US Army Corps
of Engineers
St. Paul District
Rock Island District
Saint Louis District

Engineering Objective 1 Report

Part 1

UPPER MISSISSIPPI RIVER AND ILLINOIS WATERWAY NAVIGATION STUDY

November 1995

UMR - IWW NAVIGATION STUDY
ENGINEERING OBJECTIVE 1
BASELINE WITHOUT-PROJECT CONDITION
EXECUTIVE SUMMARY

OVERVIEW:

The Navigation Study is a feasibility study of the Upper Mississippi Rivers and Illinois Waterways (UMR - IWW) navigation systems. The objective is to identify and justify investment requirements on the UMR - IWW navigation systems during the years 2000 to 2050.

The Engineering Plan is based on five objectives. Objective 1 defines the baseline without-project condition e.g. continuing operation and maintenance consistent with recent trends and experience. The Objective 1 investments defined herein must be combined with Objective 2 investments to completely define the without-project condition. Thirty seven lock sites and approximately 1250 miles of waterway are included, broken down by Reaches:

REACH 1: Mississippi River, Saint Anthony Falls L/D to L/D 10
REACH 2: Mississippi River, L/D 11 to L/D 22
REACH 3: Mississippi River, L/D 24 to confluence with Ohio River
REACH 4: Illinois WW, O'Brien L/D to confluence with Mississippi River

SUMMARY:

The system's locks and dams were constructed mainly during the 1930's. They are currently undergoing a $600 million major rehabilitation program, the first in 50 years of service. The facilities conditions, if maintained consistent with current policies and funding limitations, will gradually wear and depreciate with time.

Factors such as increased dredging costs, future restrictions on painting, zebra mussels, and increased traffic were considered but not included in the baseline estimate. These factors are expected to add 10% to the baseline estimate over the study period.

CONCLUSION:

The baseline cost of operation from year 2000 to 2050 (in year 2000 dollars) is projected as follows:

REACH	ANNUAL COST	PRESENT WORTH OF ANNUAL COST 50 YEAR PERIOD (7 3/4% interest)
1	$30,000,000	$377,830,000
2	$35,000,000	$440,800,000
3	$30,000,000	$377,830,000
4	$20,000,000	$251,886,000
TOTALS	$115,000,000	$1,448,346,000

UPPER MISSISSIPPI RIVER AND ILLINOIS WATERWAY

NAVIGATION STUDY

ENGINEERING OBJECTIVE 1 REPORT

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PART I

UPPER MISSISSIPPI RIVER AND ILLINOIS WATERWAY
NAVIGATION STUDY
SECTION A

OVERVIEW OF NAVIGATION STUDY

The Navigation Study is an inter-District effort with participation by U.S. Army Corps of Engineer Rock Island, Saint Paul, and Saint Louis Districts. The primary purpose of the study is to forecast investments on the Upper Mississippi River and Illinois Waterway navigation systems for the years 2000 to 2050. Thirty-Seven lock sites and approximately 1250 miles of waterway are included in this navigation system.

In September 1992, an Initial Project Management Plan or IPMP was produced by Rock Island, Saint Paul, and Saint Louis Districts. The IPMP forms the basis of the work required on the Navigation Study. The engineering effort has been broken down into five primary objectives. This report focuses on Objective 1 - "Baseline Without Project Condition".

Salient features from the IPMP have been included in this overview and follow. The IPMP outlines the scope of work required for each objective of the Navigation Study and provides a budget and schedule.

UPPER MISSISSIPPI RIVER AND ILLINOIS WATERWAY NAVIGATION STUDY

SYLLABUS AND SUMMARY FROM THE IPMP

The Upper Mississippi River-Illinois Waterway System Navigation (Feasibility) Study is needed to address capital investment planning for the Upper Mississippi River-Illinois Waterway System (UMR-IWWS) for the years 2000-2050. This study will establish a prioritization schedule for evaluating sites where improvements are needed, leading to a "System" Congressional Authorization for construction while also maintaining the social and environmental qualities of the river system. The system navigation feasibility study will be accomplished by executing the Initial Project Management Plan (IPMP) outlined herein. The IPMP outlines several Investment Levels for Engineering, Economics, Environmental, and Public Involvement Plans associated with improvements and additions to the system. It also recommends an appropriate level for each of these disciplines.

The Engineering Plan is based on five objectives:

(1) Baseline Without-Project Condition (maintaining the current system);
(2) Future Without-Project Condition (maintaining and enhancing current capacities);
(3) Future With-Project Small-Scale Enhancements (small-scale additions to capacity);
(4) Future With-Project Large-Scale Enhancements (large-scale additions to capacity).
(5) General Navigation Modeling (to allow for evaluation of small and large scale alternatives)

The Economic Plan analyzes the beneficial contributions to National Economic Development (NED) associated with the UMR-IWWS. It reviews the criteria of the cost savings of waterway transportation; the costs of delays at locks; recreational and fleeting analyses; the potential for accidents and hazardous spills; unemployment benefits; and emissions and fuel use.

The Environmental Plan identifies environmental analyses and coordination. It addresses the project in terms of the environmental statutes, applicable executive orders, regulations, and other Federal planning requirements with which the Corps must comply. It reviews environmental resources on the UMR-IWW; threatened and endangered species; water quality; recreational resources; fisheries; mussels and other macroninvertebrates;

waterfowl; aquatic and terrestrial macrophytes; and historic properties. It considers system-wide impacts of capacity increases, while also assessing in preliminary fashion potential construction effects of improvement projects.

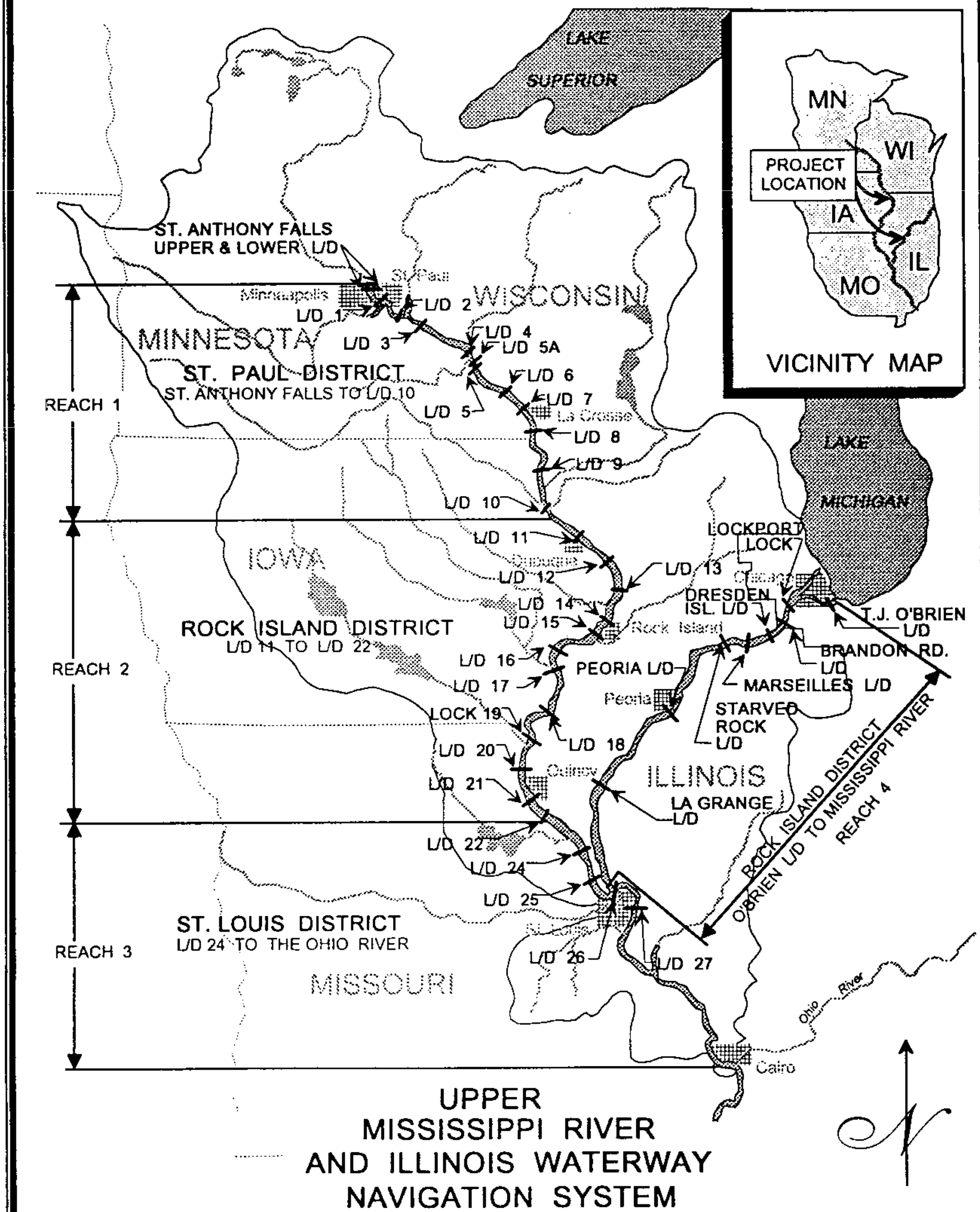
The Public Involvement Plan identifies ways to educate and listen to the public and includes the public in decision-making.

DESCRIPTION OF THE STUDY AREA

The study area comprises an entire navigation system and a portion of another; the Illinois Waterway and the Mississippi River, respectively. For the purpose of investigating potential capital improvements to expand navigation capacity on the system, the study area is defined as the entire Illinois Waterway from the confluence with the Mississippi River at Grafton, Illinois, River Mile 0.0, to T.J. O'Brien Lock in Chicago, Illinois, River Mile 327.0, and the segment of the Mississippi River from the confluence with the Ohio River, River Mile 0.0, to Upper St. Anthony Falls Lock in Minneapolis-St. Paul, Minnesota, River Mile 854.0. Its combined area includes approximately 1,250 miles of navigable waterway and a total drainage area of 697,000 square miles. The study area is highlighted in Figure 1-1.

The total Illinois and Mississippi River navigation system contains 37 lock sites and over 360 terminals. The system provides: (1) shippers a means for transporting an annual average of 137 million tons of commodities (1990 statistics) on the inland system, (2) food and habitat for at least 485 species of birds, mammals, amphibians, reptiles, and fish (including many endangered or threatened); (3) over 226,650 acres of national wildlife and fish refuge; (4) water supply for hundreds of cities, communities, farmers, and industries; (5) thousands of user days each year for recreation and boating enthusiasts, and (6) remarkable cultural evidence of our nation's past.

FIGURE 1 - 1



Illustrative Project Location Map – NOT TO SCALE

PURPOSE OF ENGINEERING OBJECTIVE 1

The following excerpt from the IPMP states the basic purpose of Objective 1:

"Objective 1 establishes the baseline for determination of the without-project condition for the Upper Mississippi River Navigation system. This objective establishes past policies, practices, and historical trends in the Operation and Maintenance (O & M) budget and provides a projection of future O & M investments to keep the existing system operational through the study period. The future O & M baseline condition will be based on current O & M funding policies which reflect no significant increases beyond recent levels. These recent levels of O & M baseline funding dictate that the Upper Mississippi River-Illinois Waterway Navigation system will continue to deteriorate and degrade. Historical experience is that diminishing system conditions will result in unacceptable performance levels and Objective 2 investments will be warranted to restore the system".

Objective 1 forecasts future (year 2000 to 2050) Operation and Maintenance (O & M) investments for the Upper Mississippi River and Illinois Waterway Locks and Dams. The years 2000 to 2050 correspond to the study period for the Navigation Study. The investment schedule excludes future rehabilitations of locks and dams and assumes continuance of current O & M funding limitations. The main tool for forecasting O & M investments is past historical cost data for each site and the projection of this information into the future. Objective 1 is also intended to collect historical data in support of Objective 2's analysis. This data is presented to be used as necessary.

The navigation system is divided into four separate "Reaches":

Reach 1: 13 total locks - Saint Anthony Falls to Lock 10 including the Mississippi River between these locks.

Reach 2: 12 lock sites - Lock 11 to Lock 22 including the Mississippi River between these locks.

Reach 3: 4 locks - Locks 24, 25, 26 (Mel Price), and 27 including the Mississippi River between these locks. Reach 3 also includes the Mississippi River to the confluence with the Ohio

River.

Reach 4: 8 locks on the Illinois Waterway including the Illinois River between these locks and to the confluence with the Mississippi River.

REPORT ORGANIZATION AND CONTENT

PART 1

Part 1 (a single volume) provides the overview, scope, and summary for the entire Objective. The primary result of Objective 1, analyzing and projecting cost data, is included. Part 1 assesses past historical maintenance practices for each Reach. The factors affecting future O & M costs are discussed. An inventory of the lock sites lists vital statistics for each lock and dam within the navigation system. This includes the location and the size of the lock structure. Part 1 also includes a component ranking list. Components at each lock and dam site were evaluated and assigned a ranking based on their current condition.

PARTS 2 AND 3

Parts 2 and 3 of Objective 1 provide a framework for collecting and organizing historical cost and maintenance data. Four separate volumes of Part 2 are provided corresponding to the number of Reaches. Similarly, four separate volumes of Part 3 (Appendices of more detailed information) are provided, one per Reach.

Part 2 presents detailed cost data, lockage data, contracts, major repairs, towboat accidents, and mean head curves for each Reach. The historical cost data section collects expenditure data for lock and dam operations, dredging, major rehab, maintenance work by Government, engineering, and contracts/miscellaneous. Recreation costs have been broken out for Reaches 2 and 4. Past historical lockage data includes the number of lockages and the percentage that is recreational traffic. Maintenance and repair data for each lock site is collected.

The Appendix, Part 3, provides periodic inspection report summaries, dredging report summaries, raw data for tow boat accidents, raw data for the lockages at each site, and technical design data for each lock site. The dredging report summaries date back to 1979 for Reach 1, 1941 for Reach 2, and 1940 for Reach 4. No data is available for Reach 3. These report summaries include dredging and channel maintenance costs and dredging quantities. The periodic inspection summaries include a brief synopsis of each periodic inspection.

UPPER MISSISSIPPI RIVER AND ILLINOIS WATERWAY

NAVIGATION STUDY - OBJECTIVE 1

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SECTION C

UPPER MISSISSIPPI RIVER AND ILLINOIS WATERWAY
NAVIGATION STUDY - OBJECTIVE 1
SUMMARY - SECTION C

ABSTRACT

The primary goal of Objective 1 is collecting, analyzing, and projecting historical cost data for the Upper Mississippi River and Illinois Waterway systems. The study period for the Navigation Study includes the years 2000 through 2050. Objective 1 establishes the baseline for determination of the without-project condition for the Upper Mississippi River and Illinois Waterway Navigation system. The baseline condition excludes any future rehabilitation or replacement of locks and dams.

The baseline estimate is established by assuming current maintenance practices, policies, and funding limitations will continue through the study period. The maintenance practices and funding limitations for each Reach are discussed. Additional factors that could cause increased maintenance and operational costs such as increased traffic, painting regulations, increased wear and aging of equipment and components, zebra mussels, and dredging costs are analyzed and investigated, but not included in baseline cost.

The baseline estimate for the system is $115,000,000 per year in year 2000 dollars. This figure is based on historical cost data from fiscal years 1981 through 1992. Fiscal year 1981 was the first year used since no cost data was available for Reaches 2 and 4 prior to this.

The system's locks and dams were mainly constructed in the 1930's and are currently undergoing a major rehabilitation. Over the study period, without an influx of funding above the baseline condition, the lock and dam navigation system will degrade and deteriorate. Eventually, a Major Maintenance and Rehabilitation effort or replacement of locks and dams will become necessary.

DISCUSSION OF HISTORICAL COST DATA FOR THE LOCK AND DAMS SYSTEMS BY REACH

GENERAL

1. Baseline Estimate. The projected baseline estimate for the navigation system is $115,000,000 per year (year 2000 dollars). This figure is the summation of the baseline costs for each Reach through the study period (year 2000 to year 2050). This translates to a present worth cost (year 2000 dollars, 7 3/4% interest) of $1,448,346,000. For all four Reaches, projection of cost data assumed no changes to recent historical trends and constant operation and maintenance (O & M) funding. Any potential cost impacts (discussed below) and major rehabilitation costs were **excluded from the baseline estimate.** The Objective 2 analysis will determine future major maintenance and rehabilitation costs.

2. Potential Cost Impacts to Baseline Estimate. The baseline estimate, by definition, is to reflect current operation and maintenance funding policies. However, certain factors could affect the baseline estimate during the study period. These potential cost impacts are discussed in SECTION C: FACTORS AFFECTING FUTURE MAINTENANCE COSTS starting on page C-25. **It is expected that potential future cost impacts will add an additional 10% to the baseline estimate over the study period. Other aspects of O & M will need to be reduced to maintain the baseline estimate during the study period.** This will affect the overall system reliability by increasing the rate of deterioration. These issues are further addressed in Engineering Objective 2. The potential cost impacts to the baseline estimate include (1) channel maintenance and dredging, (2) zebra mussels, (3) future painting regulations and lead abatement, and (4) traffic increases. Of all these items, channel maintenance and dredging costs will likely have the most impact on future operation and maintenance costs. Channel maintenance accounts for approximately 25% of the cost of the system. It is estimated a 20% increase in cost will occur after the year 2025 which means a 5% increase above the baseline estimate.

3. Zebra Mussels and Painting. The additional O & M costs for dealing with and controlling zebra mussels is expected to have some impact on the baseline cost, especially during the beginning of the study period. A 2% cost increase to the baseline estimate is anticipated. Painting costs primarily fall under the maintenance cost feature. This feature accounts for approximately 20% of cost

of the system. If a 10% increase is estimated for this cost feature, the baseline estimate will be increased by 2%. Painting costs will be "greatly" impacted only if vinyl paint is banned. This is not anticipated during the study period.

4. Increased Navigation Traffic and MMMR. Traffic increases at the locks and dams are not expected to significantly increase O & M costs over the study period. A 1% increase to the baseline estimate is anticipated. The reliability of the locks may degrade because of the increased traffic levels, however. This reliability analysis is part of Engineering Objective 2. By the year 2000, Locks 22, 24, and 25 are expected to reach 100% of capacity. By the year 2020, Locks 14, 15, 16, 17, 18, 20, and 21 are also expected to reach full capacity. Although major maintenance and rehabilitation costs are not included in the baseline estimate, this work will have an effect on O & M costs. The completion of the MMMR program will have the effect of increasing the reliability and slowing the deterioration of the locks and dams. This analysis is part of Engineering Objective 2. The locks within Reaches 1, 2, 3 and 4 are currently undergoing major maintenance and rehabilitation. This work will be completed by the year 2000 (the start of the study period).

5. Presentation of Cost Data. A slight difference in the presentation of cost data exists between the four reaches. For Reach 1, cost data has been compiled for operations, maintenance, engineering, contracts, major rehabilitation, and dredging features. Major rehabilitation costs were itemized so they could be easily identified and excluded from the baseline estimate. For Reaches 2, 3, and 4, engineering costs have been lumped together with operations and maintenance cost features and are not presented separately. Also, for Reaches 2, 3, and 4, a miscellaneous cost feature has been grouped with the contract cost feature. Painting costs for dam gates and miter gates are included with either the maintenance cost feature, contract feature, or MMMR feature. No Reach 2 and Reach 4 cost data was available for fiscal years 1977, 1978, 1979, and 1980. Because this data was not available, the baseline estimate for the system is based on cost data from 1981 to 1992.

6. Lock 26. Although cost data for the new Melvin Price lock and dam is not included in this report, data for the old Lock 26 is included. Costs were projected into the future based on the old Lock 26 data. The yearly operation and maintenance costs between the old Lock 26 and Melvin Price are not significantly different. Melvin Price Locks and Dam replaced the old Lock 26 in 1990.

