA	DAM NO. 24	DAM NO. 25	MELVIN PRICE DAM	LOCKS NO. 27
Location - mile (UMR)	0.8 (KR)	273.4	241.4	200.8	185.1
Normal upper pool elevation, ft. NVGD	368.0	449.0	434.0	419.0	---
Length of pool, miles	35.2	27.8	32.0	40.6 (Miss) 82.2 (Ill)	---
Length of canal, miles	---	---	---	---	8.4
Work on lock officially begun	1 Dec 1967	20 Jul 1936	12 Nov 1935	18 Nov 1984	19 Jul 1947
Work on dam officially begun	1 Dec 1967	25 Mar 1938	22 Jun 1937	3 Dec 1981	---
Work on canal officially begun	---	---	---	---	8 Jul 1949
Project placed in operation	9 Nov 1973	12 Mar 1940	18 May 1939	10 Oct 1989	7 Feb 1953
Full pool first reached	28 Nov 1973	14 May 1940	11 Jul 1939	1 Feb 1990	---
LOCKS					
Main lock dimensions	600' x 84'	600' x 110'	600' x 110'	1200' x 110'	1200' x 110'
Auxiliary lock dimensions	---	Incomplete	Incomplete	600' x 110' Not Completed(N.C.)	600' x 110'
Miter sills, elevation, ft. NVGD:					
Main lock - upper	350.0	430.0	416.0	396.0	380.0
Main lock - lower	325.0	422.0	407.0	377.0	380.0
Auxiliary lock - upper	---	425.0	407.0	377.0(N.C.)	380.0
Auxiliary lock - lower	---	---	---	377.0(N.C.)	380.0
Top of lock walls, elevation	385.0	457.0	444.0	434.5	432.0
Length of lock walls, including guide walls:					
Land wall	1040	1941	1969.5	1050(Aux. N.C.)	2202(East wall)
Intermediate wall (land)	---	907	907	3380(Aux. N.C.)	2002
Intermediate wall (river)	---	---	---	2430(Main)	---
River wall	2140	794	791	3080(Main)	807.5(West wall)
Elevation, out of operation (upper gage)	381.0	454.5	441.5	432.5	427.0
DAM					
Length of movable section (clearing opening)	120	1200	1140	1160	---
4 Length of low water dam (completion date)	---	---	---	---	3000 (20 Aug 1962)
Tainter gates	2 @ 60' x 30'	15 @ 60' x 25'	14 @ 60' x 25'	9 @ 110' x 42'(N.C.)	---
Roller gates			3 @ 100' x 25'		
Width of piers at base:	Pier 1 & 3 11' - 11 1/2"				
Tainter gates	Pier 2 10'	10	8	15	---
Roller gates	---	---	15	---	---
Elevation top of piers	418.0	483.0	468.0	494.0	---
Elevation top of dam	---	---	---	---	395.0
Elevation of gate sills:					
Tainter gates	340.0	424.0	409.0	379.0	---
Roller gates	---	---	409.0	---	---
Elevation at notch	---	---	---	---	391.0
Width of notch	---	---	---	---	676'
FLOWS					
Maximum high water elevations (Date) - Tailwater	(1982)	458.19 (1973)	443.93 (1973)	422.89 (1990)	426.24 (1973)
Maximum record flow c.f.s. (Date)	---	478,000 (1973)	478,000 (1973)	250,000 (1990)	---
Maximum high water elevations (Date) - Upper	388.30 (1973)	459.44 (1973)	444.41 (1973)	423.51 (1990)	430.90 (1970)
Minimum elevation of tailwater (Record to date)	341.97 (Jan 1977)	431.52 (Feb 1950)	416.1 (Jan 1940)	398.37 (Nov 1990)	376.18 (Jan 1964)
OPERATION					
Minimum and maximum regulated pool elevations	363.0 - 368.0	445.5 - 449.0	429.7 - 434.0	* - 419.0	---
Control point (mile)	Red Bud(18.8)	Louisiana (282.9)	Mosier Ldg. (280.3)	Grafton (218.0)	---
Control point elevation limits	367.5 - 368.5	448.83 - 449.53	434.0 - 435.75	417.99 - 419.99	---
Flow at beginning of drawdown	5000	72,000	70,000	112,000	---
Flow at open river	10000	146,000	95,000	210,000	---
Surface area at maximum pool, acres	---	13,000	18,000	31,000	---

*Note: This elevation is dependent upon the flow rate in the Missouri River. The optimum situation is 414.0 at the old structure.