7. Cost Data. The costs for the individual locks within a reach have been combined to form a single cost per Reach. For example, the operations feature for Reach 1 combines all the operations cost for the 13 lock sites. This data is then presented as the operation cost for Reach 1. The project cost is the summation of the

operations, maintenance, contracts/miscellaneous, engineering, and dredging features. Major rehabilitation costs were excluded. The following is a summary of the project costs for the last several years after converting to FY 1993 (constant) dollars:

FISCAL	PROJECT COST IN FY 93 DOLLARS (MMMR NOT INCLUDED)				
YEAR	REACH 1	REACH2	REACH 3	REACH 4	Sum
1993		$29,317,000		$15,246,000	
1992	$24,624,865	$29,838,171	$18,094,960	$16,975,415	
1991	$22,620,249	$30,816,473	$20,229,486	$17,070,377	
1990	$21,317,399	$25,627,517	$27,335,669	$14,500,709	= 88,780
1989	$18,871,050	$26,320,375	$32,526,086	$14,576,851	
1988	$23,008,385	$26,330,101	$22,837,697	$16,525,201	

FISCAL	TOTAL COST PER LOCKAGE IN FY 93 DOLLARS			
YEAR	REACH 1	REACH2	REACH 3	REACH 4
1992	$380	$413	$487	$396
1991	$349	$429	$590	$409
1990	$308	$332	$735	$345
1989	$276	$365	$808	$322
1988	$337	$362	$544	$388

FISCAL	TOTAL COST PER 1000 TONS CARGO IN FY 93 DOLLARS			
YEAR	REACH 1	REACH2	REACH 3	REACH 4
1992	$158	$ 79	$77	$ 101
1991	$154	$ 86	$88	$ 101
1990	$126	$ 63	$109	$ 82
1989	$136	$ 77	$150	$ 94
1988	$168	$ 76	$101	$ 105

8. Cost Index System. The cost data collected for each Reach was converted into 1993 and year 2000 dollars. This was done using the Civil Works Construction Cost Index System (CWCCIS), dated September 1993. Projection of costs from the years 2000 to 2050 were based on recent historical trends after converting to constant year dollars (year 2000). See Figure 1 for a plot of this data. The following is a table of index factors used to convert fiscal year cost data to constant dollars (either 1993 or 2000):

COST INDEX FACTORS

YEAR	fy77	fy78	fy79	fy80	fy81	fy82	fy83	fy84
1993	1.96	1.79	1.65	1.51	1.39	1.29	1.25	1.22
2000	2.48	2.27	2.09	1.92	1.76	1.64	1.59	1.54

COST INDEX FACTORS

YEAR	fy85	fy86	fy87	fy88	fy89	fy90	fy91	fy92
1993	1.20	1.19	1.17	1.13	1.09	1.07	1.05	1.03
2000	1.52	1.51	1.49	1.43	1.38	1.36	1.33	1.31

9. Operations. The Operations feature includes labor charges for the lock and dam personnel, administration costs for the area lockmasters, utility costs at the lock sites, and equipment replacement.

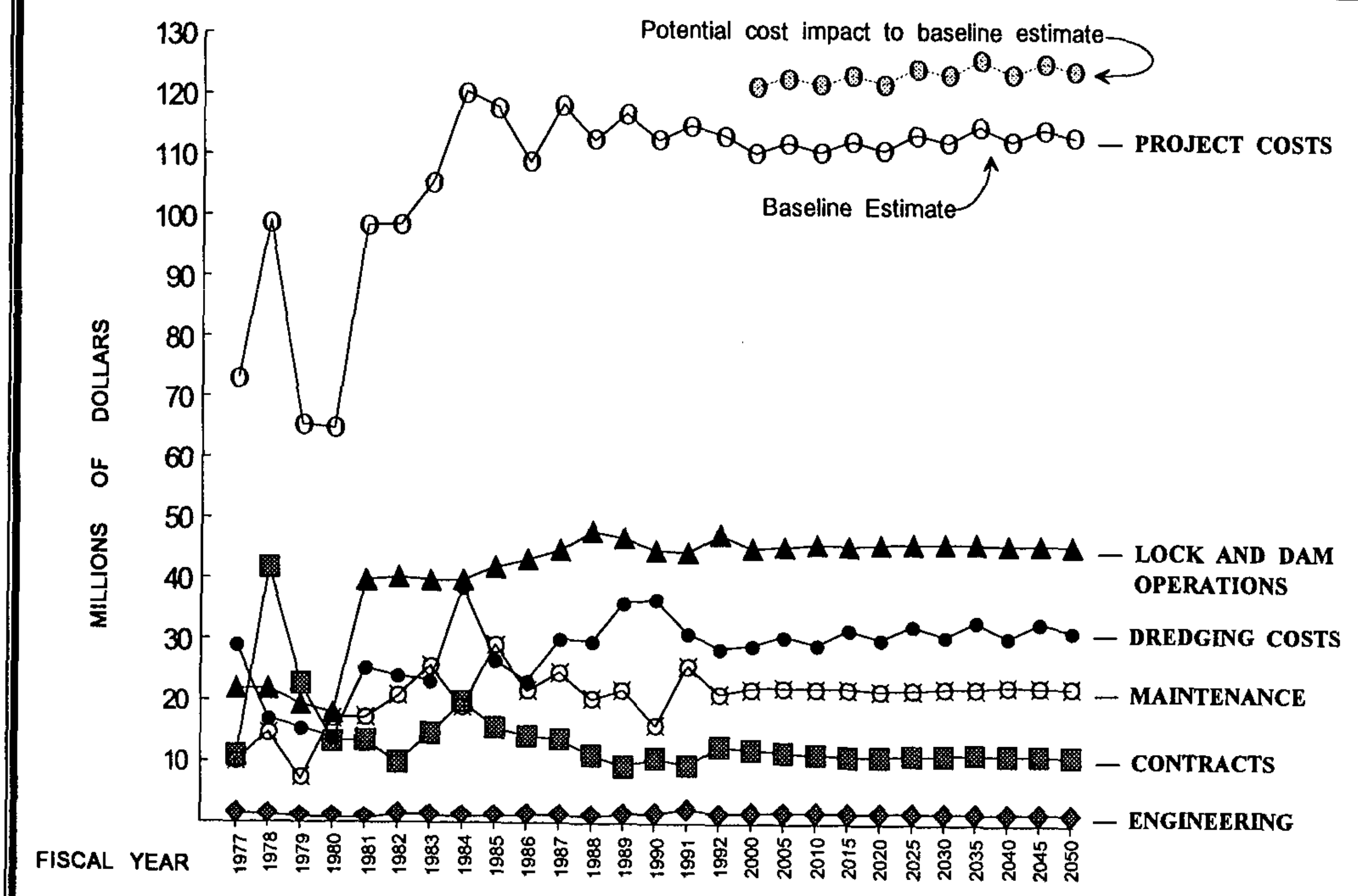
10. Engineering. The Engineering cost feature includes AE contracts but does not include any engineering associated with major maintenance and rehabilitation. As stated, for Reaches 2, 3, and 4, this cost data was put into the operations and maintenance categories.

11. Contracts. The Contracts and miscellaneous feature does not include any major rehab contracts, AE contracts, or dredging contracts. Typical items that would fall under this cost feature include aerial photography and mapping, routine contracts for sandblasting and painting gates (not part of MMMR), and general maintenance contracts at the locks and dams.

12. Maintenance. The maintenance category pertains to Government maintenance of the locks and dams. This work includes painting gates on the dam, miter gate repair, miter gate and tainter valve machinery repair, gate chain replacement, dewatering work, etc. For Reach 1, this is primarily the work of the Rivers and Harbors division based in Fountain City, Wisconsin. For Reach 2, this is the work of the Structural Maintenance, Project Maintenance, and Channel Maintenance crews.

13. Channel Maintenance. This cost feature includes all the channel maintenance work. This includes the dredging of the channel (both contract and Government), channel improvement work, hydrographic surveys, engineering pertaining to dredging, and administration.

UMR AND IWW NAVIGATION SYSTEM
HISTORICAL AND PROJECTED COSTS – FY 2000 DOLLARS



NOTE: Costs for FY 1977 to 1980 include reaches 1 & 3 only

FIGURE 1

UPPER MISSISSIPPI RIVER AND ILLINOIS WATERWAY
NAVIGATION STUDY – TOTAL SYSTEM COSTS – SHEET 1

ITEMIZATION OF COSTS – MISSISSIPPI RIVER PROJECT & ILLINOIS WATERWAY

NAVIGATION STUDY:
Itemized Mississippi River & IWW Costs
FROM FY 77 THROUGH FY 92

FY 2000 DOLLARS FY 77 – FY 84

FISCAL YEARS

	1977	1978	1979	1980	1981	1982	1983	1984
Itemized Costs:								
a) L & D OPERATIONS/RECREATION	$21,986,595	$21,921,097	$19,412,082	$17,919,010	$39,773,950	$40,165,781	$39,687,994	$39,786,346
b) ENGINEERING (ONLY REACH 1)	$1,485,631	$1,221,484	$764,699	$768,800	$613,873	$1,396,779	$1,197,571	$937,980
c) CONTRACTS/MISCELLANEOUS	$10,937,277	$41,736,515	$22,763,341	$13,245,377	$13,448,522	$9,865,850	$14,575,734	$19,911,869
d) MAINTENANCE	$10,006,180	$14,728,215	$7,156,797	$17,145,036	$17,278,322	$20,797,230	$25,725,374	$18,912,016
e) DREDGING/CHANNEL MAINTENANCE	$28,974,738	$17,041,985	$15,489,828	$13,854,929	$25,427,009	$24,093,230	$23,278,895	$38,700,683
PROJECT COST	$73,303,568	$99,068,588	$65,498,180	$64,799,603	$98,388,448	$98,619,481	$105,537,165	$120,427,089

NOTE THAT COSTS FOR FISCAL YEARS 1977–1980 INCLUDE ONLY REACHES 1 & 3

UPPER MISSISSIPPI RIVER AND ILLINOIS WATERWAY
NAVIGATION STUDY – TOTAL SYSTEM COSTS – SHEET 2

ITEMIZATION OF COSTS – MISSISSIPPI RIVER PROJECT & ILLINOIS WATERWAY

NAVIGATION STUDY:
Itemized Mississippi River & IWW Costs
FROM FY 77 THROUGH FY 92

FY 2000 DOLLARS FY 85 – FY 92

FISCAL YEARS

	1985	1986	1987	1988	1989	1990	1991	1992
Itemized Costs:								
a) L & D OPERATIONS/RECREATION	$41,896,223	$43,206,477	$44,807,778	$47,887,686	$46,843,735	$44,816,988	$44,492,794	$47,513,503
b) ENGINEERING (ONLY REACH 1)	$1,071,822	$1,311,420	$1,234,008	$1,114,540	$1,481,770	$1,685,924	$2,336,829	$1,576,020
c) CONTRACTS/MISCELLANEOUS	$15,589,353	$14,161,550	$13,696,705	$11,113,546	$9,357,285	$10,691,273	$9,557,191	$12,573,323
d) MAINTENANCE	$29,137,060	$21,596,758	$24,714,160	$20,308,142	$21,930,209	$16,081,236	$25,838,441	$21,313,859
e) DREDGING/CHANNEL MAINTENANCE	$26,574,186	$23,271,068	$30,150,904	$29,797,618	$36,203,206	$36,802,207	$31,239,901	$28,769,198
PROJECT COST	$117,895,531	$108,837,139	$118,377,648	$112,588,580	$116,996,427	$112,635,460	$115,129,070	$113,588,460

DISCUSSION OF HISTORICAL COST DATA FOR THE LOCK AND DAM SYSTEMS BY REACH

REACH 1

14. Baseline Estimate. The baseline estimate for Reach 1 is $30 million dollars (year 2000 dollars). Reach 1 includes the Saint Anthony Falls Locks to Lock 10 and the Mississippi River between these locks. The projection from years 2000 through 2050 of expenditures for the Operations, Contracts, Engineering, and Maintenance features assumed no significant changes to recent historical trends and constant O & M funding. Major maintenance costs and any potential (future) cost impacts were excluded from the baseline estimate. Dredging and channel maintenance costs show the most fluctuation from year to year of the cost features that were investigated.

15. Cost Data Summary. The summary of cost data for Reach 1 is presented in Tables 1 and 2. Table 1 presents the cost data in FY 1993 dollars and Table 2 FY 2000 dollars. Figure 2 shows the projection of costs from the year 2000 through 2050.

16. Operations Cost. After conversion to constant dollars, the yearly expenditures for the Operations cost category showed little variance. This was the most stable cost category. This trend was extended into the future. The Operations feature for Reach 1 includes the costs to operate the locks and dams, utilities, administration and overhead, and equipment replacement.

17. Engineering Cost. The Engineering cost feature includes AE contracts but does not include any engineering associated with major maintenance and rehabilitation. This cost feature also shows little variance on a year to year basis when converted to constant dollars and this trend was assumed to continue into the future.

18. Contracts. The Contracts feature does not include major rehab contracts, AE contracts, or dredging contracts. This cost feature did fluctuate considerably on a year to year basis. When the costs for this feature were projected, it was assumed that this fluctuating pattern would continue but no significant cost increase would occur. Most of the items that are currently included in the contract feature cost will continue to be needed in the future, such as general maintenance contracts. This cost feature also includes general painting contracts for dam gates.

19. Maintenance. The maintenance category pertains to Government maintenance of the locks and dams. For Reach 1, this is primarily the work of the Rivers and Harbors unit based in Fountain City, Wisconsin. This work includes painting gates on the dam, miter gate repair and painting, miter gate and tainter valve machinery repair,

gate chain replacement, dewatering work, etc. When converted to constant dollars, this cost feature also varied from year to year. Any potential items that could lead to an increase in future costs (above the current trends) were not included. For the maintenance category, this could include increased painting costs because of lead abatement procedures and vinyl paint restrictions. Also, since the lock and dam structures will continue to age, more maintenance may be required in the future. This issue is further addressed in Engineering Objective 2.

20. Channel Maintenance. Dredging costs are discussed in SECTION C: FACTORS AFFECTING FUTURE MAINTENANCE COSTS. Dredging costs vary from year to year because the quantity of material dredged varies significantly. Several factors such as disposal costs and environmental regulations have the potential for increasing the per unit dredging costs. These factors were not included in the projected baseline estimate.

21. Major Rehabilitation. The locks and dams within Reach 1 are currently undergoing major maintenance and rehabilitation (MMMR). Since 1987, MMMR costs have been the largest expenditure within Reach 1. The MMMR program will be nearly completed by the year 2000, the start of the study period. Major rehabilitation includes new machinery for both the locks and dams, new electrical distribution at the locks and dams, new controls for the locks and dams, concrete restoration, and new control buildings at the locks. The MMMR program has the potential for reducing the operation and maintenance expenditures within Reach 1 by increasing the reliability of the system. This issue is further addressed in Engineering Objective 2. The cost data retrieved dates back to 1977, which is also the time the MMMR program was being formulated. Thus, cost data for an extended period of time when the MMMR program was non-existent is not available. Increased navigation traffic and further aging of the lock and dam structures could offset the gains from the MMMR program. However, in Reach 1, traffic levels appear to be leveling off. It was assumed in the projection of costs for Contracts, Maintenance, Engineering, and Operations categories that the MMMR program will have no effect on changing the recent historical cost trends.

PROJECTED REACH 1 COSTS

FY 2000 DOLLARS – PROJECTION OF COSTS FROM 2000 TO 2050

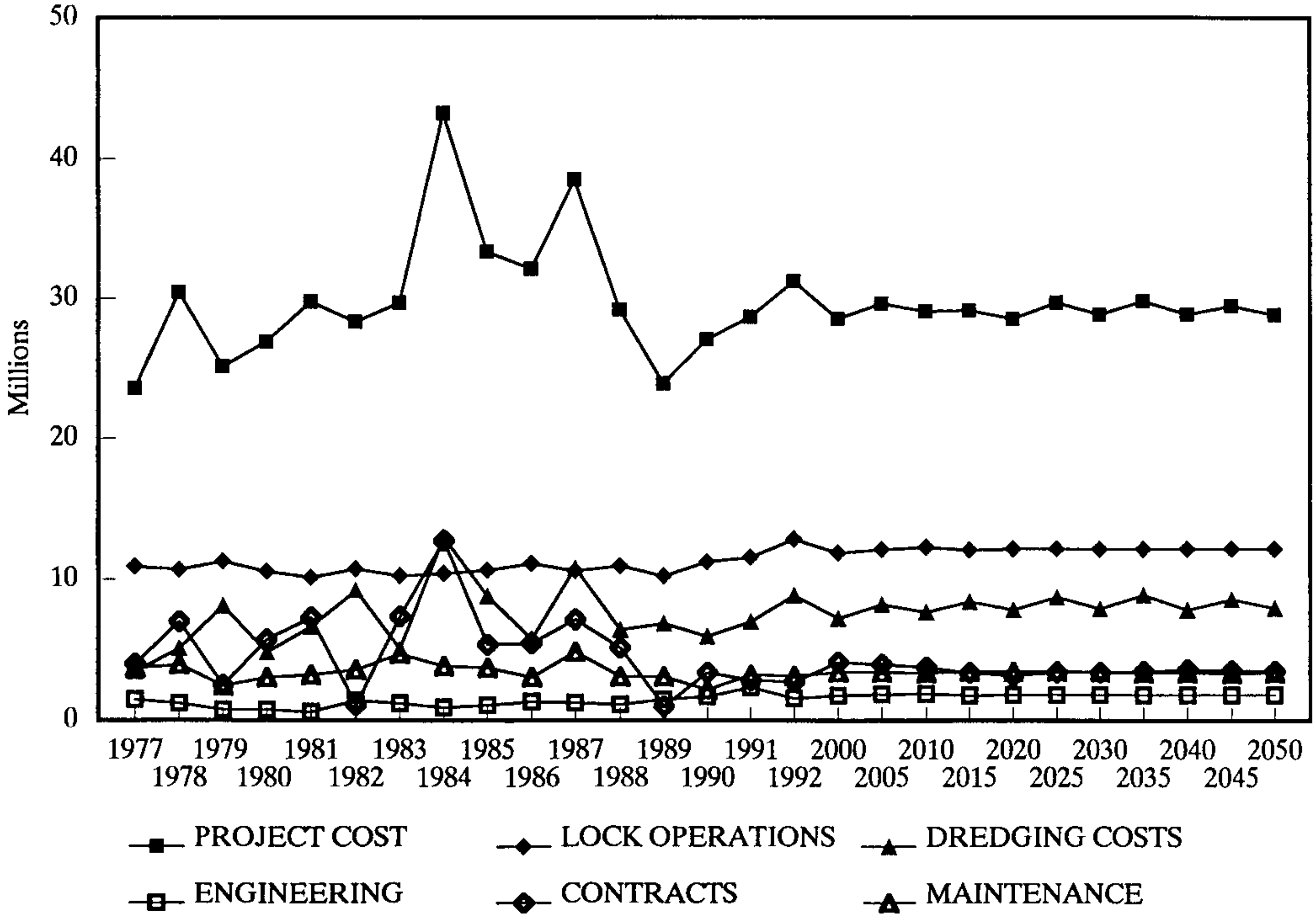


FIGURE 2

UPPER MISSISSIPPI RIVER AND ILLINOIS WATERWAY

REACH 1

NAVIGATION STUDY – TABLE 1 – SHEET 1 OF 2

ITEMIZATION OF COSTS – MISSISSIPPI RIVER PROJECT
UPPER SAINT ANTHONY FALLS LOCK AND DAM THROUGH LOCK AND DAM 10

NAVIGATION STUDY:
Itemized Mississippi River Project Costs
FROM FY 77 THROUGH FY 92

FY 93 DOLLARS FY 77 – FY 84

FISCAL YEARS

	1977	1978	1979	1980	1981	1982	1983	1984
Itemized Costs:								
TOTAL PROJECT COST (WITH MMMR)	$19,066,063	$25,166,548	$21,151,565	$46,508,000	$29,367,125	$28,585,376	$24,884,200	$35,156,125
a) LOCK & DAM OPERATIONS/SUPPORT (includes sites USAF to Lock 10)	$8,639,743	$8,452,319	$8,932,108	$8,305,000	$8,015,338	$8,461,831	$8,084,356	$8,212,007
b) ENGINEERING (INCLUDING AE) (without any major rehab)	$1,172,709	$963,621	$604,288	$604,000	$485,371	$1,101,261	$943,701	$739,328
c) CONTRACTS (without any major rehab)	$3,191,468	$5,537,011	$1,990,408	$4,530,000	$5,764,791	$847,027	$5,821,081	$10,069,467
d) MAINTENANCE (RIVERS & HARBORS)	$2,936,595	$3,131,231	$1,956,248	$2,416,000	$2,552,154	$2,825,937	$3,712,993	$3,064,508
e) DREDGING/CHANNEL MAINTENANCE	$2,733,506	$4,037,150	$6,435,000	$3,818,639	$5,251,281	$7,274,616	$3,991,554	$10,264,432
PROJECT COST (MMMR NOT INCLUDED)	$18,605,463	$24,029,898	$19,848,065	$21,140,000	$23,529,125	$22,323,892	$23,398,118	$34,066,622
f) MAJOR REHAB AND MAINTENANCE	$460,600	$1,136,650	$1,303,500	$25,368,000	$5,838,000	$6,261,484	$1,486,083	$1,089,503

UPPER MISSISSIPPI RIVER AND ILLINOIS WATERWAY

REACH 1 — NAVIGATION STUDY – TABLE 1 – SHEET 2 OF 2

ITEMIZATION OF COSTS – MISSISSIPPI RIVER PROJECT
UPPER SAINT ANTHONY FALLS LOCK AND DAM THROUGH LOCK AND DAM 10

NAVIGATION STUDY:
Itemized Mississippi River Project Costs
FROM FY 77 THROUGH FY 92

FY 93 DOLLARS FY 85 – FY 92

FISCAL YEARS

Itemized Costs:	1985	1986	1987	1988	1989	1990	1991	1992
TOTAL PROJECT COST (WITH MMMR)	$28,214,111	$28,689,807	$42,025,405	$29,800,783	$29,414,835	$34,695,684	$38,583,499	$39,851,554
a) LOCK & DAM OPERATIONS/SUPPORT (includes sites USAF to Lock 10)	$8,394,565	$8,784,210	$8,380,048	$8,649,124	$8,093,383	$8,885,980	$9,147,725	$10,164,660
b) ENGINEERING (INCLUDING AE) (without any major rehab)	$844,657	$1,033,555	$972,601	$878,075	$1,168,916	$1,328,876	$1,841,723	$1,242,260
c) CONTRACTS (without any major rehab)	$4,258,730	$4,336,830	$5,656,619	$4,079,668	$778,304	$2,655,897	$2,258,492	$2,170,541
d) MAINTENANCE (RIVERS & HARBORS)	$2,970,328	$2,402,691	$3,838,289	$2,434,277	$2,456,085	$1,731,462	$2,527,037	$2,500,019
e) DREDGING/CHANNEL MAINTENANCE	$6,944,698	$4,588,113	$8,514,851	$5,102,393	$5,443,326	$4,699,056	$5,533,895	$6,991,933
PROJECT COST (MMMR NOT INCLUDED)	$26,271,175	$25,314,442	$30,340,529	$23,008,385	$18,871,050	$21,317,399	$22,620,249	$24,624,865
f) MAJOR REHAB AND MAINTENANCE	$1,942,936	$3,375,365	$11,684,876	$6,792,399	$10,543,785	$13,378,285	$15,963,250	$15,226,690

UPPER MISSISSIPPI RIVER AND ILLINOIS WATERWAY

REACH 1

NAVIGATION STUDY – TABLE 2 – SHEET 1 OF 2

ITEMIZATION OF COSTS – MISSISSIPPI RIVER PROJECT
UPPER SAINT ANTHONY FALLS LOCK AND DAM THROUGH LOCK AND DAM 10

NAVIGATION STUDY:
Itemized Mississippi River Project Costs
FROM FY 77 THROUGH FY 92

FY 2000 DOLLARS FY 77 – FY 84

FISCAL YEARS

	1977	1978	1979	1980	1981	1982	1983	1984
Itemized Costs:								
TOTAL PROJECT COST (WITH MMMR)	$24,153,589	$31,901,060	$26,766,343	$59,197,600	$37,142,018	$36,256,132	$31,578,429	$44,602,348
a) LOCK & DAM OPERATIONS/SUPPORT (includes sites USAF to Lock 10)	$10,945,143	$10,714,141	$11,303,177	$10,571,000	$10,137,384	$10,732,524	$10,259,171	$10,418,520
b) ENGINEERING (INCLUDING AE) (without any major rehab)	$1,485,631	$1,221,484	$764,699	$768,800	$613,873	$1,396,779	$1,197,571	$937,980
c) CONTRACTS (without any major rehab)	$4,043,069	$7,018,702	$2,518,771	$5,766,000	$7,291,010	$1,074,323	$7,387,040	$12,775,067
d) MAINTENANCE (RIVERS & HARBORS)	$3,720,187	$3,969,141	$2,475,543	$3,075,200	$3,227,832	$3,584,264	$4,711,845	$3,887,922
e) DREDGING/CHANNEL MAINTENANCE	$3,462,906	$5,117,482	$8,143,200	$4,860,546	$6,641,548	$9,226,726	$5,065,343	$13,022,419
PROJECT COST (MMMR NOT INCLUDED)	$23,570,084	$30,460,245	$25,116,823	$26,908,000	$29,758,418	$28,314,407	$29,692,567	$43,220,102
f) MAJOR REHAB AND MAINTENANCE	$583,505	$1,440,815	$1,649,520	$32,289,600	$7,383,600	$7,941,725	$1,885,862	$1,382,246

UPPER MISSISSIPPI RIVER AND ILLINOIS WATERWAY

REACH 1 — NAVIGATION STUDY – TABLE 2 – SHEET 2 OF 2

ITEMIZATION OF COSTS – MISSISSIPPI RIVER PROJECT
UPPER SAINT ANTHONY FALLS LOCK AND DAM THROUGH LOCK AND DAM 10

NAVIGATION STUDY:
Itemized Mississippi River Project Costs
FROM FY 77 THROUGH FY 92

FY 2000 DOLLARS FY 85 – FY 92

FISCAL YEARS

	1985	1986	1987	1988	1989	1990	1991	1992
Itemized Costs:								
TOTAL PROJECT COST (WITH MMMR)	$35,802,085	$36,402,896	$53,320,629	$37,826,105	$37,287,550	$44,017,881	$48,955,802	$50,558,519
a) LOCK & DAM OPERATIONS/SUPPORT (includes sites USAF to Lock 10)	$10,652,221	$11,145,794	$10,632,365	$10,978,325	$10,259,531	$11,273,506	$11,606,884	$12,895,611
b) ENGINEERING (INCLUDING AE) (without any major rehab)	$1,071,822	$1,311,420	$1,234,008	$1,114,540	$1,481,770	$1,685,924	$2,336,829	$1,576,020
c) CONTRACTS (without any major rehab)	$5,404,084	$5,502,762	$7,176,956	$5,178,318	$986,613	$3,369,495	$2,865,636	$2,753,702
d) MAINTENANCE (RIVERS & HARBORS)	$3,769,175	$3,048,641	$4,869,912	$3,089,826	$3,113,443	$2,196,679	$3,206,374	$3,171,702
e) DREDGING/CHANNEL MAINTENANCE	$8,812,423	$5,821,601	$10,803,398	$6,476,463	$6,900,202	$5,961,620	$7,021,557	$8,870,464
PROJECT COST (MMMR NOT INCLUDED)	$33,336,612	$32,120,083	$38,495,193	$29,204,520	$23,921,780	$27,045,056	$28,701,193	$31,240,857
f) MAJOR REHAB AND MAINTENANCE	$2,465,474	$4,282,813	$14,825,436	$8,621,585	$13,365,770	$16,972,824	$20,254,610	$19,317,662

DISCUSSION OF HISTORICAL COST DATA FOR THE LOCK AND DAM SYSTEMS BY REACH

REACH 2

22. Baseline Estimate. The baseline estimate for Reach 2 is $35 million dollars. Reach 2 includes Locks 11 through 22 and the Mississippi River between these locks. Major rehabilitation and future cost impacts were excluded. No cost data was available for the years 1977, 1978, 1979, and 1980. Recreation costs are a fairly significant item and are included with the Operations feature. A miscellaneous cost feature is included with the Contract feature. Engineering costs are grouped with Operations and Maintenance features.

23. Cost Summary. The projection from years 2000 through 2050 of expenditures for the Operations, Contracts/Miscellaneous, Dredging, and Maintenance features assumed no significant changes to the recent historical trends. The baseline estimate only considered recent O & M practices. Dredging costs did not fluctuate nearly as much as the dredging costs in Reach 1. Since the late 1980's, Major Maintenance and Rehabilitation costs have been the largest expenditure. The summary of cost data for Reach 2 is presented in Tables 3 and 4. Table 3 presents cost data in FY 1993 dollars and Table 4 FY 2000 dollars. Figure 3 shows the projection of costs from the year 2000 through 2050.

24. Major Rehabilitation. For Reach 2, the MMMR program has been an anomaly (it created a mid-1980's peak) in an otherwise smooth trend in total operation and maintenance expenditures. The first cycle (each lock and dam rehabilitated once) of the MMMR program will be nearly complete by the year 2000. Major rehabilitation includes new machinery for both the locks and dams, new electrical distribution at the locks and dams, new controls for the locks and dams, concrete restoration, and new control buildings at the locks. The reliability aspects of the MMMR program is analyzed in Engineering Objective 2.

25. Navigation Traffic. Increased traffic levels are not expected to increase the baseline O & M cost within Reach 2. Traffic levels in Reach 2 are increasing at a fairly consistent rate, especially in the lower portion of the Reach. This will have the effect of increasing the aging process of the locks and dams within Reach 2. This will decrease the reliability of the particular lock site. Again, Engineering Objective 2 will address this issue. The lower locks in Reach 2, Locks 20, 21, and 22, have nearly double the lockages and tonnage when compared to Lock 11 (in the upper portion of the Reach). Lock 22 is expected to reach 100% capacity by the year 2000. Locks 20 and 21 are expected to reach 90% capacity by the year 2000.

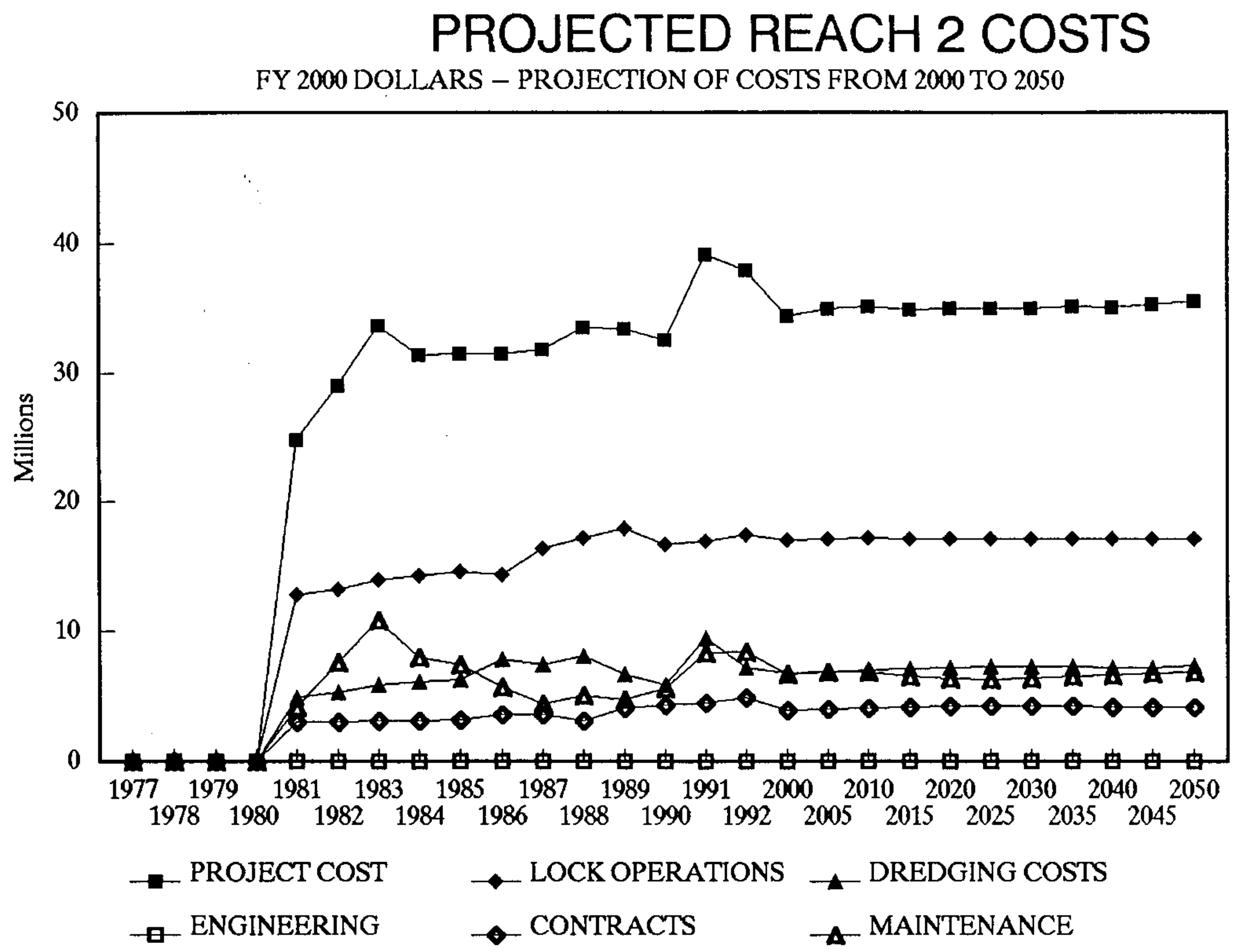

PROJECTED REACH 2 COSTS
FY 2000 DOLLARS – PROJECTION OF COSTS FROM 2000 TO 2050
Millions
0
10
20
30
40
50
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
2000
2005
2010
2015
2020
2025
2030
2035
2040
2045
2050
PROJECT COST
LOCK OPERATIONS
DREDGING COSTS
ENGINEERING
CONTRACTS
MAINTENANCE

FIGURE 3

UPPER MISSISSIPPI RIVER AND ILLINOIS WATERWAY

REACH 2

NAVIGATION STUDY – TABLE 3 – SHEET 1 OF 2

ITEMIZATION OF COSTS – MISSISSIPPI RIVER PROJECT
LOCK AND DAM 11 THROUGH LOCK AND DAM 22

NAVIGATION STUDY:
Itemized Mississippi River Project Costs
FROM FY 77 THROUGH FY 92

FY 93 DOLLARS FY 77 – FY 84

FISCAL YEARS

Itemized Costs:	1977	1978	1979	1980	1981	1982	1983	1984
TOTAL PROJECT COST (WITH MMMR)	$0	$0	$0	$0	$19,599,000	$23,054,237	$26,873,484	$35,639,845
a) LOCK & DAM OPERATIONS/SUPPORT /RECREATION	$0	$0	$0	$0	$10,076,110	$10,378,161	$10,971,216	$11,223,174
b) ENGINEERING (INCLUDING AE) (without any major rehab)	$0	$0	$0	$0	$0	$0	$0	$0
c) CONTRACTS/MISCELLANEOUS (without any major rehab)	$0	$0	$0	$0	$2,363,000	$2,356,172	$2,423,060	$2,418,179
d) MAINTENANCE	$0	$0	$0	$0	$3,313,760	$5,966,811	$8,535,666	$6,260,248
e) DREDGING/CHANNEL MAINTENANCE	$0	$0	$0	$0	$3,846,130	$4,171,849	$4,593,822	$4,809,584
PROJECT COST (MMMR NOT INCLUDED)	$0	$0	$0	$0	$19,599,000	$22,872,993	$26,523,764	$24,711,185
f) MAJOR REHAB AND MAINTENANCE	$0	$0	$0	$0	$0	$181,244	$349,720	$10,928,660

DATA NOT AVAILABLE FOR 1977, 1978, 1979, 1980

REACH 2

UPPER MISSISSIPPI RIVER AND ILLINOIS WATERWAY
NAVIGATION STUDY – TABLE 3 – SHEET 2 OF 2

ITEMIZATION OF COSTS – MISSISSIPPI RIVER PROJECT
LOCK AND DAM 11 THROUGH LOCK AND DAM 22

NAVIGATION STUDY:
Itemized Mississippi River Project Costs
FROM FY 77 THROUGH FY 92

FY 93 DOLLARS FY 85 – FY 92

FISCAL YEARS

	1985	1986	1987	1988	1989	1990	1991	1992
Itemized Costs:								
TOTAL PROJECT COST (WITH MMMR)	$31,157,543	$34,830,174	$36,875,808	$40,327,441	$55,568,994	$52,497,768	$43,488,393	$40,694,601
a) LOCK & DAM OPERATIONS/SUPPORT /RECREATION	$11,483,962	$11,268,972	$12,889,656	$13,563,445	$14,112,085	$13,171,272	$13,330,692	$13,720,548
b) ENGINEERING (INCLUDING AE) (without any major rehab)	$0	$0	$0	$0	$0	$0	$0	$0
c) CONTRACTS/MISCELLANEOUS (without any major rehab)	$2,496,879	$2,856,048	$2,840,928	$2,460,241	$3,226,087	$3,430,632	$3,517,297	$3,877,591
d) MAINTENANCE	$5,838,061	$4,484,664	$3,470,292	$3,971,548	$3,724,674	$4,428,245	$6,523,731	$6,600,462
e) DREDGING/CHANNEL MAINTENANCE	$4,960,130	$6,143,130	$5,835,388	$6,334,867	$5,257,529	$4,597,368	$7,444,753	$5,639,570
PROJECT COST (MMMR NOT INCLUDED)	$24,779,032	$24,752,814	$25,036,264	$26,330,101	$26,320,375	$25,627,517	$30,816,473	$29,838,171
f) MAJOR REHAB AND MAINTENANCE	$6,378,511	$10,077,360	$11,839,544	$13,997,340	$29,248,619	$26,870,251	$12,671,920	$10,856,430

UPPER MISSISSIPPI RIVER AND ILLINOIS WATERWAY

REACH 2 NAVIGATION STUDY – TABLE 4 – SHEET 1 OF 2

ITEMIZATION OF COSTS – MISSISSIPPI RIVER PROJECT
LOCK AND DAM 11 THROUGH LOCK AND DAM 22

NAVIGATION STUDY:
Itemized Mississippi River Project Costs
FROM FY 77 THROUGH FY 92

FY 2000 DOLLARS FY 77 – FY 84

FISCAL YEARS

	1977	1978	1979	1980	1981	1982	1983	1984
Itemized Costs:								
TOTAL PROJECT COST (WITH MMMR)	$0	$0	$0	$0	$24,787,800	$29,240,736	$34,102,860	$45,216,040
a) LOCK & DAM OPERATIONS/SUPPORT /RECREATION	$0	$0	$0	$0	$12,743,742	$13,163,093	$13,922,640	$14,238,768
b) ENGINEERING (INCLUDING AE) (without any major rehab)	$0	$0	$0	$0	$0	$0	$0	$0
c) CONTRACTS/MISCELLANEOUS (without any major rehab)	$0	$0	$0	$0	$2,988,600	$2,988,440	$3,074,900	$3,067,928
d) MAINTENANCE	$0	$0	$0	$0	$4,191,072	$7,567,978	$10,831,890	$7,942,336
e) DREDGING/CHANNEL MAINTENANCE	$0	$0	$0	$0	$4,864,386	$5,291,345	$5,829,630	$6,101,888
PROJECT COST (MMMR NOT INCLUDED)	$0	$0	$0	$0	$24,787,800	$29,010,856	$33,659,060	$31,350,920
f) MAJOR REHAB AND MAINTENANCE	$0	$0	$0	$0	$0	$229,880	$443,800	$13,865,120

DATA NOT AVAILABLE FOR 1977, 1978, 1979, 1980

UPPER MISSISSIPPI RIVER AND ILLINOIS WATERWAY

REACH 2 — NAVIGATION STUDY – TABLE 4 – SHEET 2 OF 2

ITEMIZATION OF COSTS – MISSISSIPPI RIVER PROJECT
LOCK AND DAM 11 THROUGH LOCK AND DAM 22

NAVIGATION STUDY:
Itemized Mississippi River Project Costs
FROM FY 77 THROUGH FY 92

FY 2000 DOLLARS FY 85 – FY 92

FISCAL YEARS

	1985	1986	1987	1988	1989	1990	1991	1992
Itemized Costs:								
TOTAL PROJECT COST (WITH MMMR)	$39,537,132	$44,194,065	$46,786,968	$51,187,582	$70,441,722	$66,603,110	$55,179,267	$51,628,068
a) LOCK & DAM OPERATIONS/SUPPORT /RECREATION	$14,572,488	$14,298,570	$16,354,026	$17,216,068	$17,889,105	$16,710,190	$16,914,348	$17,406,864
b) ENGINEERING (INCLUDING AE) (without any major rehab)	$0	$0	$0	$0	$0	$0	$0	$0
c) CONTRACTS/MISCELLANEOUS (without any major rehab)	$3,168,396	$3,623,880	$3,604,488	$3,122,782	$4,089,531	$4,352,390	$4,462,843	$4,919,388
d) MAINTENANCE	$7,408,164	$5,690,340	$4,403,007	$5,041,082	$4,721,562	$5,618,046	$8,277,489	$8,373,816
e) DREDGING/CHANNEL MAINTENANCE	$6,294,120	$7,794,675	$7,403,773	$8,040,841	$6,664,677	$5,832,610	$9,446,107	$7,154,760
PROJECT COST (MMMR NOT INCLUDED)	$31,443,168	$31,407,465	$31,765,294	$33,420,772	$33,364,875	$32,513,236	$39,100,787	$37,854,828
f) MAJOR REHAB AND MAINTENANCE	$8,093,964	$12,786,600	$15,021,674	$17,766,810	$37,076,847	$34,089,874	$16,078,480	$13,773,240

DISCUSSION OF HISTORICAL COST DATA FOR THE LOCK AND DAM SYSTEMS BY REACH

REACH 3

26. Baseline Estimate. The estimated baseline cost is $30,000,000 per year in year 2000 dollars. This excludes major rehabilitation and future cost impacts. Reach 3 includes Locks 24 through 27 and the Mississippi River from Lock 24 to the confluence with the Ohio River. The projection from years 2000 through 2050 of expenditures for the Operations, Contracts, Engineering, and Maintenance features assumed no significant changes to the recent historical trends. Data for the old Lock 26 was used to project the historical costs through the study period. A miscellaneous cost feature was included in the contract cost feature. Engineering costs were grouped with Operations and Maintenance costs.