TIME DATA FROM COE ROCK ISLAND

		LOCK 22	LOCK 14	BOTH
1.BOW OVER SILL				
	UP	#=15 AVE=6.62 STD DEV=1.60	#=9 AVE=7.31 STD DEV=2.17	#=24 AVE=6.88 STD DEV=
	DOWN	#=19 AVE=7.67 STD DEV=2.56	#=7 AVE=7.95 STD DEV=2.23	#=26 AVE=7.75 STD DEV=
	OVERALL	#=34 AVE=7.21 STD DEV=2.22	#=16 AVE=7.59 STD DEV=2.15	#=50 AVE=7.33 STD DEV=
2.FIRST CUT IN				
	UP	#=15 AVE=3.22 STD DEV=2.32	#=9 AVE=2.39 STD DEV=1.61	#=24 AVE=2.91 STD DEV=
	DOWN	#=19 AVE=3.10 STD DEV=1.77	#=7 AVE=1.60 STD DEV=0.60	#=26 AVE=2.70 STD DEV=
	OVERALL	#=34 AVE=3.15 STD DEV=2.00	#=16 AVE=2.05 STD DEV=1.30	#=50 AVE=2.80 STD DEV=
3.SECOND CUT LOOSE				
	UP	#=15 AVE=1.73 STD DEV=1.04	#=9 AVE=2.17 STD DEV=1.25	#=24 AVE=1.89 STD DEV=1
	DOWN	#=19 AVE=1.91 STD DEV=0.97	#=7 AVE=2.09 STD DEV=0.73	#=26 AVE=1.96 STD DEV=(
	OVERALL	#=34 AVE=1.83 STD DEV=0.99	#=16 AVE=2.13 STD DEV=1.02	#=50 AVE=1.93 STD DEV=1
4.SECOND CUT CLEAR OF GATE				
	UP	#=15 AVE=1.11 STD DEV=0.64	#=9 AVE=0.75 STD DEV=0.44	#=24 AVE=0.98 STD DEV=0
	DOWN	#=19 AVE=0.77 STD DEV=0.36	#=7 AVE=0.44 STD DEV=0.28	#=26 AVE=0.68 STD DEV=0
	OVERALL	#=34 AVE=0.92 STD DEV=0.52	#=16 AVE=0.62 STD DEV=0.40	#=50 AVE=0.82 STD DEV=0
5.START GATE CLOSURE				
	UP	#=20 AVE=1.34 STD DEV=0.18	#=17 AVE=1.73 STD DEV=0.22	#=37 AVE=1.52 STD DEV=0
	DOWN	#=26 AVE=1.53 STD DEV=0.20	#=11 AVE=1.81 STD DEV=0.21	#=37 AVE=1.61 STD DEV=0
	OVERALL	#=46 AVE=1.45 STD DEV=0.21	#=28 AVE=1.76 STD DEV=0.22	#=74 AVE=1.57 STD DEV=0
6.GATE CLOSED				
	UP	#=20 AVE=7.64 STD DEV=2.55	#=17 AVE=4.83 STD DEV=1.08	#=37 AVE=6.35 STD DEV=2
	DOWN	#=26 AVE=6.60 STD DEV=3.09	#=11 AVE=5.52 STD DEV=0.43	#=37 AVE=6.28 STD DEV=2
	OVERALL	#=46 AVE=7.05 STD DEV=2.88	#=28 AVE=5.10 STD DEV=0.94	#=74 AVE=6.31 STD DEV=2.
7.END FILL/EMPTY				
	UP	#=20 AVE=1.80 STD DEV=0.85	#=17 AVE=2.34 STD DEV=1.12	#=37 AVE=2.05 STD DEV=1.
	DOWN	#=26 AVE=1.87 STD DEV=0.96	#=11 AVE=2.10 STD DEV=0.49	#=37 AVE=1.94 STD DEV=0.
	OVERALL	#=46 AVE=1.84 STD DEV=0.91	#=28 AVE=2.24 STD DEV=0.92	#=74 AVE=1.99 STD DEV=0.
8.GATE RECESSED				
	UP	#=15 AVE=3.28 STD DEV=1.36	#=9 AVE=2.25 STD DEV=1.77	#=24 AVE=2.89 STD DEV=1.
	DOWN	#=19 AVE=1.41 STD DEV=1.65	#=7 AVE=0.37 STD DEV=0.21	#=26 AVE=1.13 STD DEV=1.
	OVERALL	#=34 AVE=1.77 STD DEV=1.77	#=16 AVE=1.43 STD DEV=1.62	#=50 AVE=1.98 STD DEV=1.
9.FIRST CUT BEGINS EXIT				
	UP	#=15 AVE=6.78 STD DEV=1.29	#=9 AVE=8.79 STD DEV=3.60	#=24 AVE=7.53 STD DEV=2.
	DOWN	#=19 AVE=13.67 STD DEV=3.32	#=8 AVE=9.76 STD DEV=1.73	#=27 AVE=12.51 STD DEV=3.
	OVERALL	#=34 AVE=10.63 STD DEV=4.33	#=17 AVE=9.24 STD DEV=2.83	#=51 AVE=10.17 STD DEV=3.
10.FIRST CUT STERN OVER GATE				
	UP	#=15 AVE=0.98 STD DEV=0.62	#=9 AVE=0.94 STD DEV=0.45	#=24 AVE=0.97 STD DEV=0.
	DOWN	#=19 AVE=2.54 STD DEV=1.02	#=8 AVE=1.68 STD DEV=1.08	#=27 AVE=2.29 STD DEV=1.
	OVERALL	#=34 AVE=1.85 STD DEV=1.17	#=17 AVE=1.29 STD DEV=0.87	#=51 AVE=1.67 STD DEV=1.
11.START GATE CLOSURE				
	UP	#=15 AVE=1.51 STD DEV=0.18	#=9 AVE=1.77 STD DEV=0.39	#=24 AVE=1.61 STD DEV=0.
	DOWN	#=19 AVE=1.46 STD DEV=0.26	#=8 AVE=1.85 STD DEV=0.06	#=27 AVE=1.58 STD DEV=0.
	OVERALL	#=34 AVE=1.48 STD DEV=0.22	#=17 AVE=1.81 STD DEV=0.28	#=51 AVE=1.59 STD DEV=0.
12.GATE CLOSED				
	UP	#=15 AVE=6.71 STD DEV=1.09	#=8 AVE=5.76 STD DEV=0.73	#=23 AVE=6.38 STD DEV=1.
	DOWN	#=19 AVE=6.74 STD DEV=2.65	#=8 AVE=5.01 STD DEV=0.41	#=27 AVE=6.23 STD DEV=2.
	OVERALL	#=34 AVE=6.72 STD DEV=2.08	#=16 AVE=5.39 STD DEV=0.69	#=50 AVE=6.30 STD DEV=1.
13.END FILL/EMPTY				
	UP	#=15 AVE=1.80 STD DEV=0.75	#=8 AVE=1.84 STD DEV=0.20	#=23 AVE=1.82 STD DEV=0.
	DOWN	#=20 AVE=1.78 STD DEV=0.51	#=8 AVE=2.21 STD DEV=0.53	#=28 AVE=1.90 STD DEV=0.
	OVERALL	#=35 AVE=1.79 STD DEV=0.61	#=16 AVE=2.02 STD DEV=0.61	#=51 AVE=1.86 STD DEV=0.
14.GATE RECESSED				
	UP	#=15 AVE=1.49 STD DEV=1.26	#=8 AVE=1.20 STD DEV=0.55	#=23 AVE=1.39 STD DEV=1.
	DOWN	#=20 AVE=1.28 STD DEV=0.86	#=8 AVE=0.96 STD DEV=0.23	#=28 AVE=1.19 STD DEV=0.
	OVERALL	#=35 AVE=1.37 STD DEV=1.04	#=16 AVE=1.08 STD DEV=0.43	#=51 AVE=1.29 STD DEV=0.
15.SECOND CUT BOW OVER GATE				
	UP	#=15 AVE=4.32 STD DEV=1.62	#=8 AVE=4.71 STD DEV=2.05	#=23 AVE=4.46 STD DEV=1.
	DOWN	#=20 AVE=4.69 STD DEV=1.57	#=7 AVE=5.39 STD DEV=1.51	#=27 AVE=4.87 STD DEV=1.
	OVERALL	#=35 AVE=4.54 STD DEV=1.58	[illegible]	[illegible]

[redacted]

	UP	#=15 AVE=1.55 STD DEV=0.98	#=9 AVE=1.59 STD DEV=0.89	#=24 AVE=1.57 STD DEV=
	DOWN	#=20 AVE=2.21 STD DEV=1.11	#=7 AVE=1.22 STD DEV=2.10	#=27 AVE=1.95 STD DEV=
	OVERALL	#=35 AVE=1.93 STD DEV=1.09	#=16 AVE=1.43 STD DEV=1.49	#=51 AVE=1.77 STD DEV=
17.START GATE CLOSURE				
	UP	#=15 AVE=1.40 STD DEV=0.26	#=9 AVE=1.80 STD DEV=0.09	#=24 AVE=1.91 STD DEV=1
	DOWN	#=20 AVE=1.45 STD DEV=0.13	#=8 AVE=1.63 STD DEV=0.22	#=28 AVE=1.87 STD DEV=0
	OVERALL	#=35 AVE=1.43 STD DEV=0.19	#=17 AVE=1.72 STD DEV=0.18	#=52 AVE=1.89 STD DEV=0
18.GATE CLOSED				
	UP	#=15 AVE=7.16 STD DEV=1.91	#=9 AVE=5.41 STD DEV=0.63	#=24 AVE=6.51 STD DEV=1
	DOWN	#=20 AVE=8.31 STD DEV=2.19	#=8 AVE=5.46 STD DEV=0.45	#=28 AVE=7.50 STD DEV=2
	OVERALL	#=35 AVE=7.82 STD DEV=2.12	#=17 AVE=5.44 STD DEV=0.54	#=52 AVE=7.04 STD DEV=2
19.END FILL/EMPTY				
	UP	#=15 AVE=1.91 STD DEV=1.32	#=9 AVE=1.90 STD DEV=0.52	#=24 AVE=1.91 STD DEV=1
	DOWN	#=20 AVE=1.82 STD DEV=0.77	#=8 AVE=2.01 STD DEV=0.37	#=28 AVE=1.87 STD DEV=0
	OVERALL	#=35 AVE=1.86 STD DEV=1.03	#=17 AVE=1.95 STD DEV=0.45	#=52 AVE=1.89 STD DEV=0
20.GATE RECESSED				
	UP	#=15 AVE=0.84 STD DEV=0.46	#=9 AVE=0.56 STD DEV=0.35	#=24 AVE=0.73 STD DEV=0.
	DOWN	#=20 AVE=0.84 STD DEV=0.58	#=8 AVE=0.47 STD DEV=0.27	#=28 AVE=0.73 STD DEV=0.
	OVERALL	#=35 AVE=0.84 STD DEV=0.53	#=17 AVE=0.52 STD DEV=0.30	#=52 AVE=0.73 STD DEV=0.
21.SECOND CUT BEGINS EXIT				
	UP	#=14 AVE=2.19 STD DEV=0.68	#=9 AVE=3.13 STD DEV=1.30	#=23 AVE=2.56 STD DEV=1.
	DOWN	#=20 AVE=3.59 STD DEV=1.23	#=8 AVE=3.37 STD DEV=0.69	#=28 AVE=3.53 STD DEV=1.
	OVERALL	#=34 AVE=3.01 STD DEV=1.24	#=17 AVE=3.24 STD DEV=1.04	#=51 AVE=3.09 STD DEV=1.
22.CUTS BUMP TOGETHER				
	UP	#=15 AVE=10.00 STD DEV=4.83	#=9 AVE=12.03 STD DEV=2.61	#=24 AVE=10.76 STD DEV=4.
	DOWN	#=20 AVE=12.37 STD DEV=4.14	#=8 AVE=11.24 STD DEV=1.75	#=28 AVE=12.05 STD DEV=3.
	OVERALL	#=35 AVE=11.35 STD DEV=4.54	#=17 AVE=11.66 STD DEV=2.22	#=52 AVE=11.45 STD DEV=3.
23.TOW STARTS EXIT				
	UP	#=15 AVE=3.54 STD DEV=1.05	#=9 AVE=6.15 STD DEV=2.58	#=24 AVE=4.52 STD DEV=2.
	DOWN	#=20 AVE=4.82 STD DEV=1.96	#=8 AVE=4.96 STD DEV=2.71	#=28 AVE=4.86 STD DEV=2.
	OVERALL	#=35 AVE=4.27 STD DEV=1.74	#=17 AVE=5.59 STD DEV=2.63	#=52 AVE=4.70 STD DEV=2.
24.TOW STERN OVER SILL				

Totals
Up 78.92
Down 92.43
Overall 86.11

Estimated totals for
a 1200' Lock Same Performance

Up 29.63
Down 30.59
Overall 30.11

Critical High Water Information - Locking in the ROCK ISLAND DISTRICT

	Pool Stage	Tail Stage	Other
O'Brien			
Lockport	565.00 STOP Navigation due to LOW WATER - Pool pulled down by Power House (Not enough water over sill)	7,000 CFS and Above Industry Provided Helper Boat Required to Pull First Cut	
Brandon Road			
Dresden Island		496.53 Elevation and Above NO Upbound and Generally NO Downbound Doubles. Downbound doubles possible if industry provided helper boat takes them down the river to tie off.	
Marseilles	484.48 (STOP Navigation - Water in Bull Gear Pits)	466.7 (RESTRICTION ON DOUBLES Water over Lower Wall)	Don't Allow Use of Moorings in Canal for Waiting Out High Water(Just for Locking
Starved Rock	461.5 (STOP Navigation - Water in Bull Gear Pits)	458.5 (RESTRICTION ON DOUBLES Water over Lower Wall)	Outdraft High (25'-170' Dam Opening) Tows Warned
Peoria	441.0 Elevation (dam goes down) OPEN PASS CONDITION	439.0 Elevation (dam goes down) OPEN PASS CONDITION	Helper Boat at 5 foot of tainter gate opening
LaGrange	429.5 Elevation (dam goes down) OPEN PASS CONDITION	426.5 Elevation (dam goes down) OPEN PASS CONDITION	442.0 Elevation Coast Guard Stopped Traffic for fear of levee damage
11		20.5 Pull Motors (STOP Navigation)	Outdraft Sign Displayed at 9.0 TWHelper Boat Suggested at 10.0 TW - Helper Boat Required at 14.5 TW
12	18.0 Gage (STOP Navigation - Pull Miter Gate Motors		
13	19.2 Gage (STOP Navigation - Pull Valve Motors)		Top of Lock Wall-592.0 (23.30 gage)
14	16.0 Gage (STOP Navigation - Pull Valve Motors)	11.0 Gage Industry Provided Helper Boat Required (Upbound-Pull 1st Cuts Downbound-Assist Tow onto Wall	
15		21.5 Gage (564.00 Elevation) STOP Navigation {At 11.0 Gage Industry provided helper boat encouraged}	
16	17.0 Gáge (STOP Navigation - water over lower miter gates)		
17	18.4 Gage (STOP Navigation)		
18	14.5 Gage / 532.57 Elevation (STOP Navigation)		
19		22.17 Gage / Elevation 500.00 STOP Navigation - Lower wall goes under water	
20	18.0 Gage (STOP Navigation)		
21	23.0 Gage / Elevation 480.80 (STOP Navigation)		
22	21.0 Gage / Elevation 467.1 (STOP Navigation)		22.4 Gage / 468.5 Gate pits flood 25.4 Gage / 471.5 Lockwall overtops

ASSESSMENT TEAM MEETING

BRAINSTORMING SESSION

4 October 1994

Brainstorming Session; October 4, 1994

Suggested Idea	Response to Idea
Ready to Serve	Covered in Report
Mandate Standard Tow Size Configuration	Covered in Report
Extended Guidewalls	Covered in Report
Mooring Cells Near Bullnose and in Approaches	Covered in Report
Improve Approaches	Covered in Report
Alignment (Navigation) Cells	Covered in Report
Floating Mooring Buoys	Covered in Report
Dedicated Lockage Times for Pleasure Craft	Covered in Report
Helper Boats	Covered in Report
Switch Boats	Covered in Report
Powered Kevel	Covered in Report
Remote/Automated Dam Gate Control	Covered in Report
N-up/N-down Policy	Covered in Report
New Lighting Standards (High Mast Lights)	Covered in Report
Improve Ice Passage	Covered in Report
Wicket Gates to Pass Ice & Allow Open Passage at Locks 17 & 20	New Item - Add to Report
Implement Automated Control System	Covered in Report
CCTV at Certain Locations	New Item - Add to Report
Traffic Management	Covered in Report
Standardize Barge Coupling Devices/Process	Covered in Report
Government-Supplied Equipment	Covered in Report
Create Indraft	New Item - Add to Report
Shut Down Dam on Approach	New Item - Add to Report

Suggested Idea	Response to Idea
Operate Gates on Dam Furthest from Lock	New Item - Add to Report
Deeper Approaches	Covered in Report
Operational Philosophy (Lockmaster's Authority) and Industry Attitudes	New Item - Add to Report
Deepen River Upstream of the Gate Bays of the Dam	New Item - Add to Report
River Traffic Scheduling	Covered in Report
Extended Guidewalls	Covered in Report
Waiting Areas Closer	Covered in Report
Widen Channel 1-2 Miles Downstream/Upstream of the Lock	Covered in Report
Mandate Minimum Horsepower	New Item - Add to Report
Identify Bottlenecks	Outside Scope of Study
Add Guardwall	Covered in Report
Charge Vessels Based on Time (Toll)	New Item - Add to Report
Crew Training	Covered in Report
Lock Staffing	Covered in Report
Switch Boats	Covered in Report
Helper Boats	Covered in Report
Bow Boats	Covered in Report
Powered Kevels	Covered in Report
Corps/Industry Communications	New Item - Add to Report
Vessel Traffic Monitoring/Information	Covered in Report
Regulate Flow of Vessel Traffic	Covered in Report
GPS Tracking	New Item - Add to Report
Regulate Time Utilization	Covered in Report
Ready to Serve Configuration	Covered in Report
Quick Couplings	Covered in Report