27. Cost Summary. The summary of cost data for Reach 3 is presented in Tables 5 and 6. Table 5 presents the cost data in FY 1993 dollars and Table 6 FY 2000 dollars. Figure 4 shows the projection of costs from the year 2000 through 2050.

28. Dredging. Dredging costs have historically been the highest cost feature within Reach 3. The dredging costs have ranged between 25% to 50% of the project cost. Similar to the other Reaches, the dredging costs have fluctuated dramatically on a year to year basis.

29. Melvin Price Lock and Dam. Melvin Price Locks and Dam opened in 1990 replacing the old Lock 26. A comparison of the historical costs for the old Lock 26 and the FY 96 costs for Melvin Price shows they are comparable in O & M costs. By definition, the baseline estimate should exclude any capital costs for Mel Price and any start-up costs. The projection of the old Lock 26 historical costs achieves this purpose.

30. Navigation Traffic. Traffic levels in Reach 3, as they are in Reach 2, are increasing fairly consistently. Reach 3 has the highest river traffic levels, on a per lock basis, among the four Reaches. This probably will have the effect of increasing the wear and aging process of the locks and dams in Reach 3. This will affect the reliability of the locks. This issue is further addressed in the Engineering Objective 2 report. It is expected that Locks 24 and 25 will reach 100% capacity by the year 2000 (the start of the study period).

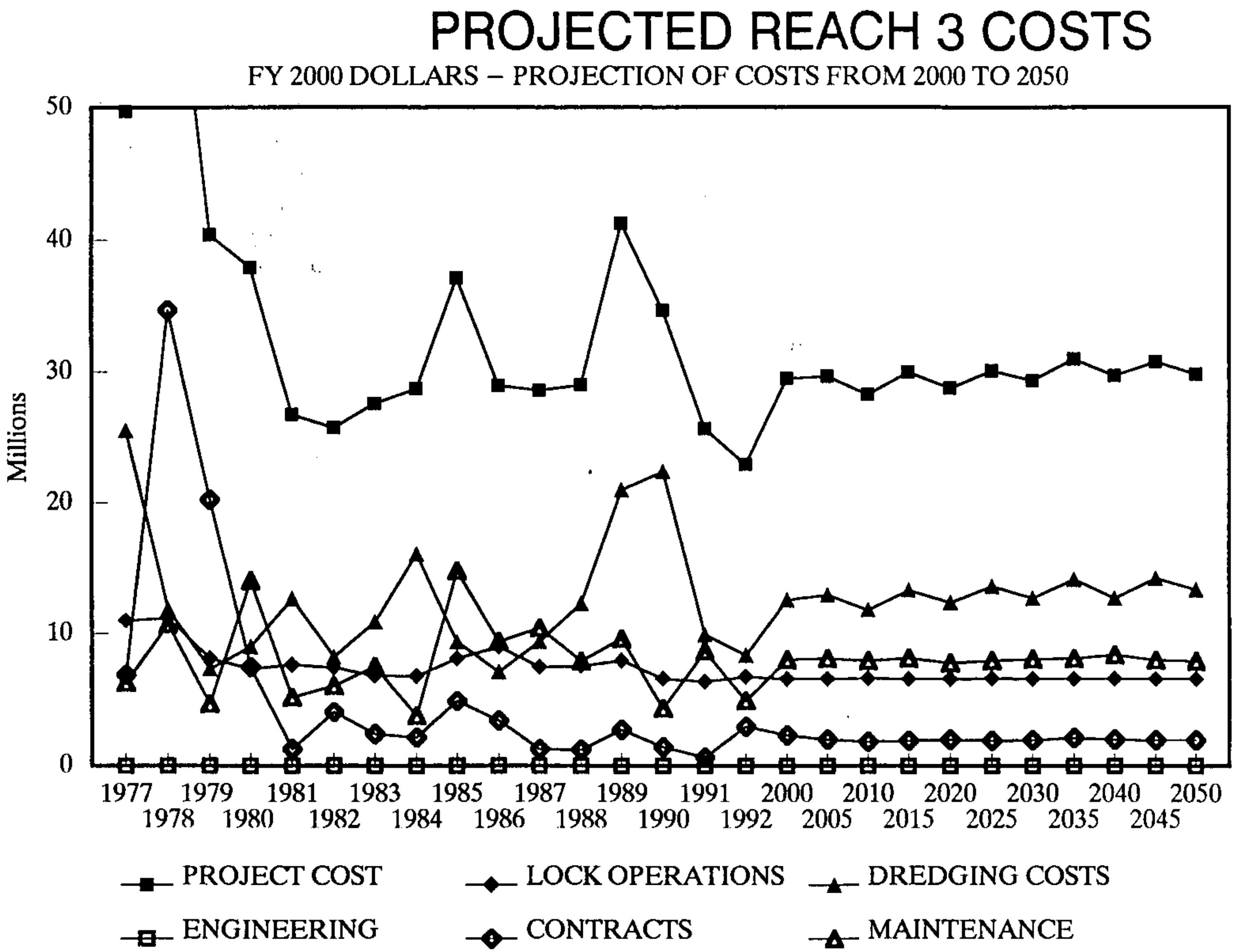

PROJECTED REACH 3 COSTS
FY 2000 DOLLARS – PROJECTION OF COSTS FROM 2000 TO 2050
Millions
50
40
30
20
10
0
1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050
PROJECT COST
LOCK OPERATIONS
DREDGING COSTS
ENGINEERING
CONTRACTS
MAINTENANCE

FIGURE 4

UPPER MISSISSIPPI RIVER AND ILLINOIS WATERWAY

REACH 3 — NAVIGATION STUDY – TABLE 5 – SHEET 1 OF 2

ITEMIZATION OF COSTS – MISSISSIPPI RIVER PROJECT
LOCK AND DAM 24 THROUGH LOCK AND DAM 27

NAVIGATION STUDY:
Itemized Mississippi River Project Costs
FROM FY 77 THROUGH FY 92

FY 93 DOLLARS   FY 77 – FY 84

FISCAL YEARS

	1977	1978	1979	1980	1981	1982	1983	1984
Itemized Costs:								
TOTAL PROJECT COST (WITH MMMR)	$39,258,006	$54,124,695	$31,910,555	$29,769,158	$21,128,969	$20,300,923	$21,756,932	$22,645,358
a) LOCK & DAM OPERATIONS/SUPPORT	$8,715,765	$8,841,098	$6,407,899	$5,772,890	$6,018,860	$5,860,975	$5,369,552	$5,342,159
b) ENGINEERING (INCLUDING AE) (without any major rehab)	$0	$0	$0	$0	$0	$0	$0	$0
c) CONTRACTS/MISCELLANEOUS (without any major rehab)	$5,442,065	$27,388,666	$15,997,864	$5,876,097	$996,028	$3,168,738	$1,884,059	$1,689,538
d) MAINTENANCE	$4,961,960	$8,487,767	$3,699,267	$11,053,825	$4,077,308	$4,774,390	$5,903,707	$2,955,644
e) DREDGING/CHANNEL MAINTENANCE	$20,138,216	$9,407,166	$5,805,525	$7,066,347	$10,036,773	$6,496,821	$8,599,615	$12,658,017
PROJECT COST (MMMR NOT INCLUDED)	$39,258,006	$54,124,695	$31,910,555	$29,769,158	$21,128,969	$20,300,923	$21,756,932	$22,645,358
f) MAJOR REHAB AND MAINTENANCE	$0	$0	$0	$0	$0	$0	$0	$0

UPPER MISSISSIPPI RIVER AND ILLINOIS WATERWAY

REACH 3 — NAVIGATION STUDY – TABLE 5 – SHEET 2 OF 2

ITEMIZATION OF COSTS – MISSISSIPPI RIVER PROJECT
LOCK AND DAM 24 THROUGH LOCK AND DAM 27

NAVIGATION STUDY:
Itemized Mississippi River Project Costs
FROM FY 77 THROUGH FY 92

FY 93 DOLLARS FY 85 – FY 92

FISCAL YEARS

	1985	1986	1987	1988	1989	1990	1991	1992
Itemized Costs:								
TOTAL PROJECT COST (WITH MMMR)	$29,268,196	$22,810,559	$22,552,266	$22,837,697	$32,526,086	$27,335,669	$20,229,486	$18,094,960
a) LOCK & DAM OPERATIONS/SUPPORT	$6,381,290	$7,109,275	$5,891,401	$5,942,355	$6,259,926	$5,202,839	$5,034,855	$5,307,875
b) ENGINEERING (INCLUDING AE) (without any major rehab)	$0	$0	$0	$0	$0	$0	$0	$0
c) CONTRACTS/MISCELLANEOUS (without any major rehab)	$3,856,708	$2,678,586	$995,612	$950,126	$2,146,594	$1,114,917	$519,742	$2,335,581
d) MAINTENANCE	$11,633,599	$7,408,749	$8,254,580	$6,246,479	$7,585,461	$3,391,315	$6,838,229	$3,876,715
e) DREDGING/CHANNEL MAINTENANCE	$7,396,599	$5,613,949	$7,410,673	$9,698,737	$16,534,105	$17,626,598	$7,836,659	$6,574,790
PROJECT COST (MMMR NOT INCLUDED)	$29,268,196	$22,810,559	$22,552,266	$22,837,697	$32,526,086	$27,335,669	$20,229,486	$18,094,960
f) MAJOR REHAB AND MAINTENANCE	$0	$0	$0	$0	$0	$0	$0	$0

UPPER MISSISSIPPI RIVER AND ILLINOIS WATERWAY

REACH 3 — NAVIGATION STUDY – TABLE 6 – SHEET 1 OF 2

ITEMIZATION OF COSTS – MISSISSIPPI RIVER PROJECT
LOCK AND DAM 24 THROUGH LOCK AND DAM 27

NAVIGATION STUDY:
Itemized Mississippi River Project Costs
FROM FY 77 THROUGH FY 92

FY 2000 DOLLARS FY 77 – FY 84

FISCAL YEARS

	1977	1978	1979	1980	1981	1982	1983	1984
Itemized Costs:								
TOTAL PROJECT COST (WITH MMMR)	$49,733,484	$68,608,343	$40,381,356	$37,891,603	$26,722,825	$25,748,583	$27,609,877	$28,730,019
a) LOCK & DAM OPERATIONS/SUPPORT	$11,041,452	$11,206,956	$8,108,905	$7,348,010	$7,612,342	$7,433,741	$6,814,043	$6,777,562
b) ENGINEERING (INCLUDING AE) (without any major rehab)	$0	$0	$0	$0	$0	$0	$0	$0
c) CONTRACTS/MISCELLANEOUS (without any major rehab)	$6,894,208	$34,717,812	$20,244,569	$7,479,377	$1,259,725	$4,019,054	$2,390,900	$2,143,506
d) MAINTENANCE	$6,285,993	$10,759,074	$4,681,254	$14,069,836	$5,156,768	$6,055,576	$7,491,894	$3,749,806
e) DREDGING/CHANNEL MAINTENANCE	$25,511,832	$11,924,503	$7,346,628	$8,994,383	$12,693,991	$8,240,213	$10,913,042	$16,059,144
PROJECT COST (MMMR NOT INCLUDED)	$49,733,484	$68,608,343	$40,381,356	$37,891,603	$26,722,825	$25,748,583	$27,609,877	$28,730,019
f) MAJOR REHAB AND MAINTENANCE	$0	$0	$0	$0	$0	$0	$0	$0

UPPER MISSISSIPPI RIVER AND ILLINOIS WATERWAY

REACH 3

NAVIGATION STUDY – TABLE 6 – SHEET 2 OF 2

ITEMIZATION OF COSTS – MISSISSIPPI RIVER PROJECT
LOCK AND DAM 24 THROUGH LOCK AND DAM 27

NAVIGATION STUDY:
Itemized Mississippi River Project Costs
FROM FY 77 THROUGH FY 92

FY 2000 DOLLARS FY 85 – FY 92

FISCAL YEARS

	1985	1986	1987	1988	1989	1990	1991	1992
Itemized Costs:								
TOTAL PROJECT COST (WITH MMMR)	$37,139,659	$28,943,046	$28,613,669	$28,987,867	$41,231,509	$34,680,342	$25,667,727	$22,956,555
a) LOCK & DAM OPERATIONS/SUPPORT	$8,097,491	$9,020,563	$7,474,841	$7,542,626	$7,935,359	$6,600,761	$6,388,362	$6,733,948
b) ENGINEERING (INCLUDING AE) (without any major rehab)	$0	$0	$0	$0	$0	$0	$0	$0
c) CONTRACTS/MISCELLANEOUS (without any major rehab)	$4,893,940	$3,398,709	$1,263,204	$1,205,994	$2,721,118	$1,414,478	$659,463	$2,963,084
d) MAINTENANCE	$14,762,369	$9,400,548	$10,473,174	$7,928,649	$9,615,667	$4,302,509	$8,676,532	$4,918,276
e) DREDGING/CHANNEL MAINTENANCE	$9,385,859	$7,123,227	$9,402,450	$12,310,597	$20,959,365	$22,362,593	$9,943,369	$8,341,247
PROJECT COST (MMMR NOT INCLUDED)	$37,139,659	$28,943,046	$28,613,669	$28,987,867	$41,231,509	$34,680,342	$25,667,727	$22,956,555
f) MAJOR REHAB AND MAINTENANCE	$0	$0	$0	$0	$0	$0	$0	$0

DISCUSSION OF HISTORICAL COST DATA FOR THE LOCK AND DAM SYSTEMS BY REACH

REACH 4

31. Baseline Estimate. The baseline estimate for Reach 4 is $20,000,00 per year (year 2000 dollars). Reach 4 includes the Illinois Waterway Locks and Dams (as listed on page C-24) and the Illinois River between these locks. The projection from years 2000 through 2050 of expenditures for the Operations, Contracts, Engineering, and Maintenance features assumed no significant changes to the recent historical trends. Recreation costs were not as significant as for Reach 2 but were still included with the Operations cost feature. A miscellaneous cost feature was included with contract costs. The Reach 4 Locks and Dams are also undergoing a MMMR program. However, all MMMR costs were excluded from the baseline estimate. Future cost impacts were also excluded from the baseline estimate.

32. Cost Summary. The summary of cost data for Reach 4 is presented in Tables 7 and 8. Table 7 presents the cost data in FY 1993 dollars and Table 8 FY 2000 dollars. Figure 5 shows the projection of costs from the year 2000 through 2050. After conversion to constant dollars, the yearly expenditures for the all the cost features showed little variance. In 1986, 1987, and 1988, MMMR expenditures were the largest. Excluding MMMR, operations cost are the largest expenditure in Reach 4.

33. Major Rehabilitation. For Reach 4, the MMMR program has been an anomaly (it created a mid-1980's peak) in an otherwise smooth trend in total operation and maintenance expenditures. The first cycle (each lock and dam rehabilitated once) of the MMMR program will be nearly complete by the year 2000. Major rehabilitation includes new machinery for both the locks and dams, new electrical distribution at the locks and dams, new controls for the locks and dams, concrete restoration, and new control buildings at the locks.

34. Navigation Traffic. Navigation traffic increases within Reach 4 are not expected to affect the baseline O & M cost. Traffic levels in Reach 4 appear to have leveled off. Only moderate increases in traffic are expected through the study period. None of the locks within Reach 4 are expected to reach 100% capacity by the year 2020. Any reliability issues from increased traffic are addressed in Engineering Objective 2.