Suggested Idea	Response to Idea
Institutional Inducements on Quick Couplings	Covered in Report
Channel Realignment to reflect River Conditions	Outside Scope of Study
GPS System Tracking and Scheduling	New Item - Add to Report
Mooring Cells at Lock	Covered in Report
Extended Guidewalls	Covered in Report
Tow Haulage Systems	Covered in Report
Staging Areas	Covered in Report
Publish Lockage Times by User	New Item - Add to Report
Ice Chutes	New Item - Add to Report
Excess Lockage Time Charges	New Item - Add to Report
Minimize Lock Maintenance Down-time	Covered in Report
Dual Channels at Restrictive Bridges	Outside Scope of Study
Guide Cells	Covered in Report
Speed Filling/Emptying Time	Covered in Report
Recreational Craft Management	Covered in Report
Recreational Craft Landing Above and Below the Lock	New Item - Add to Report
Industry Mandated Training of Deckhands	Covered in Report
Passing Zones	Outside Scope of Study
Widen Approach Channels for Passing	Covered in Report
Use Upper Gate as a Filling Valve	Covered in Report
Wicket Gates in Dam	New Item - Add to Report
Navigable Passes	New Item - Add to Report
Helper Boats	Covered in Report
Automated Lockage System from Queue Point (Auto Car Wash)	New Item - Add to Report
Eliminate Outdraft	Covered in Report

Suggested Idea	Response to Idea
Create Indraft	New Item - Add to Report
Clean Ice from Barges	New Item - Add to Report
Standardization of Tow Configuration to Maximize Tonnage through Lock	Covered in Report
Licensing of Recreational Craft Operators	New Item - Add to Report
Wall Extensions	Covered in Report
Real-time Pilot Communication & Data Sharing	New Item - Add to Report

Appendix V

ASSESSMENT TEAM MEETING

EVALUATION SESSION

4 October 1994

SCHEDULING OF LOCK OPERATIONS

ITEM: N-UP/N-DOWN

ADVANTAGES:

Present Policy is working
Reduces approach time
Reduces waiting time
Reduces overall time
Gate Wickets more effective (empty chamber)
Good for congested areas

DISADVANTAGES:

Interrupts 1st-come/1st-served
More benefits with extended guidewall and powered kevel
Recreational Craft
Short-term time impact to a particular tow

ITEM: READY TO SERVE POLICY

ADVANTAGES:

Present Policy is working
No capital investment
No environmental impacts
Reduces Congestion/Delay
Lock efficiency

DISADVANTAGES:

Can reduce maneuverability
Need an area for reconfiguration of the tow

ITEM: SELF HELP POLICY

ADVANTAGES:
Industry Run
Reduces Delay
No government investment
No environmental Impact

DISADVANTAGES:

Requires Industry coordinator
Requires cooperation

ITEM: LOCK SCHEDULING PROCEDURES

ADVANTAGES:

Traffic Management practices currently being used by industry
Based on Economics
Reduces congestion
Helps decision making
Efficiency
Little cost

DISADVANTAGES:

More Government Regulations
Loss of autonomy by lockmaster (if he has it)
Does not consider whole river - too narrow in scope?
Recreational craft impact
May need for timely and accurate data

ASSISTANCE TO MULTI-CUT LOCKAGES

ITEM: HELPER BOATS

ADVANTAGES:

Safety
Risk Management Decision
Current Policy appears to be working
Environment
Outdraft remedy
More efficient approach
More efficient removal

DISADVANTAGES:

Costs
More Government Regulations
Cost
False security
Low power
User's discretion
Industry provided - cost to industry
Dedicated to lock
Liability

ITEM: SWITCH BOATS

ADVANTAGES:

Safety
Risk Management Decision
Current Policy appears to be working
Power
Extraction Remote Makeup
Efficiency
Clears approach channel

DISADVANTAGES:

Greater cost for boat and remote mooring
More Government Regulations
User's discretion?
Management
Cost to industry
Liability
Need area off channel to reconfigure

ITEM: ENDLESS CABLE SYSTEM

ADVANTAGES:

Eliminates cable pulling time
Improved Safety
Quicker removal of first cut
Cost effective removal (no helper boat required)

DISADVANTAGES:

More congestion along lock walls
Reliability/Safety (cable breaks)
Interface
Attachment point needed
Water level variation
Ice conditions
Cost of system
Maintenance of system

ITEM: UNPOWERED TRAVELING KEVELS

ADVANTAGES:

In place at some sites - works well
Safety
Allows use of existing capacity
Control unpowered cut
Efficiency

DISADVANTAGES:

No checking capacity
Not strong enough to use against outdraft
Manual effort
Upbound requires tow haulage/winch system
Some Cost
May require structural modifications
Extension of walls

ITEM: POWERED TRAVELING KEVEL

ADVANTAGES:

Reduced time for unpowered cut extractions
No environmental problems
Safety
No need for helper boat on tow haulage

DISADVANTAGES:

Unknown reliability
Cost impacts
Interference
Wall Stability
Structural modifications

ITEM: HYDRAULIC ASSISTANCE
* (downbound only)

ADVANTAGES:

Flushing
Cost
Efficiency

DISADVANTAGES:

Additional wear on Tow Haulage Equipment
Not Corps policy to use, but it is done
Loss of control
Safety
Need head differential
Valve control
Structural modifications
Cost
Experience operators/deckhands required

IMPROVEMENTS TO APPROACH CHANNELS

ITEM: IMPROVE APPROACH CHANNELS

ADVANTAGES:

Reduces approach time/distance
Improves Safety
Reduces risk of accidents, environmental spills, damage to structures
Maintenance cost Savings
Reduce Outdraft
Improved Control
Efficiency

DISADVANTAGES

Cost
Environmental Impacts
Site Specific
Dredging
Disposal
Maintenance

ITEM: ADJACENT MOORING FACILITIES

ADVANTAGES:

Improved Efficiency
Safety
Environmental Benefits (less bank erosion)
Fuel savings
Hold closer to lock

DISADVANTAGES

Cost
Environmental Impacts
Site Specific
Maintenance
May interfere with departure
Channel interference
Cells views. Buoys

ITEM: FUNNEL-SHAPED GUIDEWALLS

ADVANTAGES:

Safety

DISADVANTAGES:

Debris & ice trapped
High Cost
Minor benefits over extended guidewalls
Not effective in open river conditions
Space required
False sense of security
Interference with outbound tows

ITEM: WIND DEFLECTORS

ADVANTAGES:

Common in Dutch Locks

DISADVANTAGE:

Not Practical
Limited directional application
Visibility

ITEM: EXTEND GUIDEWALLS

ADVANTAGES:

Good measure
Improve Safety
Reduce lockage time
Environmental hazard prevention
Better control
Enhances traffic views, N-up/N-down, self help, etc.
Double lockages makeup occurs outside chamber
Safer approach
Improve queuing time for same-direction traffic
Improved efficiency
More room to land on wall
Prevent damage to gates

DISADVANTAGES:

Cost
Environmental Impacts
May not be feasible at all locations

ITEM: ADD GUIDE CELLS

ADVANTAGES:

Proven
Facilitates movement of recreational craft (must do with extended guidewall)
Lock recreational vessel through during turnback of double lockage
Efficiency
Less damage to structure
Safety

DISADVANTAGES:

Cost
Obstacle
Environmental impacts during construction
Reduced face-up length of guidewall

<u>ITEM: RECONFIGURE BULLNOSE</u>

ADVANTAGES:

Directs glancing blows into chamber

DISADVANTAGES:

Little Benefit
Cost

<u>ITEM: RADAR REFLECTORS</u>

ADVANTAGES:

Boats have radar
Deflectors would enhance radar
Can't replace deckhand
Minor cost

DISADVANTAGES:

Minor effects

<u>ITEM: ELECTRONIC GUIDANCE SYSTEM</u>

ADVANTAGES:

Info to pilot to help approach

DISADVANTAGES:

Corps Policy?
Unproven Technology
Cost
Liability

AREA-WIDE CHANNEL IMPROVEMENTS

ITEM: REMOVE/ADJUST BENDS, ONE-WAY REACHES, BRIDGES
* (Urban areas are largest problem)

ADVANTAGES:

Limited sites
Safety
Efficiency
Environmental
Reduce accidents

DISADVANTAGES

Major cost impact
Site Specific (limited)
Environmental Impacts
Doesn't change lock capacity
Dredging
Disposal

ITEM: IMPROVE NAVIGATION AIDS AND CHANNEL MARKINGS

ADVANTAGES:

Current System Adequate
Need more reflectors on bridges (for spotlights)
Safety
GPS is big help

DISADVANTAGES:

Maintenance of system difficult/ongoing
Timeliness in correcting position of aids

ITEM: INNOVATIVE DREDGING STRATEGIES
* (hinge point causes water to be too shallow at upstream approach)
* (combine with innovative dredging?)

ADVANTAGES:

This is ongoing
LTRMS
Use in approaches
Reduces Interference
River disposal
Move minimal amount of material
Less environmental impact
Reduce dredging
Reduce interference with navigation

DISADVANTAGES:

ITEM: WATER FLOW MANAGEMENT POLICIES

ADVANTAGES:

Improvements to approaches
Reduce outdraft
Reduce maintenance

DISADVANTAGES:

Cost
Environmental Impacts

ITEM: INCREASE CHANNEL WIDTH

ADVANTAGES:

Adequate if maintained
Safety
Some efficiency

DISADVANTAGES:

Environmental Problems
Authority Uncertain
Cost
Dredging Disposal

ITEM: ISOLATE RECREATIONAL FACILITIES & MARINA AWAY FROM CHANNEL

ADVANTAGES:

Safety

DISADVANTAGES:

Cost
Dredging

NOTES:

Boater behavior is more of a problem than location
Industry involved in ongoing process

ITEM: IMPROVE BRIDGE OPERATIONS & MAINTENANCE

ADVANTAGES:

Ongoing
Fix shear fences
Efficiency
Reduce Fuel Consumption
Reduce waiting time

DISADVANTAGES:

NOTE:
Coast Guard Issue

TOW CONFIGURATION AND OPERATIONS

ITEM: MANDATE USE OF BOW THRUSTERS

ADVANTAGES:

Can use in place of tow haulage
Efficiency
Safety

DISADVANTAGES

No need
Not practical to implement
One less barge
Helper boats are better
Mandating impact small

Proficient operators needed

ITEM: MANDATE USE OF PROTOTYPE BOW THRUSTERS

ADVANTAGES:

DISADVANTAGES:

ITEM: PROMOTE TOW SIZE STANDARDIZATION

ADVANTAGES:

Fills chamber
Increases lock utilization

DISADVANTAGES:

Reduces maneuverability
Intermediate customers
Requires Industry cooperation

NOTES:

Economics will drive this
Industry working w/Coast Guard

ITEM: COOPERATIVE EQUIPMENT SHARING/SCHEDULING

ADVANTAGES:

Sharing of barges is already on-going, similar to railroads
More efficient use of chamber
Cost reduction
Fewer lockages

DISADVANTAGES:

Requires Cooperation

ITEM: INSTITUTE WATERWAY TRAFFIC MANAGEMENT

ADVANTAGES:

Coordination
(See Scheduling)

DISADVANTAGES:

ITEM: INCREASE NUMBER AND SIZE OF FLEETING AREAS

ADVANTAGES:

Needs based on economic conditions
Approaches with mooring areas needed
Better tow configuration for locking

DISADVANTAGES:

Environmental Impacts
Cost
Savings depends on tow configuration

ITEM: FUEL MONITORING AND MANAGEMENT

ADVANTAGES:

Ongoing

DISADVANTAGES:

Can slow traffic and impact others

ITEM: USE OF HEAVY FUELS

ADVANTAGES:

Ongoing

DISADVANTAGES:

ITEM: NEW BARGE AND BOAT BOTTOM TREATMENTS

ADVANTAGES:

Ongoing
Combat Zebra Mussels
Reduce ice adhesion

DISADVANTAGES:

Cost
Maintenance

ITEM: IMPROVED BARGE AND BOAT HULL DESIGNS

ADVANTAGES:

Ongoing
Safety

DISADVANTAGES:

ITEM: IMPROVED BOAT AND BARGE RIGGING

ADVANTAGES:

Ongoing

DISADVANTAGES:

<u>ITEM: BARGE STACKING FOR BACKHAULS</u>

ADVANTAGES:

Increase lock utilization
Fuel savings
Fewer tows

DISADVANTAGES:

Cost
Equipment needed to stack and unstack
Viability
Cleaning bottoms
Structural design of barges

<u>ITEM: CONTAINER MOVEMENT</u>

ADVANTAGES:

Ongoing
Market Development
Allow more goods to ship on waters

DISADVANTAGES:

Need for this type of traffic and commodity
Need facilities to accommodate handling of containers

<u>ITEM: NEW BACKHAUL OPPORTUNITIES</u>

ADVANTAGES:

Ongoing
More utilization

DISADVANTAGES:

Need markets

ITEM: UNIVERSAL COUPLERS/HAND WINCHES

ADVANTAGES:

Implemented by Industry?
Reduces lockage time
Less labor
Safer system

DISADVANTAGES:

Large variety of barge design types
Not practical
Standards must be mandated
Cost

ITEM: INCREASE SPEED LIMITS IN RESTRICTED REACHES

ADVANTAGES:

Efficiency

DISADVANTAGES:

Environmental concerns
Safety
Not a major problem

ITEM: REDUCE LIABILITY OF TOW OPERATORS FOR DAMAGE

ADVANTAGES:

DISADVANTAGES:

Safety

NOTES:

Talk to your Congressman

ITEM: REQUIRE MINIMUM CREW SIZE AND TRAINING

ADVANTAGES:

Ongoing
Nav Notice #1
Large time impacts
Low Cost
Safety
Reduce damage to structure
Efficiency

DISADVANTAGES:

LOCK OPERATING PROCEDURES

ITEM: MODIFY INTAKE STRUCTURES

ADVANTAGES:

Increase lock efficiency
Speed filling
Reduce filling time

DISADVANTAGES:

Costs
O & M
Not Practical
Time to implement
Shut down to modify structure
Model study

ITEM: MODIFY DISCHARGE STRUCTURES

ADVANTAGES:

Dump faster
Safety
Increase lock efficiency

DISADVANTAGES:

Costs
O & M
Not Practical
Time to implement
Shut down to modify structure
Model study

ITEM: MODIFY WALL PORTS

ADVANTAGES:

Safety
Reduce hawser stress

DISADVANTAGES:

Costs
O & M
Not Practical
Impacts during construction
Model
Safety to recreational boaters

ITEM: INSTALL SELF-CLEANING TRASH RACKS

ADVANTAGES:

Fixes large problem (esp. on Illinois Waterway)
Improve filling conditions and time

DISADVANTAGES:

Site Specific
Cost

ITEM: CENTRALIZE CONTROLS

ADVANTAGES:

May reduce staff - cost savings

DISADVANTAGES:

Safety
Cost savings eliminated if staff not reduced
Maintenance

ITEM: AUTOMATE CONTROLS

ADVANTAGES:

DISADVANTAGES:

Down time
Difficult to program all situations

ITEM: INSTALL FLOATING MOORING BITS

ADVANTAGES:

Site Specific
Exist everywhere they are practical
Better control

DISADVANTAGES:

Structural limitations
Costly
Minor need
More important with high lift locks
Liability