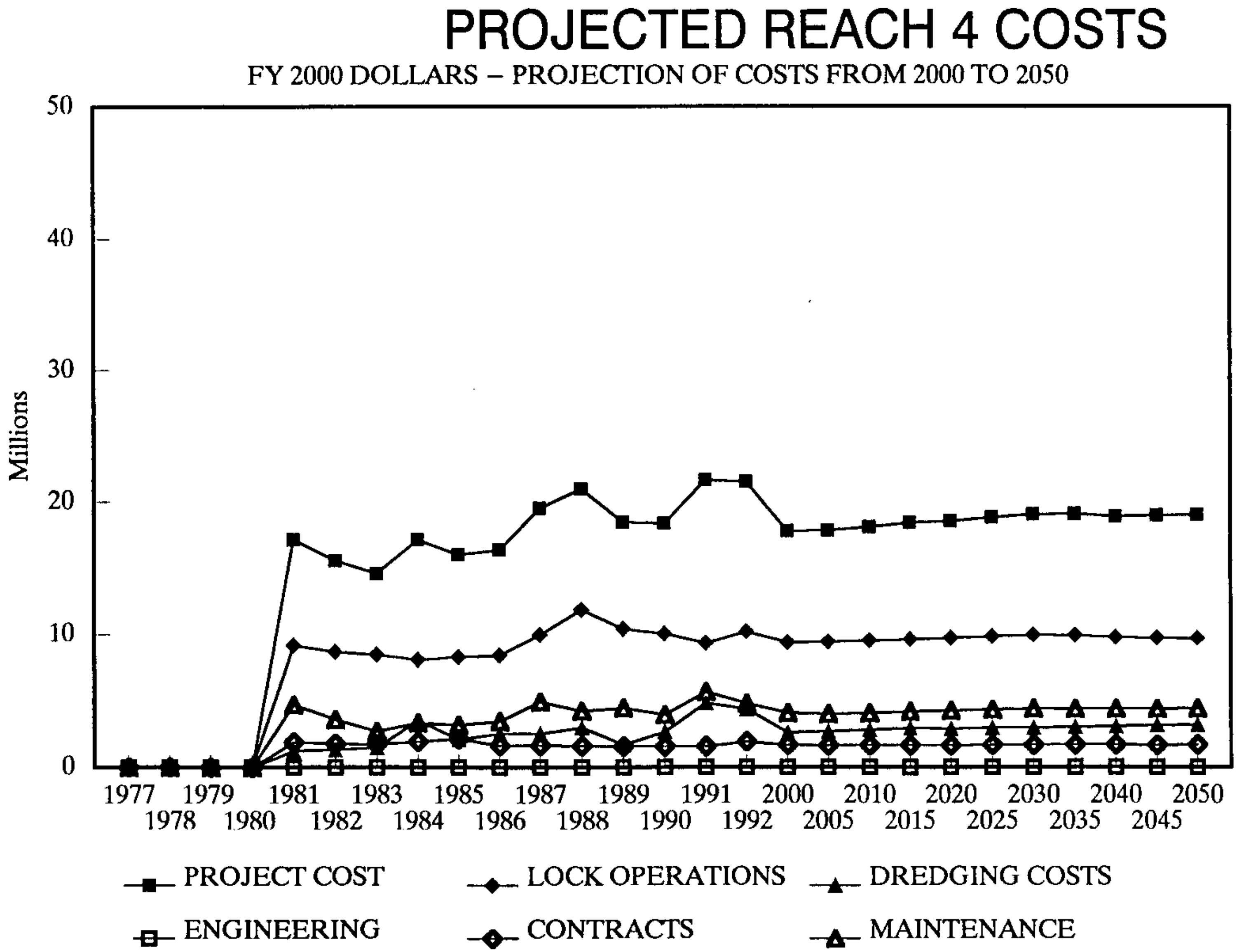

PROJECTED REACH 4 COSTS
FY 2000 DOLLARS – PROJECTION OF COSTS FROM 2000 TO 2050
Millions
0
10
20
30
40
50
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
2000
2005
2010
2015
2020
2025
2030
2035
2040
2045
2050
PROJECT COST
LOCK OPERATIONS
DREDGING COSTS
ENGINEERING
CONTRACTS
MAINTENANCE

FIGURE 5

UPPER MISSISSIPPI RIVER AND ILLINOIS WATERWAY

REACH 4 NAVIGATION STUDY – TABLE 7 – SHEET 1 OF 2

ITEMIZATION OF COSTS – ROCK ISLAND DISTRICT – ILLINOIS WATERWAY PROJECT
LA GRANGE TO THOMAS O'BRIEN LOCK AND DAM

NAVIGATION STUDY:
Itemized Illinois Waterway Project Costs
FROM FY 77 THROUGH FY 92

FY 93 DOLLARS FY 77 – FY 84

FISCAL YEARS

	1977	1978	1979	1980	1981	1982	1983	1984
Itemized Costs:								
TOTAL PROJECT COST (WITH MMMR)	$0	$0	$0	$0	$13,535,820	$16,181,205	$19,058,491	$24,821,932
a) LOCK & DAM OPERATIONS/SUPPORT /RECREATION	$0	$0	$0	$0	$7,337,810	$6,966,890	$6,849,516	$6,582,753
b) ENGINEERING (INCLUDING AE) (without any major rehab)	$0	$0	$0	$0	$0	$0	$0	$0
c) CONTRACTS (without any major rehab)	$0	$0	$0	$0	$1,509,540	$1,406,583	$1,357,663	$1,517,599
d) MAINTENANCE	$0	$0	$0	$0	$3,718,250	$2,829,996	$2,119,553	$2,626,286
e) DREDGING/CHANNEL MAINTENANCE	$0	$0	$0	$0	$970,220	$1,052,510	$1,159,072	$2,772,326
PROJECT COST (MMMR NOT INCLUDED)	$0	$0	$0	$0	$13,535,820	$12,256,626	$11,485,804	$13,498,964
f) MAJOR REHAB AND MAINTENANCE	$0	$0	$0	$0	$0	$3,924,580	$7,572,687	$11,322,968

DATA NOT AVAILABLE FOR 1977, 1978, 1979, 1980

UPPER MISSISSIPPI RIVER AND ILLINOIS WATERWAY

REACH 4 — NAVIGATION STUDY – TABLE 7 – SHEET 2 OF 2

ITEMIZATION OF COSTS – ROCK ISLAND DISTRICT – ILLINOIS WATERWAY PROJECT
LA GRANGE TO THOMAS O'BRIEN LOCK AND DAM

NAVIGATION STUDY:
Itemized Illinois Waterway Project Costs
FROM FY 77 THROUGH FY 92

FY 93 DOLLARS FY 85 – FY 92

FISCAL YEARS

	1985	1986	1987	1988	1989	1990	1991	1992
Itemized Costs:								
TOTAL PROJECT COST (WITH MMMR)	$19,226,809	$27,821,394	$58,370,288	$38,913,056	$28,109,615	$18,966,418	$17,375,636	$17,084,701
a) LOCK & DAM OPERATIONS/SUPPORT /RECREATION	$6,756,826	$6,889,380	$8,154,776	$9,572,738	$8,487,980	$8,065,464	$7,552,800	$8,258,310
b) ENGINEERING (INCLUDING AE) (without any major rehab)	$0	$0	$0	$0	$0	$0	$0	$0
c) CONTRACTS (without any major rehab)	$1,672,993	$1,289,520	$1,302,092	$1,265,621	$1,230,648	$1,225,608	$1,236,771	$1,526,911
d) MAINTENANCE	$2,519,698	$2,724,708	$3,915,652	$3,347,190	$3,533,749	$3,124,498	$4,475,034	$3,822,948
e) DREDGING/CHANNEL MAINTENANCE	$1,640,566	$1,995,174	$2,002,948	$2,339,652	$1,324,474	$2,085,139	$3,805,772	$3,470,346
PROJECT COST (MMMR NOT INCLUDED)	$12,590,083	$12,898,782	$15,371,952	$16,525,201	$14,576,851	$14,500,709	$17,070,377	$16,975,415
f) MAJOR REHAB AND MAINTENANCE	$6,636,726	$14,922,612	$42,998,336	$22,387,855	$13,532,764	$4,465,709	$305,259	$109,286

UPPER MISSISSIPPI RIVER AND ILLINOIS WATERWAY

REACH 4 — NAVIGATION STUDY – TABLE 8 – SHEET 1 OF 2

ITEMIZATION OF COSTS – ROCK ISLAND DISTRICT – ILLINOIS WATERWAY PROJECT
LA GRANGE TO THOMAS O'BRIEN LOCK AND DAM

NAVIGATION STUDY:
Itemized Illinois Waterway Project Costs
FROM FY 77 THROUGH FY 92

FY 2000 DOLLARS FY 77 – FY 84

FISCAL YEARS

	1977	1978	1979	1980	1981	1982	1983	1984
Itemized Costs:								
TOTAL PROJECT COST (WITH MMMR)	$0	$0	$0	$0	$17,119,404	$20,523,358	$24,185,515	$31,491,424
a) LOCK & DAM OPERATIONS/SUPPORT /RECREATION	$0	$0	$0	$0	$9,280,482	$8,836,423	$8,692,140	$8,351,496
b) ENGINEERING (INCLUDING AE) (without any major rehab)	$0	$0	$0	$0	$0	$0	$0	$0
c) CONTRACTS/MISCELLANEOUS (without any major rehab)	$0	$0	$0	$0	$1,909,188	$1,784,033	$1,722,895	$1,925,368
d) MAINTENANCE	$0	$0	$0	$0	$4,702,650	$3,589,412	$2,689,745	$3,331,952
e) DREDGING/CHANNEL MAINTENANCE	$0	$0	$0	$0	$1,227,084	$1,334,946	$1,470,880	$3,517,232
PROJECT COST (MMMR NOT INCLUDED)	$0	$0	$0	$0	$17,119,404	$15,545,635	$14,575,660	$17,126,048
f) MAJOR REHAB AND MAINTENANCE	$0	$0	$0	$0	$0	$4,977,723	$9,609,855	$14,365,376

DATA NOT AVAILABLE FOR 1977, 1978, 1979, 1980

UPPER MISSISSIPPI RIVER AND ILLINOIS WATERWAY

REACH 4 NAVIGATION STUDY – TABLE 8 – SHEET 2 OF 2

ITEMIZATION OF COSTS – ROCK ISLAND DISTRICT – ILLINOIS WATERWAY PROJECT
LA GRANGE TO THOMAS O'BRIEN LOCK AND DAM

NAVIGATION STUDY:
Itemized Illinois Waterway Project Costs
FROM FY 77 THROUGH FY 92

FY 2000 DOLLARS FY 85 – FY 92

FISCAL YEARS

	1985	1986	1987	1988	1989	1990	1991	1992
Itemized Costs:								
TOTAL PROJECT COST (WITH MMMR)	$24,397,716	$35,301,015	$74,058,548	$49,392,304	$35,632,995	$24,062,402	$22,046,684	$21,674,868
a) LOCK & DAM OPERATIONS/SUPPORT /RECREATION	$8,574,024	$8,741,550	$10,346,546	$12,150,667	$10,759,740	$10,232,530	$9,583,200	$10,477,080
b) ENGINEERING (INCLUDING AE) (without any major rehab)	$0	$0	$0	$0	$0	$0	$0	$0
c) CONTRACTS/MISCELLANEOUS (without any major rehab)	$2,122,932	$1,636,200	$1,652,057	$1,606,452	$1,560,024	$1,554,910	$1,569,249	$1,937,148
d) MAINTENANCE	$3,197,352	$3,457,230	$4,968,067	$4,248,585	$4,479,537	$3,964,002	$5,678,046	$4,850,064
e) DREDGING/CHANNEL MAINTENANCE	$2,081,784	$2,531,565	$2,541,283	$2,969,718	$1,678,962	$2,645,384	$4,828,868	$4,402,728
PROJECT COST (MMMR NOT INCLUDED)	$15,976,092	$16,366,545	$19,503,492	$20,975,422	$18,478,263	$18,396,826	$21,659,363	$21,536,220
f) MAJOR REHAB AND MAINTENANCE	$8,421,624	$18,934,470	$54,555,056	$28,416,883	$17,154,732	$5,665,576	$387,321	$138,648

DISCUSSION AND ANALYSIS OF HISTORICAL MAINTENANCE PRACTICES ON THE LOCK AND DAM SYSTEM BY REACH

REACH 1

35. General. The lock and dam system on the Mississippi River was primarily built during the 1930's. During this period, the Corps of Engineers built 24 locks and dams on the Upper Mississippi River including most of the locks and dams within Reach 1. Table 9 shows a construction history of the locks and dams within Reach 1.

36. Lock 1 and Saint Anthony Falls. Lock and Dam No.1 was rebuilt during the early 1980's. The lock was dewatered, a new control building constructed, and new machinery and electrical systems were installed. At Upper and Lower Saint Anthony Falls Lock and Dams, no MMMR program is being slated at this time. These locks were built during the late 1950's and early 1960's.

37. Major Rehab Program. Since the mid-1980's, Lock and Dams 2 through 10 have been undergoing a Major Maintenance and Rehabilitation (MMMR) program. At each of the rehabilitated sites, new miter gate machinery, tainter valve machinery, electrical system, and motor control centers are installed. New control buildings will be erected at Locks 2 through 10. Also, as part of the MMMR program, the locks are dewatered. During dewatering, concrete repairs and concrete restoration is done and miter gates painted and prestressed. Tainter valves are also painted. Dam rehabilitation is also part of the MMMR program. New bridges and dam machinery are installed at some sites. A new electrical system will be installed on all the dams. Completion of the MMMR program is targeted for the year 2000, the same year as the start of the study period.

38. For Reach 1, the MMMR program was established because the lock concrete, mechanical and electrical components, miter gates, etc. were in need of repair and past their design life. The most frequent malfunctions (up to 85%) encountered in the operation of the locks, prior to MMMR, was electrical. The electrical system includes brakes, motors, control systems, and the distribution system.

39. Maintenance Schedule. The maintenance schedule was and still is primarily preventative for the locks and dams within Reach 1. Nearly all of the lock and dam miter gates and tainter valves are

mechanically driven with open gear type machinery. Greasing machinery and general inspection of equipment are performed on regular intervals. Motors were also pulled and inspected on a yearly basis before the MMMR program started. As part of the MMMR program, the locks are dewatered for inspection and repair. Dewatering was also performed on a regular schedule even before the MMMR program. The locks within Reach 1 are closed to navigation during the winter months. This allows for detailed inspections and periodic dewatering. Each lock site has a number of survey markers and monuments installed. This permits regular monitoring of any movement of the lock monoliths. A periodic inspection program has been in place for the Reach 1 locks and dams since the early 1970's. Periodic inspections provide the opportunity to inspect critical items of the locks and dams such as machinery, surface concrete, gates, monoliths, and the electrical system. Painting of gates and equipment at the lock and dam sites within Reach 1 Saint Paul District has been done regularly.

40. Painting. Painting of dam gates in Reach 1 has been done on a 10 to 15 year cycle. A painting schedule and history is shown in Table 10. It should be noted that this is not a complete list since not all data was available. Painting of miter gates and tainter valves are done during all dewaterings. At Lock 10, miter gates and tainter valves were painted after bulkheading and setting poiree dams since the lock could not be dewatered for most of its history. Painting of dam gates is done primarily by the Government Rivers and Harbors Unit with some of the work contracted out. Painting of miter gates and tainter valves is nearly always done by Rivers and Harbors. Some of the dam gates will be painted as part of the MMMR program, such as Dam 2 when the new service bridge was installed.

41. Maintenance Philosophy. The basic maintenance philosophy for the sites within Reach 1 is primarily preventative. At each lock site, the lock forces repair most of the machinery that has malfunctioned, broken down, or is badly worn. When the scope of the repairs exceed the capability of the lock force, the work is either contracted out to a private contractor or given to the Government Maintenance Section, Rivers and Harbors Unit. The Rivers and Harbors Division is based in Fountain City, Wisconsin. Some of the maintenance services provided include welding, machinery repair, hoisting, floating plant, and painting and sandblasting.

42. Staffing Lists. Staffing lists are shown in the Appendix (Part 3 Appendix 1), Section A. Generally, within Reach 1, at each lock site, there is one lockmaster, one to five head operators, one equipment repair person, and several operators. A total staff of 10 to 12 people is typical. The equipment repair person handles both electrical and mechanical repairs.

TABLE 9 - CONSTRUCTION DATA FOR REACH 1

LOCK AND DAM SITE	START OF CONSTRUCTION	CONSTRUCTION COMPLETE	CONSTRUCTION COST
SAINT ANTHONY			
FALLS - UPPER	NOV 2, 1959	DEC 13, 1963	$31,748,535
- LOWER	JULY 6, 1950	NOV 8, 1956	
LOCK 1			
RIVERWARD LOCK	JAN 4, 1930	SEP 30, 1930	$5,661,629
LANDWARD LOCK	FEB 14, 1931	MAY 28, 1932	
LOCK 2			
RIVERWARD LOCK	DEC 8, 1928	NOV 30, 1930	$8,455,143
LANDWARD LOCK	JUNE 10, 1941	DEC 14, 1942	
LOCK 3	AUG 5, 1935	APRIL 13,1937	$5,631,685
LOCK 4	DEC 4, 1932	JAN 5, 1934	$4,871,327
LOCK 5	APRIL 21, 1933	JUNE 16, 1934	$5,088,946
LOCK 5A	DEC 22, 1933	FEB 15, 1935	$4,558,005
LOCK 6	NOV 13, 1933	FEB 3, 1935	$4,881,301
LOCK 7	NOV 15, 1933	APRIL 18, 1935	$5,587,201
LOCK 8	DEC 7, 1933	MARCH 4, 1935	$6,076,325
LOCK 9	DEC 29, 1933	APRIL 24, 1935	$6,560,252
LOCK 10	FEB 24, 1934	MAY 29, 1935	$4,802,286
		TOTAL COST REACH 1	**$93,922,635**

TABLE 10 - PAINTING SCHEDULE - REACH 1

LOCK	DATE	REMARKS
USAF	1962-1963	Miter Gates
	1978	Miter Gates
LSAF	1955-1956	Miter Gates and Tainter Gates
	1966	Tainter Gates and Auxiliary Lock Gate
	1979	Upper Valve and Main Lock Tainter Gate
	1982-1983	Lock Miter and Tainter Gates, Tainter Valves
	1988	Service Bridge and Bulkheads
LOCK 1	1930	River Lock Miter Gates
	1932	Land Lock Miter Gates
	1949-1950	Miter Gates, Valves
	1959-1960	Miter Gates, Valves
	1962	No. 6 and No. 7 Stoney Valve
	1963	No. 1,2, and 5 Stoney Valve
	1979-1980	Miter Gates, Tainter Valves
LOCK 2	1930	Miter Gates. Tainter Gates 4,7,11,15,19
	1935	Tainter Gates 14,16,17,18,20
	1936	Tainter Gates 1 through 13
	1936-1937	Miter Gates
	1939	Tainter Gates 5,19
	1940	Tainter Gates 1,2,3,4,20
	1943	Tainter Gate 4
	1955	Tainter Gates
	1960-1961	Miter Gates, Valves
	1979	Miter Gates and Tainter Valves
	1986-1987	Miter Gates, Valves during Stage 1
	1988-1990	Tainter Gates during Phase A Dam Work
LOCK 3	1936	Miter Gates
	1937	Roller Gates and Service Bridge
	1961-1962	Miter Gates, Valves
	1985	Dam Roller Gates
	1986	Dam Roller Gates
	1987-1988	Miter Gates, Valves during STAGE 1 MMMR
	1990	Dam Roller Gates
LOCK 4	1933	Miter Gates
	1934	Roller Gates and Tainter Gates
	1935	Service Bridge
	1939	Roller Gates 1-6, Tainter Gates 7-28
	1955	Exterior of Roller and Tainter Gates
	1957	Tainter Gates and Roller Gates
	1957	Auxiliary Lock Gates

	1967 Interior of Roller Gates
	1972-1973 Miter Gates, Valves
	1981 Roller and Tainter Gates
	1988-1989 Miter Gates, Valves during STAGE 1 MMMR
LOCK 5	1933 Miter Gates
	1934 Service Bridge and Roller gates
	1938 Roller Gates 1-6 and Tainter Gates 7-34
	1957 Tainter Gates and Roller Gates
	1977-1978 Miter Gates, Valves
	1978-1979 Roller Gates and Tainter Gates
	1985 Service Bridge
	1985 Auxiliary Lock Gate
	1989-1990 Miter Gates, Valves during STAGE 1 MMMR
	1989-1990 Tainter Valves
	1991 Roller Gates and Tainter Gates
LOCK 5A	1934 Miter Gates
	1935-1940 Service Bridge, Roller and Tainter Gates
	1940 Roller Gates 1-5, Tainter Gates 6-10
	1957 Auxiliary Lock Gates
	1960 Roller Gates and Tainter Gates
	1960-1961 Miter Gates, Valves
	1977-1978 Roller Gates and Tainter Gates
	1981-1982 Miter Gates, Valves during Dewatering
	1982 Auxiliary Miter Gates
	1982 Roller and Tainter Gates
	1990 Roller and Tainter Gates
LOCK 6	1934 Miter Gates
	1935-1936 Service Bridge, Tainter and Roller Gates
	1949 Roller and Tainter Gates
	1956 Auxiliary Lock Gate
	1961 Roller and Tainter Gates
	1965 Surface of Roller and Tainter Gates
	1976-1977 Miter Gates, Valves during Dewatering
	1983 Auxiliary Lock Gates
	1986 Roller and Tainter Gates
	1987 Roller and Tainter Gates
	1989 Roller and Tainter Gates
	1993-1994 Miter Gates, Valves during Stage 1 MMMR
LOCK 7	1934 Miter Gates
	1936 Service Bridge, Tainter and Roller Gates
	1940 Roller Gates and Tainter Gates
	1941 Roller Gate 1, Tainter Gates 6,7,13,16
	1954 Miter Gates, Valves during Dewatering
	1959 Roller and Tainter Gates
	1981 Roller and Tainter Gates
	1983 Roller and Tainter Gates
	1984 Roller and Tainter Gates
	1985 Roller and Tainter Gates

LOCK 8	1934 Miter Gates 1936 Service Bridge, Tainter and Roller Gates 1938 Roller Gates 1945 Roller Gates and Tainter Gates 1952 Miter Gates, Valves during Dewatering 1956 Auxiliary Lock Gates 1964 Roller and Tainter Gates 1973-1974 Miter Gates, Valves during Dewatering 1983 Auxiliary Miter Gates 1985 Roller and Tainter Gates 1989 Roller and Tainter Gates 1990 Roller and Tainter Gates 1991-1992 Miter Gates, Valves during STAGE 1 MMMR
LOCK 9	1934 Miter Gates 1937 Service Bridge, Tainter and Roller Gates 1939 Service Bridge 1949 Roller and Tainter Gates 1957 Miter Gates, Valves during Dewatering 1962 Roller Gates and Tainter Gates 1964 Roller and Tainter Gates 1974-1975 Miter Gates, Tainter Valves 1984 Auxiliary Gates 1989 Roller and Tainter Gates 1991 #6,7,8,9,10 Tainter Gates Exterior #5 Roller 1992-1993 Miter Gates, Valves during STAGE 1 MMMR 1992 Exterior of #1,2,3,4 Roller Gates Interior of #1 and 2 Roller Gates
LOCK 10	1934 Miter Gates 1935 Service Bridge, Roller Gates and Miter Gates 1939 Miter Gates, Submerged Roller Gates 1939 Tainter Gates 1958 Miter Gates 1958 Roller and Tainter Gates 1968 Miter Gates and Auxiliary Lock Gates 1979 Tainter Valves 1983 Miter Gates #1 and #3 1983-84 Tainter Gates, Roller Gate #5 and 6 1983-84 Lower Miter Gates 1985 Auxiliary Lock Gate 1986 Service Bridge 1990-1991 Miter Gates, Valves during STAGE 1 MMMR

DISCUSSION AND ANALYSIS OF HISTORICAL MAINTENANCE PRACTICES ON THE LOCK AND DAM SYSTEM BY REACH

REACH 2

43. General. Except for Lock 19, which was built during the 1950's, Locks and Dams 11 through 22 on the Mississippi River were all built during the 1930's. The first lock and dam constructed on the entire Mississippi River among those currently in operation is Locks and Dam 15, initiated in 1930 and completed in 1933. The remainder of the locks and dams in Reach 2 were completed from 1936-1939. Table 11 shows a construction history of the locks and dams within Reach 2.