ITEM: UPGRADE VALVE OPERATING EQUIPMENT

ADVANTAGES:

Ongoing
Less down time
Improve liability
Better control
More efficient

DISADVANTAGES:

Minor time savings
Cost

ITEM: UPGRADE GATE OPERATING EQUIPMENT

ADVANTAGES:

Better equipment
Less down time
Improve liability
Better control
More efficient

DISADVANTAGES:

Minor time savings

Cost

ITEM: INSTALL GATE WICKETS IN MITER GATES

ADVANTAGES:

Can use during turnback
More effective filling/emptying

DISADVANTAGES:

Surging problems
Site specific
Would require other mods to retrofit
Cost
Turbulence

ITEM: PROVIDE EXPLICIT OPERATING GUIDES

ADVANTAGES:

Nav. Notice # 1
O & M Manual

DISADVANTAGES:

ITEM: FENDERS, ENERGY ABSORBERS

ADVANTAGES:

Ongoing
Reduce damage
Reduce down time
Replacement costs

DISADVANTAGES:

Safety
Initial cost

ITEM: REQUIRE VESSELS TO STAY CLEAR OF EMPTYING/FILLING SYSTEM

ADVANTAGES:

Safety

DISADVANTAGES:

Minor impact
Site specific

ICE CONDITIONS

ITEM: MECHANICAL ICE CUTTING DEVICE

ADVANTAGES:

Improve efficiency
Eliminate need to reduce to 2-wide

DISADVANTAGES

In testing phase
Limited application
Cost

ITEM: SKIN PLATES

ADVANTAGES:

Reduce ice load on gates

DISADVANTAGES:

Limited value
Other methods available
Cost
Maintenance

ITEM: AIR BUBBLER SYSTEM

ADVANTAGES:

Ongoing
Reduce stress on gate if ice can be removed from behind
Improve ability to get tow out of upper river in the fall

DISADVANTAGES:

Cost
Maintenance

ITEM: HEAT PLATES

ADVANTAGES:

Reduce stress on gate if ice can be removed from behind
Improve ability to get tow out of upper river in the fall

DISADVANTAGES:

Testing Phase
O & M
Cost
Maintenance

ITEM: HEATED WATER JET

ADVANTAGES:

Reduce stress on gate if ice can be removed from behind
Improve ability to get tow out of upper river in the fall

DISADVANTAGES:

Cost
Maintenance

RECREATIONAL VESSELS

ITEM: RECREATIONAL VESSEL BYPASS LIFTS

ADVANTAGES:

Safety
reduced delays to tows and recreational vessels

DISADVANTAGES:

Peaking makes this prohibitive
Requires additional staff
Cost
Maintenance

ITEM: SCHEDULING OF RECREATIONAL VESSEL USAGE

ADVANTAGES:

Ongoing at certain sites
Lock utilization
Minimum cost
Reduces delays to recreational craft
Safety

DISADVANTAGES:

Negative response from users

COST ALLOCATION

ITEM: APPLY CONGESTION TOLLS

ADVANTAGES:

DISADVANTAGES:

ITEM: LOW HEAD HYDROELECTRIC UNITS

ADVANTAGES:

DISADVANTAGES:

Fluctuation downstream

NOTES:

Not applicable for this forum?

ITEM: ALLOCATION OF OPERATIONS AND MAINTENANCE COSTS

(same as congestion fee)

ADVANTAGES:

DISADVANTAGES:

NOTES:

Objective 1 & 2

ITEM: PRIVATIZATION OF LOCK OPERATIONS

ADVANTAGES:

Reduce cost

DISADVANTAGES:

Safety
Maintenance

OTHER

ITEM: INCREASE LOCK STAFFING

ADVANTAGES:

More assistance to tows
Reduces maintenance backload

DISADVANTAGES:

No Brainer
Increased labor costs to Corps

ITEM: AUTOMATE DAM CONTROLS

ADVANTAGES:

DISADVANTAGES:

Safety (need to look for debris)
Requires TV camera

ITEM: RADAR AT LOCK

ADVANTAGES:

DISADVANTAGES:

GPS is better

ITEM: REAL-TIME CHANNEL DEPTH & WEATHER MONITORING

ADVANTAGES:

Ongoing
Better decisions
Less chance for accidents

DISADVANTAGES:

Cost
Liability for data

ITEM: IMPROVED LIGHTING

ADVANTAGES:

Safety

DISADVANTAGES:

ADDED ITEMS

ITEM: PUBLISH LOCKAGE TIMES BY USER

ADVANTAGES:

Industry Accepted

Peer pressure
Safety (training)
Improved lockage time

DISADVANTAGES:

Safety (rushing)

ITEM: GPS DATA TRACKING SYSTEM

ADVANTAGES:

Provides information
Position tracking
No false reports
Improved safety

DISADVANTAGES:

Cost to Industry
Problem with Recreational Vessel Implementation
Government managed

ITEM: EXCESS LOCKAGE TIME CHARGES

ADVANTAGES:

DISADVANTAGES:

Safety would be sacrificed to meet time
Hardship on small operator
Bias on some tows
Does not impact root of the problem
Difficult criteria

ITEM: POSITIVE WATERFLOW MANAGEMENT RELATIVE TO NAVIGATION

ADVANTAGES:

More reliable channel
Reduces Congestion
Reduces Channel Maintenance
Hydropower Impacts

DISADVANTAGES:

Recreation impacts
Impacts outside study area

ITEM: DUAL CHANNEL AT RESTRICTIVE BRIDGES

ADVANTAGES:

Reduced congestion
Safety
Speed
Easier passing

DISADVANTAGES

Channel Maintenance Costs
Construction costs & interference
Disposal
Environmental impacts
Needs model study

ITEM: CLEAR ICE FROM BARGES

ADVANTAGES:

Better chamber use
No sill damage
Fuel efficiency

DISADVANTAGES:

Not Practical
Time to remove
Cost

ITEM: CREATE INDRAFT (via Bendway Weirs?)

ADVANTAGES:

Safety
Speed (line up quicker)

DISADVANTAGES:

Not tested/modeled
Impacts on Recreational Craft

Cost
Dredging
Training structures
Maintenance
Ice control

ITEM: LICENSE RECREATIONAL CRAFT OPERATORS

ADVANTAGES:

Efficiency
Safety

DISADVANTAGES:

Not an issue in this forum
Cost to state
Public reaction
Politics

ITEM: SHUT DOWN DAM ON APPROACH

ADVANTAGES:

DISADVANTAGES:

Not Practical

ITEM: OPERATE DAM GATES BASED ON LOCKAGE/SHUT DOWN DAM ON APPROACH

ADVANTAGES:

Minimize Outdraft
Safety
Efficiency

DISADVANTAGES:

Water fluctuations downstream and upstream
Time to respond
Number of personnel
Silt & scour control

ITEM: OPERATIONAL PHILOSOPHY / INDUSTRY ATTITUDE

ADVANTAGES:

A great idea
Improve procedures
Make more efficient (i.e lighting, operating procedures)

DISADVANTAGES:

Added time to participants
Difficult for operators to participate

ITEM: DEEPEN RIVER UPSTREAM OF DAM GATES

ADVANTAGES:

DISADVANTAGES:

Structural Integrity of Dam Foundation
Environmental impact
Disposal
Maintenance

ITEM: CHARGE VESSELS BASED ON TIME (TOLL)

ADVANTAGES:

Speed up lockages

DISADVANTAGES:

Safety (rushing)
Administration difficult

ITEM: WICKET GATES (for ice) (for open pass at 17 & 20)

ADVANTAGES:

Pass Ice
Hydraulic operations

DISADVANTAGES:

Open pass is site specific
Difficult to operate
Costly
Unsafe

ITEM: PILOT COMMUNICATION (BULLETIN BOARD)

ADVANTAGES:

Safety
Efficiency
Faster dissemination of information
Identify channel problems

DISADVANTAGES:

Needs to be managed

Appendix VI

REFERENCES

The American Canal and Transportation Center. Towpaths and Towboats: A History of American Canal Engineering. 1992.