44. Routine maintenance is accomplished with the Lock and Dam operations staff (staffing levels are included in Part III, Appendix 2, Section A). Generally, the lock and dam operators have been able to perform maintenance duties at otherwise idle times between locking boats. River traffic tends to be variable with some periods having tows continuously in the queue and other periods with no tows for several hours. However, traffic levels are generally increasing. As a given lock approaches capacity (i.e., non-stop traffic), it will become more difficult for the lock and dam operators to perform the maintenance functions.

45. Structural Maintenance Crew. In addition to the lock and dam operators, maintenance is performed by a Structural Maintenance crew, Channel Maintenance crew, and Project Maintenance crew. Staffing levels for each of these sections is included in Part III, Appendix 2, Section A. The Structural Maintenance crew is responsible for maintenance and repair of the lock and dam structural features beyond the routine level. The Channel Maintenance crew conducts channel surveys and oversees the dredging program. The Project Maintenance crew is responsible for wing dam maintenance and closure dam maintenance. The maintenance philosophy is generally one of prevention, however, the maintenance activity is limited by the availability of funds. Thus the backlog of work is prioritized to make the best use of limited resources.

46. Periodic Inspections. A periodic inspection program has been in place for the Reach 2 locks since 1968. On a cycle of once every five years, each lock and dam is inspected and deficiencies are noted. (Summaries of the latest inspection reports for Reach 2 are included in Part III, Appendix 2, Section E). Recommendations are made for the disposition of each deficiency, whether that be continued monitoring, interim repairs, major repairs or replacement, or other appropriate action. From the periodic inspection reports, an initial list of work items to include in Major Maintenance and Major Rehabilitation contracts is derived.

47. Major Rehab. Beginning with Lock 20 in 1986, Locks 13, 15-18, and 20-22 have undergone or are undergoing restoration under the Major Maintenance or Major Rehabilitation (MMMR) programs. Lock 19 is not yet in need or such rehabilitation and Locks and Dams 11, 12, and 14 are scheduled and awaiting funding. The MMMR programs help reduce the backlog of maintenance and repair work as well as accomplish the infrequent, high cost activities necessary to extend the project life. The restorations at each site include, in general, new miter gate machinery, new tainter valve machinery, complete electrical replacement, concrete resurfacing, scour protection, and miter gate, tainter valve, and dam gate rehabilitation. Each site is inspected and rehabilitation plans prepared for the specific needs of the site. For example, some lock chambers required complete resurfacing of vertical lockwall monoliths, while others only needed selective resurfacing of a few monoliths. Needed repairs are viewed from the perspective of the optimum time for repair, taking into account the duration of construction, whether interim repairs are appropriate, economies of scale if similar work is already being included, consequences of delaying the work, and other similar considerations.

48. Under the MMMR programs, the locks are closed to navigation typically for about two months to allow work to be completed that cannot be done while the boats are being locked through. Some of the work included during the closure periods is the miter gate and tainter valve rehabilitation, miter gate and tainter valve machinery replacements, electrical replacements, and work requiring dewatering of the locks. The locks are dewatered for concrete resurfacing below normal water levels, pintel repairs, bubbler system installation, miter gate quoin work, and general inspection among other work. The closure periods are selected during the Winter months (typically January and February) because this is normally a slow or no traffic period and industry impacts are thereby minimized.

49. If properly maintained, the lock and dam systems can remain in operation indefinitely. Maintenance must be sufficient to avoid safety hazards and undue risks of failure that could cause economic losses, injury, or loss of life. In addition, maintenance must assure the basic functioning of the dams to maintain pool and regulate flow and of the locks to efficiently and safely lock boats.

TABLE 11 - CONSTRUCTION DATA FOR REACH 2

LOCK AND DAM SITE	START OF CONSTRUCTION	COMPLETION OF CONSTRUCTION	CONSTRUCTION COST
L/D 11	1935	1937	$ 6,655,000
L/D 12	1934	1938	$ 5,621,000
L/D 13	1935	1939	$ 8,276,000
L/D 14	1935	1939	$ 5,472,000
L/D 15	1930	1933	$ 7,480,000
L/D 16	1933	1937	$ 5,688,000
L/D 17	1935	1939	$ 5,638,000
L/D 18	1934	1937	$ 5,886,000
Lock 19	1952	1957	$13,500,000
L/D 20	1933	1936	$ 4,450,000
L/D 21	1933	1939	$ 5,721,000
L/D 22	1933	1939	$ 5,135,000
		TOTAL COST REACH 2	**$79,522,000**

DISCUSSION AND ANALYSIS OF HISTORICAL MAINTENANCE PRACTICES ON THE LOCK AND DAM SYSTEM BY REACH

REACH 3

50. General. Reach 3 contains the smallest number of locks among the four Reaches of the navigation system. However, this Reach has the highest traffic levels on a per lock basis. Locks 24, 25, Melvin Price, and 27 are included in Reach 3. The new Melvin Price lock replaced the old Lock 26 in 1990.

51. Staffing Lists. Staffing lists are shown in Part 3, Appendix 3, Section A. Generally, within Reach 3, at each lock site, there is one lockmaster, one assistant lockmaster, two equipment mechanics, five operator leaders, and four operators. An electrician is usually also shared between two sites. Mel Price lock and dam has two full time electricians. There is no Government maintenance unit as in Reaches 1 and 2.

52. Shutdowns. Lock sites within this Reach are open on a year round basis. Shutdowns of lock sites must be planned and coordinated in advance. Any shutdown of a lock in this Reach will have a large impact on shipping because of the high traffic levels.

TABLE 12 - CONSTRUCTION DATA FOR REACH 3

LOCK AND DAM SITE	START OF CONSTRUCTION	CONSTRUCTION COMPLETE	CONSTRUCTION COST
LOCK 24	APRIL 21, 1933	JUNE 16, 1934	$5,088,946
LOCK 25	DEC 22, 1933	FEB 15, 1935	$4,558,005
OLD LOCK 26	NOV 13, 1933	FEB 3, 1935	$4,881,301
LOCK 27	NOV 15, 1933	APRIL 18, 1935	$5,587,201

DISCUSSION AND ANALYSIS OF HISTORICAL MAINTENANCE PRACTICES ON THE LOCK AND DAM SYSTEM BY REACH

REACH 4

54. General. Reach 4 (the Illinois Waterway) as well as Reach 2 of the Mississippi River are both within the Rock Island District. As such, the maintenance philosophy for both reaches is generally the same. The reader is therefore referred to the narrative on Reach 2 maintenance practices. Only reach-specific differences are discussed below.

55. History. The lock and dam system on the Illinois Waterway was initiated by the State of Illinois. However, after construction was initiated at several sites, the State petitioned the Federal Government to take over the project. The Federal Government's agent, the U.S. Army Corps of Engineers, picked up the project and carried it to completion, maintaining operational and maintenance responsibilities as well as ownership. Table 13 shows a construction history of the locks and dams within Reach 4. With the exception of O'Brien Lock and Controlling Works which were built from 1958-1960, all of the Illinois Waterway Locks and Dams were all built during the late 1920's through the 1930's.

56. Staffing. The lock and dam operations staff, responsible for operation and routine maintenance, are listed in Part III, Appendix 4, Section A). Also listed there are Illinois Waterway maintenance staff responsible for all aspects of maintenance of the Illinois Waterway locks and dams including structural maintenance, dredging, and any other maintenance required. They provide the same functions and use the same prioritization as do the Structural Maintenance crew, Channel Maintenance crew, and Project Maintenance crew for Reach 2.

57. Periodic Inspections. Reach 4 has also had a periodic inspection program since 1968. Summaries of the latest inspection reports for Reach 4 are included in Part III, Appendix 4, Section E.

58. Major Rehab. Beginning with Marseilles Lock in 1975, each of the Illinois Waterway Locks and Dams, except O'Brien, have undergone or are undergoing restoration under the Major Maintenance or Major Rehabilitation (MMMR) programs. O'Brien Lock and Controlling Works is not yet in need or such rehabilitation. The work included in and philosophy followed for the Illinois Waterway MMMR programs is similar to that described for Reach 2. One significant difference is that the Illinois Waterway remains open for navigation year-round. Thus, the closure periods have been selected during the months that usually have the lowest commercial traffic, i.e., July, August, and September. Besides minimizing

impacts to the navigation industry, selecting this time of year for closure offers much better conditions for the construction activities involved in the MMMR work. For example, the floating plant needed for MMMR does not have to contend with ice; the weather is typically dry and warm, reducing the risk of flooding, providing better conditions for concrete placement, and providing more comfortable working conditions for the labor; and there are more hours of daylight each day than during a winter closure.

59. Having year-round navigation has necessitated design measures to deal with winter operating conditions. For example, the first bubbler systems (primarily to clear ice from interfering with miter gate movement) were installed at Starved Rock Lock under a Cold Regions Research Laboratory (CRREL) program. Various side seal heating devices (for dam tainter gates) have been experimented with as well. Ice passage capability had to be considered at each site because backed-up ice hinders tow movement. To improve the ice passage capability of Marseilles Dam, the deteriorated non-submersible tainter gates were replaced with new submersible tainter gates. The Peoria and LaGrange wicket dams had no significant ice passage capability during low flows, so a submersible tainter gate was added to each dam providing ice passage cababilty and leaving enough wickets to maintain open-pass navigation (bypassing the lock) during sufficient flows.

60. It is reported by operations staff that Illinois River water quality improvements (including reduced thermal pollution), have correlated with greater formation of ice. Reportedly the upper end of the Illinois didn't even freeze during the 1930's and now regularly freezes. Although there is a limit to this trend, ice problems for Winter navigation may eventuate a reduction in Winter navigation or the need for additional measures to address the problems.

61. O'Brien Lock and Controlling works is unique on the Illinois Waterway in the following ways: its lockwalls consist of sheetpile cells, it is the only lock with sector gates, it normally operates with very low head (about 2 feet), and it was built much later than the other locks. Unlike a concrete gravity structures that can be resurfaced indefinitely, the options are limited for repairing sheetpile cell lockwalls as they age and corrode. It is likely that at some time, the lockwalls would have to be completely rebuilt. A corrosion study at O'Brien Lock is currently underway to determine the extent of corrosion to date and aide in determining an estimate of remaining life of this facility. This work will be part of Engineering Objective 2.

62. Just as for Reach 2, the Illinois Waterway Locks and Dams, with the exception of O'Brien, could be kept in operation indefinitely with proper maintenance including Major Maintenance or Major Rehabilitation type work.

TABLE 13 - CONSTRUCTION DATA FOR REACH 4 (ILLINOIS WATERWAY)

LOCK AND DAM SITE	START OF CONSTRUCTION	COMPLETION OF CONSTRUCTION	CONSTRUCTION COST
O'BRIEN	1958	1960	$6,955,000 (6,955,000) Fed. (0) State
LOCKPORT	1930	1933	$ 2,154,000 (134,000) Fed. (2,020,000) State
BRANDON ROAD	1927	1933	$ 4,435,000 (2,032,000) Fed. (2,403,000) State
DRESDEN ISLAND	1930	1933	$ 3,916,000 (2,503,000) Fed. (1,413,000) State
MARSEILLES	1930	1933	$ 3,650,000 (1,854,000) Fed. (1,796,000) State
STARVED ROCK	1926	1933	$ 4,463,000 (885,000) Fed. (3,578,000) State
PEORIA	1935	1938	$ 3,381,000 (3,381,000) Fed. (0) State
LAGRANGE	1936	1939	$ 2,745,000 (2,745,000) Fed. (0) State
		TOTAL COST REACH 4	$31,699,000 (20,489,000) Fed. (11,210,000) State

FACTORS AFFECTING FUTURE MAINTENANCE COSTS - ALL REACHES CHANNEL MAINTENANCE AND DREDGING

63. Introduction. Dredging and channel maintenance costs show the most fluctuation from year to year of any of the cost features that were investigated. Channel maintenance expenditures account for approximately 25% of the total O & M expenditures on the Upper Mississippi River. Fluctuations in cost are due primarily to the large variance of total material dredged every year. Drought conditions and flood conditions usually necessitate increased dredging requirements. For example, in 1988 (a drought year) and 1993 (a flood year) increased dredging was required to keep the navigation channel open. In current dollars, a 10% increase in channel maintenance costs is expected by the year 2025. After the year 2025, a 20% cost increase is expected. These costs are not included in the baseline estimate. Significant reductions in dredging quantities have already been achieved and further major deductions in dredging quantities are not expected through the study period.

64. Channel Maintenance Program. The channel maintenance program involves a number of components that should be considered when evaluating future costs. In addition to the actual act of dredging, major elements of the channel maintenance program include hydrographic survey operations and dredged material placement site planning and management. Other channel maintenance activities include management of the navigation channel through the use of control structures and other improvement techniques.

65. Objectives. Key objectives of the channel maintenance program are minimizing or controlling dredging requirements and long range planning for dredged material placement. Two of the most important factors affecting dredging costs are the actual quantity of material dredged and disposal and placement costs of the dredged material. These factors are discussed in the following paragraphs.

66. Dredging Types. Dredging on the Upper Mississippi River is accomplished by using a combination of hydraulic and mechanical dredging equipment. With hydraulic dredging, underwater material is agitated with a cutter device, then pumped to the surface through a "vacuum" pipeline and transported. Mechanical dredging makes use of a clamshell bucket or crane mounted on a barge to lift the underwater material from the river, dump it into a barge, and then

transport the material for varying distances. The government dredge William A. Thompson is used for the majority of hydraulic dredging. Hydraulic dredging equipment is the most cost effective when dredging jobs are larger (+15,000 cy) and the placement site is within 1.5 miles of the cut. Mechanical dredging is generally performed by contract, with supplemental government equipment as necessary. The cost for mechanical dredging is approximately twice as much per cubic yard as hydraulic dredging. It is well suited for small jobs, though, with placement sites that are more remote from the cut. There are approximately 90 locations in the St. Paul District that require dredging with varying frequency and volume. The average quantity and number of dredging locations per year is 700,000 cubic yards at 25 sites. Since 1974, the St. Paul District (Reach 1) has actively pursued measures to reduce or control dredging requirements. The average annual quantity has decreased from approximately 1.5 million cubic yards per year.

67. Dredging in the St. Louis District is accomplished by using hydraulic cutterhead and dustpan dredges. The Government dustpan dredge POTTER is best suited for open river conditions where water disposal is the preferred option and the disposal area is close to the dredge cut. A contract cutterhead dredge or the Government Dredge William &A. Thompson are used for areas requiring long discharge lines or for on shore disposal. There are approximately 90 locations in the St. Louis District (Reach 3) that require dredging with varying frequency and volume. The average quantity and number of dredging location per year is approx. 8 million cubic yards at 48 sites.

68. Policy Changes. The reduction in dredging quantities has been accomplished by changes in dredging policy and by various structural and non-structural techniques. The Great River Environmental Action Team (GREAT) report, released in 1981, was one of the first reports to investigate dredging procedures and costs. The objective of the GREAT study was to develop a total river resource management plan for the river corridor with a principle secondary objective to develop a detailed channel maintenance plan. The GREAT Study also initiated investigations into how dredge material could be put to productive use.

69. Based on hydraulic engineering principles and operational considerations, dredging dimensions, both width and depth, have been reduced from historic practices. The dredge scheduling and planning process is now initiated when depths reach 10.5 feet below low control pool elevation versus the traditional 11.0 feet. Improved survey capability has made it possible to more closely monitor shoaling and scouring patterns which has resulted in a reduction of dredging quantities. Channel control structures have been modified to improve sediment transport efficiency, which reduces shoaling in the navigation channel. Sediment trap dredging has been used to control when and where dredging is accomplished. Assisting the U.S. Coast Guard on positioning of navigation aids

has also contributed to a reduction in dredging. The St. Louis District assists the U.S. Coast Guard in portioning buoys with the channel patrol boat MV Pathfinder under a formal Memorandum of understanding. An ongoing regulating works program has improved sediment transport efficiency, which reduces shoaling in the navigation channel.

70. **The more significant reductions in dredging quantities have already been achieved. Large reductions in dredging quantities in the future are not expected.** Maintenance and improvement of channel control structures should be continued at the existing funding level or slightly higher to assure that shoaling conditions and/or navigation alignment at individual locations does not deteriorate.

71. The Saint Paul, Saint Louis, and Rock Island Districts have developed long term management plans for dredged material placement at each of the historic dredging locations. Sites that will provide dredged material placement capacity for a projected 40 year period (year 2025) have been selected through an alternative evaluation process that considers environmental, economic, social and cultural impacts. The actual life of a site depends upon variables such as actual dredging quantities and beneficial use removal. When a site nears its capacity, the planning process is reinstated to develop another future long term site. As indicated, the existing dredged material placement plan at most locations should provide capacity until 2025 and therefore costs related to placement of material should not change signicantly during that time period. As longer range planning and implementation takes place it is anticipated that selected sites will be further from the dredging location and/or more sites will require periodic excavation to maintain capacity. This will result in an increase in channel maintenance costs.

72. Saint Paul District - Reach 1. During the period 1980 through 1994, the Saint Paul District total channel maintenance costs have averaged nearly $6.0 million annually. Costs associated with hydrographic survey operations, general engineering, planning and management of the program are not expected to change beyond normal inflation. As discussed above, costs for channel control structure maintenance, the dredging and placement site related work will likely increase in the future. A 5 to 10 percent annual cost increase for the total program prior to 2025 and 15 to 20 percent increase after 2025 is considered to be a reasonable projection for future channel maintenance costs. Another factor that could impact future costs is changes in dredging equipment. If the Dredge Thompson is replaced in favor of contract hydraulic equipment, a cost increase is anticipated to assure the same level of response capability. The following is an average channel maintenance cost:

1980 - 2000	$6 mil (1995 dollars)
2000 - 2025	$6.3 - 6.6. mil (1995 dollars)

2025 - 2050 $6.9 - 7.2 mil (1995 dollars)

73. Saint Louis District - Reach 3. The Saint Louis District is developing long term management plans for dredged material placement at all historic dredging location. The majority of current sites are open water location. As environmental concerns become more prevalent, it is anticipated that dredging cost will increase due to longer pumping distance and more restrictive disposal methods. The end result will be an increase in channel maintenance costs. During the period 1980 through 1994 total channel maintenance costs have averaged approximately $8 million annually. Cost associated with hydrographic survey operation, general engineering, planning and management of the program are not expected to change beyond normal inflation. As discussed above, costs for channel control structure maintenance, and dredging and placement site related work will likely increase in the future. A 5 to 10 percent annual cost increase for the total program is considered reasonable.

FACTORS AFFECTING FUTURE MAINTENANCE COSTS - ALL REACHES

ZEBRA MUSSELS

74. Introduction. The Upper Mississippi River and Illinois Waterway are experiencing the infestation of zebra mussels (ZM). They have been detected at all lock and dam structures in all reaches. Therefore, zebra mussels have the potential to impact future maintenance at the lock and dam structures on the Upper Mississippi River and Illinois Waterway. Effects range from accelerated corrosion of unprotected steel to clogging of water intake pipes. It is the intent of this article to site the potential problems and estimate the cost of control measures in future operation and maintenance budgets for the subject river navigation system. Most of the information regarding the impacts of ZM's is taken from the Zebra Mussel Research Program at the Waterways Experiment Station. This program was established in early 1992. Since that time, there have been a number of studies and research papers on zebra mussels. For example, the US Army Corps of Engineers, Waterway Experiment Station, published Technical Notes ZMR-2-14 and ZMR-3-17, Control Methods in May of 1994. An impact of 2% to the baseline estimate or an additional $2 million dollars per year, over the study period, is estimated for the control of zebra mussels.

75. Background. Zebra Mussels are bivalve fresh water mollusks that possess distinctive light and dark colored stripes on their shell. Although the mature adult is only 1/2 inch long, they are extremely prolific and can rapidly create encrustations that can impede the efficient operation of water control and navigation structures in navigable waterways. The lifespan of a zebra mussel is highly variable depending on a number of environmental conditions. Lifespans average around 3.5 years but can reach 8 to 10 years. Mature female mussels can produce 30,000 to 40,000 eggs per year, as the water temperatures reach 54 deg F. The mussel was accidently introduced into Lake St. Clair, MI, from northern Europe via ballast water from an ocean going vessel. Zebra Mussels then travelled to the Illinois Waterway from the Great Lakes where they were discovered in 1988 on intake pipes[1]. They travelled with the current and on barges down the Illinois Waterway to the Mississippi River. They have been carried up the Mississippi River by barges. They were noticed in the Mississippi River in September 1991 at Melvin Price Locks and Dam[2], in January 1992 at Lock and Dam 24[3], and in December 1993 at Lock and Dam 6[4]. During the dewatering of Lock 7 in the Winter of 1994/95, zebra mussels were found on gates, valves, and concrete. Also, prior to the Midwest Flood of 1993 and until the swollen Illinois River receded, Lagrange Lock and Dam, the lowest lock on the Illinois River, was underwater for at least six months. After the river receded, lock personnel discovered that every surface of the lock was covered with ZM's except the galvanized handrails. In July of 1995, discussions with personnel

at Locks and Dams 24, 25, 27, Melvin Price, Peoria, and LaGrange, have revealed lower levels of ZM infestation than noticed in 1993. In August of 1995, four locks, Brandon Road, Lockport, Marsailles and Dresden Island on the Illinois Waterway, were dewatered for major rehabilitation. The level of infestation was found to vary at each lock, but overall levels were less than those observed at the Melvin Price main lock earlier in the same year. These observations show that the level of infestation of ZM's on the Upper Mississippi and Illinois Waterway could be transient. It is not known if this varying state of infestation is a trend or if the ZM colonization has reached a steady state. Based on documented experiences at other locations (the Great Lakes, Europe) where ZM's have established colonies, they have an adverse effect and cost implication on operating systems.

76. Problem Statement. There are thirty-seven locks and dams on the two rivers in the Navigation Study. Each of which has many components that reference material[5] considers susceptible to infestation of ZM's. The components are as follows: raw water intake pipes and screens, bubbler pipes, gage wells, floating mooring bitts, wicket gates, culvert valves, pressure transducers, trash racks, bulkhead slots/seals, miter gates, lift gates, tainter gates and machinery, gate recesses, and ladders. Many control strategies are recommended in the literature. Some require physically removing the ZM's. Others require replacement materials/coatings that are toxic to ZM's. Control strategies will be quantified and have a cost computed to determine their impact on operation and maintenance expenditures on the river navigation system. Control strategies are summarized as follows:

- monitoring and documentation
- removal by scraping, steaming, and other means
- coatings (paint and other)
- modifications of lock components and features
- modification of operational procedures (chlorine flushes)

77. Solution. ZM population is somewhat controlled by normal lock operation. ZM's can be killed by prolonged exposure of the mussel to ambient air temperatures resulting from dewatering a lock, pulling a gate/valve out for maintenance, or fluctuating water levels. These occurrences control the adverse impacts on isolated components by reducing the population of ZM's on the component. Several agencies (Federal, local, State) have performed research and testing with the goal of controlling zebra mussels. Powerplants along the Great Lakes have also been actively involved in control strategies of zebra mussels. Several means are now available to prevent infestation on navigational structures. Because of these efforts, it is expected that O & M costs related to control of zebra mussels will be minimized during the study period.

78. Cost Summary. A range of cost estimates could be envisioned

for the control of ZM's due to the uncertainty of both the level of infestation and the adverse impacts upon infestation. It is possible, but unlikely, that ZM could add no additional cost to the normal operation and maintenance budget and hence not impact the baseline estimate. At the other extreme, a cost estimate considering a likely scenario of infestation with deleterious effects on many lock and dam components with many capital improvements made can be considered. This analysis showed a $6 million dollar a year impact or 5% of the baseline estimate. As stated, it is expected that the final impacts of zebra mussels will be minimized because of on-going research and current control measures. Thus, the dollar impact "guesstimated" is on the lower side of the above range. A final figure of $2 million dollars per year or a 2% impact to the baseline estimate was selected.

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FACTORS AFFECTING FUTURE MAINTENANCE COSTS - ALL REACHES

PAINTING AND LEAD ABATEMENT

79. Introduction. The main purpose of Objective 1 is to project Operating and Maintenance costs into the future for the baseline condition assuming continuation of past maintenance practices. A concern was expressed that a cost projection of past painting costs would not reflect recent and proposed changes to painting laws and regulations. These new laws prohibit (or may prohibit) some of the past painting practices. This article is a report of the findings of an investigation on projected changes in painting costs. Much of this information was provided by Mr. Al Beitelman, a paint researcher with the Construction Engineering Research Laboratory (CERL) in Champaign, IL. A 2% increase to the baseline estimate is the estimated impact from future painting regulations. It is also assumed that vinyl paint systems will not be banned, at least for the first half of the study period.

80. Hydraulic Structures. Historically, the Corps has applied vinyl paint systems to all steel structures that are periodically or continuously inundated by water. These structures include tainter and roller gates, lock gates, and lock valves. Within the last few years, there have been proposed Federal regulations to eliminate vinyl paint systems nationwide. However, the most recent draft Federal law does not ban the use of vinyl paint. Although States may enact stricter painting regulations than the Federal government, the states having jurisdiction over the Upper Mississippi River and Illinois Waterway (UMR&IW) system have no current proposals to ban vinyl systems.[1] So with no definite plans to eliminate vinyl paint systems, forecasting changes from past trends of painting costs becomes very uncertain.

81. Cost Scenario for Banning Vinyl Paint. As a worst case scenario, it could be assumed that vinyl paint systems will be banned immediately. The leading alternative paint system based on CERL research consists of an epoxy primer with a urethane top coat. Preparation costs are the same, however, the complete costs of the two systems compare as follows: $19 per square foot for the vinyl, and $27 per square foot for the epoxy/urethane. In addition, the epoxy/urethane system is expected to have about one-half of the service life as the vinyl system.[2] The net result is that changing immediately from the vinyl to the epoxy/urethane would have about

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[1]The State of Wisconsin limits the amount of vinyl paint that may be applied per day. However, within the portion of the UMR&IW system included in the Navigation Study, the State of Wisconsin only has jurisdiction over Lock and Dam 4, 6, 8, 9, and 11 for onsite painting.

[2]CENCR (vinyl) painting cycles has run about 20 to 25 years for dam gates and 15 to 20 years for miter gates.

a 4.6-fold increase in painting costs assuming a 20-year painting cycle for the vinyl and a 10-year cycle for the epoxy/urethane.[3] Mr. Beitelman reports that the durability of the epoxy/urethane system may eventually be made equal to the vinyl. If this happened the increase would only be 42 percent (the same as the difference between the unit prices of $19/s.f. and $27/s.f.).

82. Vinyl and Epoxy Paint Comparison. The gates in the Rock Island District, Reach 2, will be used to compare vinyl and epoxy paint systems. Assuming that Rock Island District paints all 2,274,220 s.f. of its Mississippi River miter gates, tainter valves, tainter gates, and roller gates[4] on a 20-year cycle with the vinyl paint system, the total painting cost (present worth) would be $11,600,000. The same surface area painted with the epoxy/urethane system would cost from $16,500,000 to $52,300,000 (present worth) depending on the assumption of service life, varying from equal to that of vinyl to one-half that of vinyl. Therefore, the worst case scenario of an immediate ban on vinyl would represent a present worth cost increase of $4.9 to 40.7 million, depending on the actual painting cycle. This represents increases in the total L/D 11 - L/D 22 operating and maintenance budget (excluding Major Rehabilitation) of 1.3 to 11 percent. The above cost increases are based on an assumption that vinyl paint systems will be banned, an action that may not happen.

83. Painting Non-Hydraulic Structures. For steel structures not subject to immersion in water (such as service bridges and cranes), the commonly used coating has been lead-based paint. Recent environmental regulations have required complete containment and capture of particles of paint removed in preparation for repainting. Then, the blast sand waste must be disposed of as a contaminated material. If the concentrations of lead are high enough in the blast sand (or in the paint otherwise removed), the waste must be handled and disposed of as a hazardous material. These requirements, mainly put into effect in 1992 by OSHA regulations, have increased painting costs of structures coated with lead-based paints. The total cost of repainting steel structures coated with lead-based paint (including removal and disposal, surface preparation, and repainting) has increased from about $4 per s.f. to $12 per s.f. With the estimated 1,200,000 s.f. of steel structures coated with lead paint from L/D 11 through L/D 22, the additional cost will be about $10,000,000. However,

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[3]This also assumes 8% interest and that the gates have just been painted.

[4]The surface areas for Mississippi River Locks and Dams 11 through 22 is broken down as 830,000 s.f. for miter gates; 72,860 s.f. for tainter valves; 907,940 s.f. for tainter gates (outsides only), and 463,421 s.f. for roller gates (outsides only) for a total of 2,274,220 square feet.

this is a one-time expenditure and some of these costs have already been incurred. Once the lead is removed and non-lead paints are used, costs will again be comparable to historic costs adjusted for inflation. For purposes of the Navigation Study, it is suggested that the lead-based paint cost impact be ignored since most of the costs will have been incurred by the year 2000 (the start of the Navigation Study planning period).

84. Lead Cables. Lead is also contained in the electrical cable system at most of the lock sites. It may be necessary to incorporate rigid abatement and removal procedures for this lead cable. However, this cost is expected to be minimal compared to the overall maintenance budget of the system.

85. Estimated Cost Impacts. A wide range of cost impacts could be estimated because of the uncertainty of any future painting regulations. It will be assumed, however, that vinyl paint will not be banned. This will limit any future cost impacts. On the low estimate side, it can be assumed that no impact to operation and maintenance costs and the baseline estimate will occur. However, it is likely future regulations will have some impact on costs. Painting costs fall primarily under the Maintenance cost category. This particular cost category accounts for approximately 20% of the baseline estimate. It is "guesstimated" a 10% increase in the Maintenance cost will occur over the study period. This means a 2% increase in the baseline estimate (10% of 20%).

FACTORS AFFECTING FUTURE MAINTENANCE COSTS - ALL REACHES
FUTURE TRAFFIC INCREASES AT THE LOCK AND DAM SITES:

86. Introduction. It is concluded that increasing traffic levels may increase O & M costs slightly over the study period but the effect will be insignificant. A 1% impact to the baseline estimate is "guesstimated". Barge and recreational traffic varies considerably among the four Reaches. More detailed tabulated data on navigation traffic and commercial tonnage for each lock site and Reach is provided in the separate volumes of Objective 1 Part 2 and Part 3 (Appendix). To fully analyze the effect navigation traffic has and will have on operation and maintenance costs, the current traffic levels and capacities of the locks need to be determined. In general, traffic appears to have leveled off in Reaches 1 and 4. Traffic is increasing almost linearly in Reaches 2 and 3. Reach 3 has the highest per lock traffic. The current and future traffic levels are discussed further in the following paragraphs.

87. Graphs have been constructed showing the cumulative number of lockages for all the sites on a yearly basis in the four separate volumes of Objective 1, Part 2. Data for recent trends in the number of lockages and the total tonnage shipped through the locks (by Reach) are shown below:

FISCAL	TOTAL NUMBER OF LOCKAGES			
YEAR	REACH 1	REACH2	REACH 3	REACH 4
1992	64,787	72,112	37,089	42,892
1991	64,757	71,773	34,299	41,711
1990	69,099	77,115	37,160	41,994
1989	68,329	71,982	40,245	45,207
1988	68,245	72,662	41,977	42,593

FISCAL	TOTAL TONNAGE SHIPPED THROUGH SYSTEM*			
YEAR	REACH 1	REACH2	REACH 3	REACH 4
1992	155,325,700	377,744,000	234,938,760	167,932,000
1991	146,551,000	356,979,000	231,104,111	168,416,000
1990	168,502,000	404,298,000	250,513,313	176,480,000
1989	139,043,000	340,738,000	216,112,150	154,674,000
1988	136,648,000	347,971,000	226,366,739	156,838,000

* Commercial traffic only. Includes all the locks within each Reach. Cargo includes coal, grain, oil, etc.

88. Navigation Traffic Reports. The 1988 and 1992 Inland Waterway Review Reports both discuss in detail the traffic capacities and utilization of fuel taxed waterways (across the United States), including the Upper Mississippi River and Illinois Waterway. These

reports are produced by the US Army Corps of Engineers, Water Resources Support Center, Fort Belvoir, VA. Several tables and graphs are excerpted from these reports and follow this write-up. The trends in future lock traffic on the Upper Mississippi River and Illinois waterway will be analyzed based on these reports.

89. Lock Performance. The following information is excerpted from the 1992 Inland Waterway Review Report. "The capacity of a lock depends on many variables. Capacity is an estimate of the maximum number of tons of cargo of a specified mix that may transit a lock in a given period of time under a specific set of assumptions. The difference between high and low capacity estimates can be substantial, depending on assumptions about the level and type of future lock traffic, vessel operating practices, and lock operating conditions. The low capacity estimate is used in this Review.

Although lock time utilization and capacity utilization measures are not identical, the two generally can be expected to correlate closely. Either measure has certain limitations. Lock capacity utilization rates reflect the actual mix of traffic, existing conditions, and other variables. The unutilized or idle time can be a good indication of residual capacity. However, the utilization rate as used herein does not distinguish between processing time and stall time. A high time utilization rate may reflect high traffic levels or excessive stall time or downtime. It implies a lock is approaching capacity, but it may be due to operating problems that can be cured without replacement."

"A closer look at the main chamber locks with time utilization of at least 60% in 1990 shows that 19 are on the Mississippi River from Melvin Price Lock and Dam, north of St. Louis to Lock and Dam 1 near St. Paul, Minnesota."

90. Recreational Lockages. Recreational and pleasure boat lockages account for a large portion of the total number of lockages for all the Reaches. This trend should continue into the future. Recreational lockages account for approximately 50% of the total lockages in Reach 1, 23% for Reach 2, and 20% for Reach 4. The locks within Reach 1 (St. Paul District) have some of the highest recreational traffic in the U.S. In 1990, 16 of the 28 locks with the highest recreational use were on the Upper Mississippi River, north of Davenport, Iowa.

91. Trends in Future Lock Traffic. As stated, the number of lockages in Reaches 1 and 4 has appeared to level off. The traffic in Reaches 2 and 3, when viewed on a long term basis, is increasing linearly. If this trend continues, a 25% to 50% increase in traffic can be expected through the study period for both Reach 2 and Reach 3. Locks 22, 24, and 25 are expected to reach 100% capacity by the year 2000. Locks 14, 15, 16, 17, 18, 20, and 21 are expected to reach 100% capacity by the year 2020. Thus, traffic increases and the effect on the lock structures will primarily impact the locks

and dams within Reaches 2 and 3. The following is excerpted from the 1992 Inland Waterway Review Report:

"Traffic projections for the Upper Mississippi are driven by recovery and growth in farm products traffic in particular (53% of total), as well as increases in coal and industrial and agricultural chemicals. Total traffic is projected to increase from 85.1 million tons in 1990 to between 93.3 and 112.4 million tons by the year 2000."

"Traffic on the Illinois Waterway peaked at 45.8 million tons in 1975. It began to falter in the late 1970's and into the recession years of the early 1980's as the traditional heavy industries of this region fell on hard times."

"Projections of traffic on the Illinois Waterway anticipate moderate growth through 2000. Total tonnage is expected to increase from 43 million tons in 1990 to between 50.1 and 60.1 million tons by the turn of the century."

92. Operation & Maintenance Effects. Operation and maintenance costs can be measured both on a per unit basis (cost per lockage or cost per 1000 tons cargo) and on an absolute basis (total cost of Reach 1 O & M, for example). Both of these costs have been presented in this report. The O & M costs on a per unit basis will certainly decrease as the amount of cargo shipped and navigation traffic increases. The data from the Inland Waterway Review Report and the data obtained from this Engineering Objective 1 Report substantiates this relationship. The following is excerpted from the 1992 Inland Waterway Review Report:

"High traffic volume waterway segments generally have lower O & M costs per ton-mile than segments with low traffic volume. Overall O & M costs averaged 1.6 mills per ton mile in FY 1990, and ranged from an average of 0.6 mills for the lower Mississippi to about 29 mills for the AIWW/IWW."

Reach 2 has the highest number of lockages and also the largest amount of cargo shipped. The cost per lockage, however, is only slightly higher than that for Reach 1. The total cost per 1000 tons of cargo shipped is half of the Reach 1 cost.

The effect of increased traffic on absolute O & M costs is more difficult to ascertain. The effects of increased traffic will be more evident in Reaches 2 and 3. It is possible that no impact to the baseline estimate will occur over the course of the study period. This will probably be the case for Reaches 1 and 4. However, it is more likely that O & M costs will increase at least slightly in Reaches 2 and 3. A 1% total impact to the baseline estimate is "guesstimated". This is approximately a cost of $1.2 million dollars per year for the system.

93. Reliability. The increased traffic levels will affect the reliability of the system, however. This is an issue that is further examined in Engineering Objective 2. Increases in the commercial and recreational traffic levels logically dictate an increased wear and tear on the mechanical equipment, gates, valves, electrical equipment, etc. This could possibly affect electrical equipment and mechanical equipment by shortening their life span. The miter gates and anchorage will be put through a greater number of cycles. This could lead to more repairs and maintenance. To help prevent an unexpected shutdown or breakdown, a more rigorous preventative maintenance program may need to be put into effect. Periodic inspections may need to be done more frequently.