Cornell and Hoffman. American Merchant Seaman's Manual 6th Edition. 1982.

Leeper, Cambridge & Campbell, Inc. Upper Mississippi River Transportation Economics Study, Supplement 2: Efficiency Measure Analysis. April 1989.

Louis Berger & Associates, Inc. Inventory of Potential Structural and Non-Structural Alternatives for Increasing Navigation Capacity - Upper Mississippi River System Master Plan. April 1981.

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

Peat, Marwick, Mitchell & Co. Evaluation of Operational Improvements at Lock and Dam No. 26, Mississippi River. July 1975.

U.S. Army Corps of Engineers. Comprehensive Master Plan for the Management of the Upper Mississippi River System, Technical Report A: Navigation and Transportation. (No date indicated).

U.S. Army Corps of Engineers. Lock and Dam No. 24, Periodic Inspection Report No. 8. November 1993.

U.S. Army Corps of Engineers. Regulations Prescribed by the Secretary of the Army for Ohio River, Mississippi River above Cairo, Ill. and their Tributaries (33 CFR 207.300).

U.S. Army Corps of Engineers. Upper Mississippi River Navigation Charts. 1989.

U.S. Army Engineer District, Corps of Engineers, Chicago, IL. Charts of the Illinois Waterway. 1974.

Appendix VII

Minnesota Department of Transportation

Office of Railroads and Waterways
Mail Stop 470, 925 Kelly Annex
395 John Ireland Blvd.
St. Paul, MN 55155

Phone: 612/ 296-0355
Fax: 612/ 297-1887

December 9, 1994

Mr Paul Kosterman
Corps of Engineers
St. Paul District
190 Fifth Street East
St. Paul, Minnesota 55101-1638

Dear Paul

Thank you for asking for our comments on the " Small Scale Improvements Study Upper Mississippi Navigation Study etc." Paul Keranen nor I will be able to attend the December 14th meeting in St Louis, but would like to make a few comments below.

The options for analysis for improving the efficiency of the locking system seem to be almost endless. In reviewing the " General Assessment" document I was struck by the long time it took to approach and enter the lock as well as departing the facility. I also noticed that only 2 locks were actually studied and that others may vary in their approach and departure times. Caution and safety are paramount but I feel that we should be looking for solutions to reduce the approaching and departing times of tows. This time is also lost to other vessels waiting their turn to lock.

Each lock in the system has its own peculiarities and deficiencies and must be studied in conjunction with this Study. Lock 3, for example, on the Upper Mississippi has always been a big problem for downbound tows.

I also agree with the Wisconsin Department of Transportation that in our upper reaches of the Mississippi, the recreational boater is a big issue during the summer months of our navigation season and should be included in this Study. The use of guidecells to allow recreational boaters access to locks during a double locking operation may be a help to relieve recreation congestion.

In the late fall and early Spring, ice is a big factor on the Upper Mississippi and a better system of washing the ice jams away from the upper miter gates would do a lot to improve efficiency in these critical times of the year.

Finally the glossary could be expanded with a listing of acronyms of Corps terms.

Sincerely,

Richard F. Lambert
Director
Ports & Waterways

DEPARTMENT OF NATURAL RESOURCES **STATE OF MINNESOTA**

DIVISION OF WATERS

Office Memorandum

Date: December 13, 1994

To: Paul Kosterman, COE-St. Paul

From: Steve Johnson, River Management Supervisor
(612) 296-4802
Fax: (612) 296-0445

Subject: Draft General Assessment of Small Scale Improvements
UMRS-IWW Navigation Feasibility Study

VIA FAX - 3 PAGES

Thank you for providing me with a copy of the above-referenced document. I have several comments that I hope can be useful to you in revising the draft. I'm sorry we were provided only a few days for review, so I was not able to route it for normal review by DNR staff. In the future, we would appreciate more than a week's turnaround time on a document as large as this.

In general, we found the document very good. Understanding the short timeframe in which it was prepared, it is a complete and thorough document. Detailed comments follow.

Page VI-1: Definition B.6 says cost is a plus if the measure is expensive, and a negative if the measure is inexpensive. Shouldn't that be the other way around? In reading the document, alternatives appeared to get a plus if they were *inexpensive*.

Page VI-14: We support further evaluation of mandatory helper boats. In our region, this would be particularly helpful at the upper approach to Lock/Dam 3.

Page VI-25: While we support further study of adjacent mooring facilities, we would caution that experiments with this at Lock/Dam 9 have not been completely successful. We're not sure why there has been a problem there, but this would be an appropriate question to address in further study.

Page VI-29: We support further study of guidewall extensions. While there is potential for significant environmental impacts in specific cases, there is sufficient potential benefit to warrant a more detailed evaluation.

Page VI-30: We support further study of guide cells; it has the potential to reduce delays for recreational lockages.

Page VI-37: We would support further study of improved navigation aids and channel markings. While we recognize that work of this type would not reduce lockage time, it certainly seems valuable to move tows through the system as efficiently as possible. This would reduce fuel consumption, possibly enabling the industry to be able to accept increased costs associated with other options. This could also be true with improved bridge operations (p. VI-42), dual channel at restrictive bridges (page VI-43), new barge and boat bottom treatments (p. VI-54), improved barge and boat hull designs (p. VI-55), container movements (p. VI-57) and new backhaul opportunities (p. VI-58).

Page VI-45: We would support further study of mandatory bow thrusters. It would appear the only barrier described here is the cost to industry. As noted above, there may be other ways to reduce industry costs to compensate for increased costs at the locks. It is also appropriate to consider that the industry may indeed have to pay more in the future to be able to operate on the system. While there may be additional environmental damage from prop wash, such potential damage might be offset by having a bow thruster available to reduce environmental damage when groundings occur.

Page VI-46: We would also support further study of mandatory prototype bow thrusters, for the same reasons discussed above.

Page VI-49: We are surprised traffic management is not being proposed for further study. When dealing with congested highway systems, the first thing departments of transportation look at is traffic management. It appears to us that the time has come when unrestricted traffic movements on the Mississippi River are going to be a thing of the past. We strongly recommend traffic management alternatives be included for further study.

Page VI-61: We were operating with a different definition of the issue of tow operator liability. To us, a concern has been that the tow operator is liable for environmental damage in the case of a grounding, for example, while the decision to operate with barges that are drafted overdepth---the possible cause of the grounding---rests with a corporate decision-maker. If the company were liable for damage rather than the tow operator, the Coast Guard might be more willing to write tickets for environmental damage from groundings. While this alternative might not reduce lockage time, it could reduce environmental damage.

Page VI-62: We strongly support further study of requiring minimum crew size and training.

Page VI-80: We strongly support the decision to not recommend further study of operating the dam gates based on lockage. This would have profound negative impacts on aquatic life.

Page VI-97: We support further study of congestion tolls, which would spread out lockages over time. As noted in our comment on traffic mangement (p. VI-49), it is time to begin evaluting management of the commercial users of the system.

Page VI-101 - VI-102: We support further study of excess lockage time charges, but are surprised you do not also consider further study of charging vessels based on time. They are quite similar, and both should receive further study.

Thank you for providing for our continued involvement in this phase of the Navigation Feasibility Study. While our travel is limited and we are unable to attend most meetings in St. Louis, we do remain interested in the process and hope to provide input whenever possible.

cc: Scot Johnson
Jim Cooper
John Line Stine
Dick Lambert, MnDOT

ALTER BARGE LINE, INC.
OPERATIONS & ENGINEERING DEPARTMENT
1200 EAST BROADWAY TEL. 618/465-1755
ALTON, ILLINOIS 62002

January 5, 1995

Paul Kosterman
Corps of Engineers
St. Paul District
190 Fifth Street East
St. Paul, MN 55101-1638

Dear Paul:

I am writing in reference to the Upper Mississippi River navigational study for improvements.

In general we at Alter Barge Line, Inc. believe any improvements to our system would be beneficial to the industry, our customers, and the general public.

The following comments are a result of the small scale improvement meeting held in St. Louis, Missouri.

1. The ready to serve policy is in our opinion, not a beneficial policy to the industry. The minimal time saved by forcing boats to make set overs or other moves before they get to the locks will be greatly offset by the additional time consumed by stopping before arriving and after departing the lock.

2. The self help policy currently being used by the industry should be considered as a viable method of pulling cuts during heavy congestion periods. Obviously, this method is not helpful when there is not a stack up of boats waiting for the lock.

3. Helper boats are also a good idea, but they are not always available and they should not be made mandatory.

4. Using switchboats to move cuts away from the lock to be made up at another location would be a costly and inefficient policy. At times, it could also be dangerous for a tug to move a cut away from a lock wall.

5. The requirement of a minimum crew size would not be helpful as the industry now utilizes a three man crew when locking.

6. The mandatory bow thruster concept is another area for safety concern. i.e.- Who would operate the thruster?
- Do they have sufficient, proper experience?
- Licensing requirements?
- Is the thruster powerful enough in any situation, i.e. a running river, ice?

7. The idea of adjacent mooring facilities would be a good idea if placed properly. Some time could be saved at the locks without safety, or efficiency sacrifices.

8. The guidewall extension proposal would prove to be helpful at certain locks. This should be considered at any rate.

Thank you for allowing us to participate as a group striving to improve our waterways. The future demands placed on our industry and infrastructure depend heavily on our willingness to improve.

Sincerely,

Dennis Dorris

Captain Wayne Williams
Alter Barge Line, Inc.

Iowa Department of Transportation
800 Lincoln Way, Ames, IA 50010 515-239-1685
FAX: 515-239-1639

January 13, 1995

Paul Kosterman
Corps of Engineers
St. Paul District
190 Fifth Street East
St. Paul, MN 55101-1638

Dear Mr. Kosterman:

Thank you for the opportunity to participate in the December 14, 1994, review of small scale improvement alternatives. The Sverdrup General Assessment of Small Scale Improvements, December 2, 1994, provided a wealth of information concerning the relative merits of small scale improvements.

As I expressed at the December meeting, I believe it is of the greatest importance to further explain the rationale for eliminating alternatives. A more detailed quantitative analysis of the cost and expected capacity increase for each alternative would help. Given the controversy associated with lock capacity improvements, the existing document does not totally convince the reader that an alternative is either a winner or loser. A more comprehensive approach would include the cost for each one percent increase in lock capacity for each alternative. I appreciate the complexity of doing an expanded analysis because of the uniqueness of lock sites, but believe it would be worth the additional effort and cost.

It is my understanding that in addition to the nine alternatives identified on page VIII-2 of the Sverdrup Report, additional study will be given to the following alternatives:

- Bow Thrusters
- Barge Stacking for Backhauls
- Publish Locking Times by User
- Self-Cleaning Trash Racks (site specific)
- Mechanical Ice Cutting Devices (site specific)

We look forward to continued participation in this very important study.

Sincerely,

Jim Hall
Director's Staff

cc: Professor Lowell Greimann

Orgulf

Orgulf Transport Co.
2202 Union Road
St. Louis, MO 63125
(314) 638-5279

Jan. 6, 1995

Mr. Paul Kosterman
U.S.C.O.E., St. Paul District
190 Fifth St. East
St. Paul, MN 55101-1638

Mr. Paul Kosterman:

Having reviewed the draft copy of Small Scale Improvements Study, Upper Mississippi Navigation Study for the Army Corps of Engineers, I would like to submit the following comments. First, the draft is very informative and the report is the results of a thorough investigation into improvements that could result in making the Upper Mississippi River system a more productive waterway. This, in turn, would help to stimulate the national economy, thus impacting the populous outside the midwest region. This report helps to identify areas that could help to stimulate safe efficient transportion while co-exsisting with recreational and environmental interest.

Now it is time to move into the next phase. For favorable results, there needs to be some action taken. Steps have been taken that have brought improvement ideas to the forefront and should be acted on. I sincerely hope that this report is only the beginning. Ideas have now been identified that would work to better the use of this "Great Waterway", may we move forward to implementation them.

Sincerely,

Buddy G. Compton

Captain Buddy G. Compton
Port Captain, Orgulf Transport Company

cc: Dave Diestelkamp
R.I.A.C.
I.R.C.A.

bcc: Scott Noble

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Rock Island Field Office (ES)
4469 - 48th Avenue Court
Rock Island, Illinois 61201

COM: 309/793-5800
FAX: 309/793-5804

IN REPLY REFER TO:

January 11, 1995

District Engineer
U.S. Army Engineer-St. Paul District
190 Fifth Street East
St. Paul, Minnesota 55101-1638

Attn: Mr. Paul Kosterman

Dear Mr. Kosterman:

Enclosed are our comments on the final draft of the "Small Scale Improvements" Report on the Upper Mississippi River Navigation Study. The purpose of the report is to identify small scale improvement measures of reducing delays associated with passing traffic through lock facilities on the Upper Mississippi River and Illinois Waterway, and to recommend measures with potential for further study.

The proposed improvements beginning with 4 a "Remove/Adjust Bends, One-Way Reaches, Bridges and ending with 4h "Dual Channel at Restrictive Bridges" were all given a ranking of 4 and therefore not considered for further study. Two proposed measures, 4c and 4d, were given negative ranks environmentally and this is not entirely true. In many cases the current policies and strategies pertaining to dredging and water flow management have negative effects on the natural resources. To say that new strategies and policies pertaining to dredging and water flow management will have negative environmental impacts may be premature. We offer the following comments on specific proposals from the contractors report.

4c. Innovative Dredging Strategies- We would like to see this proposal evaluated further. Although there are negative impacts to the environment through dredging positive points could be found with innovative dredging techniques. If new techniques were found to improve the present dredging strategies, positive effects could be noticed both environmentally and for navigation.

4d. Water Flow Management Policies- The water flow management discussed in this section focuses on the maintenance of the navigation channel at the cost of the natural flow of the river. Changing the water flow management could positively impact the aquatic environment of the river. Policies that provide natural flow in side channels, create riffles, and generally enhance the aquatic habitat for fisheries could be found with different water flow management. This management may also aid in navigation.

5e. Traffic Management- We strongly recommend further study of waterway traffic management in the small scale improvements study. Waterway traffic management has the potential to reduce waiting times, decrease environmental impacts including the risk of accidental spills, and increase safety. The technology for Vehicle Traffic System already exists and is used effectively in coastal harbors. It has been pointed out that the Corps of Engineers does not have the authority or resources to use VTS on a systemwide basis and it may not be feasible. The alternative of using a personal computer program at a lock to manage traffic locally and in conjunction with nearby locks may serve as a substitute for a systemwide VTS. The advantages to the industry and the natural resources make this proposed measure favorable for further study. We would like to see it included with the further study of a scheduling program.

If there are any questions, please contact Mr. Jon Duyvejonck or Scott Estergard of my staff. We appreciate the opportunity to provide comment on this report and look forward to working with you on future projects.

Sincerely,

Wayne A. Fischer

fa Richard C. Nelson
Field Supervisor

SE:sjg