APPENDIX TABLE 8

PERFORMANCE MONITORING SYSTEM

1990 PMS DATA FOR WATERWAY SYSTEMS LOCKS

LOCK NAME	AVERAGE DELAY TIME (MIN)	AVERAGE PROCESSING TIME (MIN)	TOTAL DELAY TIME (HRS)	TOTAL STALL TIME (HRS)	TOTAL NO. OF STALLS	LOCK UTIL. RATE (%)	LOCK TRAFFIC (MILLIONS OF TONS)
#1 UPPER MISSISSIPPI							
UPPER ST. ANTHONY (UPPER MISS)	1	12	38	4	7	41	1.2
LOWER ST. ANTHONY (UPPER MISS)	2	14	36	3	5	41	1.5
L&D 1 (UPPER MISS)	1	12	65	1	2	44	1.5
L&D 2 (UPPER MISS)	9	22	1181	5	2	61	14.2
L&D 3 (UPPER MISS)	7	16	1167	25	10	61	14.1
L&D 4 (UPPER MISS)	6	18	806	3	3	58	14.7
L&D 5 (UPPER MISS)	7	23	694	2	2	57	14.7
L&D 5A (UPPER MISS)	7	19	681	1	2	55	14.9
L&D 6 (UPPER MISS)	8	23	1104	8	3	60	17.0
L&D 7 (UPPER MISS)	10	22	1456	47	14	61	17.0
L&D 8 (UPPER MISS)	15	34	1494	11	11	60	17.5
L&D 9 (UPPER MISS)	10	29	893	14	9	59	18.3
L&D 10 (UPPER MISS)	12	34	1417	5	4	60	20.9
L&D 11 (UPPER MISS)	23	45	3574	77	37	66	20.4
L&D 12 (UPPER MISS)	27	56	3137	38	20	59	24.7
L&D 13 (UPPER MISS)	24	50	2952	61	50	63	25.3
L&D 14 CHM 1 (UPPER MISS)	163	220	13351	105	39	70	31.6
L&D 14 CHM 4 (UPPER MISS)	0	5	0	0	0	68	0.0
L&D 15 CHM 1 (UPPER MISS)	176	260	10166	933	525	70	31.5
L&D 15 CHM 4 (UPPER MISS)	3	11	72	208	18	30	0.4
L&D 16 (UPPER MISS)	77	133	6522	103	78	77	34.1
L&D 17 (UPPER MISS)	178	250	12721	86	48	81	37.3
L&D 18 (UPPER MISS)	120	177	10228	80	97	80	37.7
L&D 19 (UPPER MISS)	41	85	3467	72	60	45	39.2
L&D 20 (UPPER MISS)	247	316	18954	961	87	65	39.8
L&D 21 (UPPER MISS)	102	162	8748	302	77	65	40.8
L&D 22 (UPPER MISS)	218	288	18556	285	83	73	41.4
L&D 24 (UPPER MISS)	241	304	22687	183	391	73	42.4
L&D 25 (UPPER MISS)	127	177	14312	175	204	70	42.3
MELVIN PRICE CHM 1 (UPPER MISS)	163	197	31574	520	500	82	79.9
MELVIN PRICE CHM 4 (UPPER MISS)	173	246	510	5	33	96	0.5
#2 MIDDLE MISSISSIPPI							
L&D 27 CHM 1 (MID MISS)	73	113	9644	239	73	68	74.1
L&D 27 CHM 4 (MID MISS)	140	168	11374	950	41	31	11.3
KASKASKIA (MID MISS)	1	13	39	11	8	13	3.4
#3 LOWER MISSISSIPPI							
NORRELL (McCLELLAN-KERR)	2	32	61	8	7	12	5.8
L&D 2 (McCLELLAN-KERR)	6	45	160	8	8	16	5.9
L&D 3 (McCLELLAN-KERR)	4	34	86	21	6	7	5.5
EMMETT SANDERS (McCLELLAN-KERR)	4	34	92	20	4	8	5.2
L&D 5 (McCLELLAN-KERR)	3	32	56	0	0	14	4.7
DAVID TERRY (McCLELLAN-KERR)	3	26	71	1	1	12	4.7
MURRAY (McCLELLAN-KERR)	4	24	34	0	1	15	4.0
TOAD SUCK FERRY (McCLELLAN-KERR)	3	40	45	5	2	11	3.9
ARTHUR ORMOND (McCLELLAN-KERR)	4	45	53	7	5	10	4.1
DARDANELLE (McCLELLAN-KERR)	8	44	124	3	2	12	3.7
OZARK (McCLELLAN-KERR)	6	47	75	6	3	12	3.7
JAMES TRIMBLE (McCLELLAN-KERR)	5	38	105	4	2	14	4.1
W.D. MAYO (McCLELLAN-KERR)	2	42	48	14	11	12	3.5
ROBERT S. KERR (McCLELLAN-KERR)	4	50	57	12	13	12	3.5
WEBBERS FALLS (McCLELLAN-KERR)	3	59	51	3	3	13	3.5
CHOUTEAU (McCLELLAN-KERR)	2	56	20	0	0	10	3.0
NEWT GRAHAM (McCLELLAN-KERR)	3	71	31	1	1	9	2.9

APPENDIX TABLE B (con't)

PERFORMANCE MONITORING SYSTEM

1990 PMS DATA FOR WATERWAY SYSTEMS LOCKS

LOCK NAME	AVERAGE DELAY TIME (MIN)	AVERAGE PROCESSING TIME (MIN)	TOTAL DELAY TIME (HRS)	TOTAL STALL TIME (HRS)	TOTAL NO. OF STALLS	LOCK UTIL. RATE (%)	LOCK TRAFFIC (MILLIONS OF TONS)
#3 LOWER MISSISSIPPI (CONT.)							
JONESVILLE (OUACHITA & BLACK)	1	24	9	0	1	4	0.8
COLUMBIA (OUACHITA & BLACK)	2	28	11	0	0	8	0.6
FELSENTHAL (OUACHITA & BLACK)	2	8	0	0	0	30	0.0
H.K. THATCHER (OUACHITA & BLACK)	3	12	0	1	1	29	0.0
L&D 1 (RED R.)	4	22	65	3	2	16	1.7
JOHN H. OVERTON (RED R.)	6	39	78	11	2	14	1.6
OLD RIVER (OLD RIVER)	15	64	659	44	24	25	6.3
BERWICK (ATCHAFALYA)	2	19	20	2	2	42	0.1
#4 ILLINOIS WATERWAY							
T.J. O'BRIEN (ILLINOIS)	0	9	118	8	8	30	7.7
LOCKPORT (ILLINOIS)	44	96	3789	102	41	53	17.4
BRANDON ROAD (ILLINOIS)	36	87	3182	36	69	54	17.5
DRESDEN (ILLINOIS)	20	54	2344	27	22	47	19.7
MARSEILLES (ILLINOIS)	38	83	4035	135	122	60	21.5
STARVED ROCK (ILLINOIS)	24	62	2662	34	43	51	23.7
PEORIA (ILLINOIS)	36	57	3218	84	33	22	32.9
LAGRANGE (ILLINOIS)	78	108	5292	67	37	26	36.0
#5 OHIO RIVER SYSTEM							
BELLEVILLE CHM 1 (OHIO)	13	67	671	28	7	33	36.5
BELLEVILLE CHM 4 (OHIO)	1	23	8	1	1	8	0.5
RACINE CHM 1 (OHIO)	50	102	1428	1524	47	39	32.0
RACINE CHM 4 (OHIO)	85	136	1750	1055	24	29	6.4
GALLIPOLIS CHM 1 (OHIO)	301	406	18597	1606	83	82	39.5
GALLIPOLIS CHM 2 (OHIO)	199	243	5851	26	8	16	2.1
GREENUP CHM 1 (OHIO)	26	77	2258	15	6	50	52.5
GREENUP CHM 4 (OHIO)	7	40	173	0	0	14	1.6
MELDAHL CHM 1 (OHIO)	38	94	2536	413	10	49	50.5
MELDAHL CHM 4 (OHIO)	32	48	2433	9	3	17	2.6
WILLOW ISLAND CHM 2 (OHIO)	14	69	704	12	5	31	33.3
WILLOW ISLAND CHM 4 (OHIO)	18	41	476	497	6	6	0.6
EMSWORTH CHM 1 (OHIO)	42	101	3267	98	80	55	21.8
EMSWORTH CHM 4 (OHIO)	3	20	113	17	18	21	0.9
DASHIELDS CHM 1 (OHIO)	60	124	4768	132	71	62	23.8
DASHIELDS CHM 4 (OHIO)	67	83	285	3382	16	10	0.2
MONTGOMERY CHM 1 (OHIO)	63	132	4547	83	109	60	25.2
MONTGOMERY CHM 4 (OHIO)	5	22	109	212	12	11	0.3
NEW CUMBERLAND CHM 1 (OHIO)	16	74	816	30	14	35	29.1
NEW CUMBERLAND CHM 4 (OHIO)	15	45	532	570	7	17	1.7
PIKE ISLAND CHM 1 (OHIO)	16	65	909	108	10	34	34.4
PIKE ISLAND CHM 4 (OHIO)	18	46	159	628	10	15	1.5
HANNIBAL CHM 1 (OHIO)	20	72	1052	133	66	35	35.5
HANNIBAL CHM 4 (OHIO)	66	98	704	895	13	7	0.6
MARKLAND CHM 2 (OHIO)	28	82	2144	77	31	49	50.8
MARKLAND CHM 4 (OHIO)	34	61	970	961	5	20	0.5
McALPINE CHM 2 (OHIO)	39	84	4495	93	85	62	56.7
McALPINE CHM 4 (OHIO)	2	10	0	0	0	66	0.0
L&D 52 CHM 1 (OHIO)	61	80	11612	53	46	39	95.4
L&D 52 CHM 5 (OHIO)	28	67	715	15	16	78	3.8
CANNELTON CHM 2 (OHIO)	49	104	4441	119	82	59	59.4
CANNELTON CHM 4 (OHIO)	3	27	14	2	4	9	0.5
NEWBURGH CHM 2 (OHIO)	32	77	3548	28	71	58	68.9
NEWBURGH CHM 4 (OHIO)	1	22	42	1	2	17	2.9
UNIONTOWN CHM 2 (OHIO)	50	92	6653	74	105	65	79.9
UNIONTOWN CHM 4 (OHIO)	1	17	19	2	9	15	0.6

LOCKS WITH AVERAGE DELAY OF AT LEAST ONE HOUR IN 1990 (MAIN CHAMBER DATA ONLY)

LOCK (WATERWAY)	AVERAGE DELAY (RANK)	AVERAGE DELAY TIME PER VESSEL (HRS)(1)	AVERAGE PROCESS TIME (HRS)(2)	TOTAL DELAY TIME (HRS)(3)	TOTAL STALL TIME (HRS)	TOTAL NO. OF STALL EVENTS	LOCK TIME UTIL (%)(4)	LOCK TRAFFIC (MILLIONS) OF TONS)
INNER HARBOR (GIWW)	1	8.5	9.2	148374	2397.6	229	92.9	23.4
WINFIELD (KANAWHA)(6)	2	5.4	7.5	14764	1870.2	264	93.5	13.8
GALLIPOLIS (OHIO)(6)	3	5.0	6.8	18596	1606.4	87	82.2	39.5
LONDON (KANAWHA)	4	4.7	5.9	2585	3584.6	391	32.0	2.8
L&D 20 (UPPER MISS)	5	4.1	5.3	18954	960.7	87	65.3	39.8
L&D 24 (UPPER MISS)	6	4.0	5.1	22687	183.4	391	73.3	42.4
PORT ALLEN (GIWW)	7	3.6	4.5	32719	16533.7	5151	73.6	27.6
L&D 22 (UPPER MISS)	8	3.6	4.8	18556	285.0	83	73.2	41.4
BAYOU SORREL (GIWW)	9	3.0	3.9	28089	289.0	72	71.7	37.2
L&D 17 (UPPER MISS)	10	3.0	4.2	12721	85.6	48	81.2	37.3
L&D 15 (UPPER MISS)	11	2.9	4.3	10165	933.5	525	70.2	31.5
ALGIERS (GIWW)	12	2.8	3.8	40438	91.5	41	88.3	24.8
L&D 14 (UPPER MISS)	13	2.7	3.7	13350	105.2	39	69.5	31.6
KENTUCKY (TENNESSEE)	14	2.4	3.6	12089	185.7	321	78.8	28.9
MARMET (KANAWHA)	15	2.3	4.2	4663	477.1	45	74.2	9.1
L&D 25 (UPPER MISS)	16	2.1	2.9	14312	175.0	204	69.7	42.3
L&D 18 (UPPER MISS)	17	2.0	3.0	10228	79.9	97	79.9	37.7
L&D 21 (UPPER MISS)	18	1.7	2.7	8748	302.3	77	65.5	40.8
HARVEY (GIWW)	19	1.3	1.9	12621	529.9	301	51.0	3.6
LAGRANGE (ILLINOIS)	20	1.3	1.8	5292	67.2	37	26.0	36.0
L&D 16 (UPPER MISS)	21	1.3	1.7	6522	102.7	78	77.0	34.1
L&D 27 (MID MISS)	22	1.2	1.9	9644	239.4	73	68.1	74.1
*BONNEVILLE (COLUMBIA)(5)(6)	23	1.1	1.2	2507	26.3	11	75.2	7.6
FORT LOUDON (TENNESSEE)	24	1.1	1.6	717	1987.2	269	25.0	0.6
CALCASIEU (GIWW)	25	1.1	1.7	19273	1204.9	518	76.2	46.3
AVERAGE DELAY AVERAGE (200 LOCKS)		.94						

NOTES:
(1) Average delay time = (wait time + stall time) / no. of vessels.
(2) Average process time = (wait time + approach time + entry time + chamber time + exit time + turnback time + stall time) / no. of vessels.
(3) Commercial vessels only. Due to overlapping time between vessels, there may be more delay than the number of hours in a year.
(4) Lock time utilization based on main chamber if multiple chamber lock.
(5) Not on fuel taxed system.
(6) Replacement lock in construction and/or just completed, so future operation should be more smooth.
* No data available for January and May 1990.

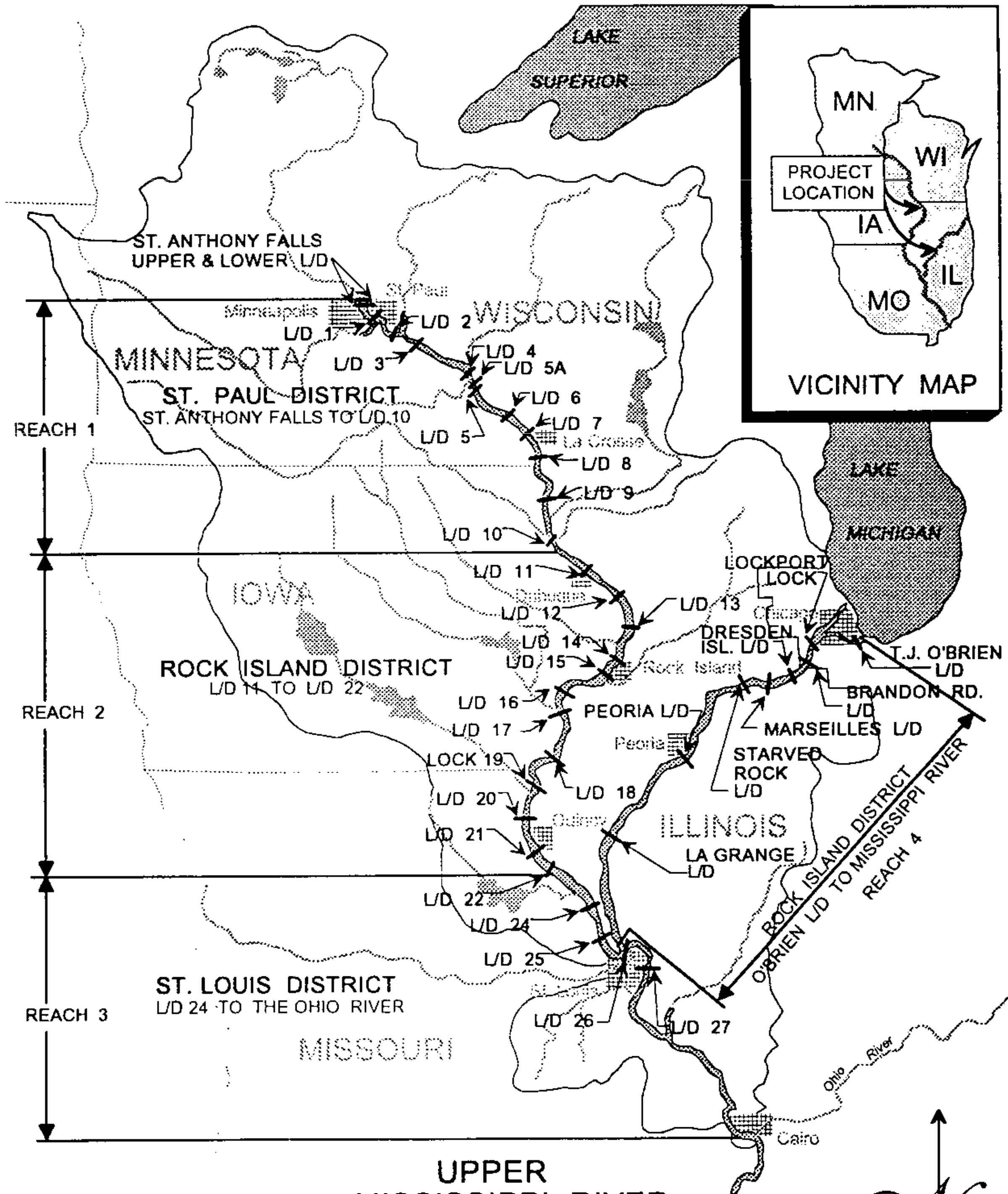
LOCKS WITH OVER 3,000 RECREATIONAL VESSELS IN 1990 (MAIN CHAMBER DATA ONLY)

LOCK (WATERWAY)	REC. VESSELS (RANK)	REC. VESSELS (000)	REC. LOCKAGES (%)	REC. TIME UTIL. (1)
L&D 3 (UPPER MISS)	1	17.8	91.2	55.8
T.J. O'BRIEN (ILLINOIS)	2	15.7	83.6	24.8
L&D 7 (UPPER MISS)	3	12.6	87.0	53.0
L&D 2 (UPPER MISS)	4	12.2	86.8	53.0
L&D 4 (UPPER MISS)	5	12.1	87.8	50.9
ALBEMARLE & CHEASPEAKE (AIWW)	6	11.2	80.7	19.6
L&D 5A (UPPER MISS)	7	10.7	85.5	47.3
L&D 6 (UPPER MISS)	8	10.2	85.1	50.9
L&D 5 (UPPER MISS)	9	8.7	83.7	47.8
L&D 2 (ALLEGHENY)	10	7.8	77.9	23.1
L&D 8 (UPPER MISS)	11	7.6	80.9	48.6
L&D 11 (UPPER MISS)	12	7.2	74.8	49.5
L&D 9 (UPPER MISS)	13	7.0	79.4	46.5
L&D 1 (UPPER MISS)	14	6.7	83.3	37.0
L&D 10 (UPPER MISS)	15	6.0	73.6	44.0
CHICKAMAUGA (TENNESSEE)	16	6.0	88.0	33.2
L&D 13 (UPPER MISS)	17	4.8	60.9	38.4
UPPER ST. ANTHONY (UPPER MISS)	18	4.7	68.9	28.1
LOWER ST. ANTHONY (UPPER MISS)	19	4.6	75.5	31.3
L&D 12 (UPPER MISS)	20	4.5	59.8	35.1
DRESDEN (ILLINOIS)	21	3.7	52.9	25.1
L&D 4 (ALLEGHENY)	22	3.6	67.9	11.7
L&D 3 (ALLEGHENY)	23	3.5	62.8	15.6
MARSEILLES (ILLINOIS)	24	3.4	52.0	31.1
STARVED ROCK (ILLINOIS)	25	3.4	50.3	25.5
COLORADO R. WEST (GIWW)	26	3.3	26.7	5.7
COLORADO R. EAST (GIWW)	27	3.0	24.8	5.7
BERWICK (ATCHAFALYA)	28	3.0	74.1	38.3

NOTES: (1) *Utilization rate times percent of recreational lockages.*
* The idle time (used in determining the utilization rate) was reported as more than the number of hours in a year. Therefore, rec. time util. is negative.

SECTION D: VITAL STATISTICS AND INVENTORY OF LOCK SITES IN NAVIGATION STUDY

FIGURE 1 - 1



UPPER
MISSISSIPPI RIVER
AND ILLINOIS WATERWAY
NAVIGATION SYSTEM

Illustrative Project Location Map – NOT TO SCALE

					CHAMBER		
	LOCK NAME OR NUMBER	RIVER MILE	YEAR OPENED	AGE IN 2000	WIDTH (feet)	LENGTH (feet)	LIFT (feet)
1	Upper St. Anthony Falls	853.9	1963	37	56	400	49
2	Lower St. Anthony Falls	853.3	1959	41	56	400	25
3	No. 1 Main Chamber	847.6	1930	70	56	400	38
	No. 1 Auxiliary Chamber	847.6	1932	68	56	400	38
4	No. 2 Main Chamber	815.0	1930	70	110	500	12
	No. 2 Auxiliary Chamber	815.0	1948	52	110	600	12
5	No. 3	769.9	1938	62	110	600	8
6	No. 4	752.8	1935	65	110	600	7
7	No. 5	738.1	1935	65	110	600	9
8	No. 5a	728.5	1936	64	110	600	5
9	No. 6	714.0	1936	64	110	600	6
10	No. 7	702.0	1937	63	110	600	8
11	No. 8	679.0	1937	63	110	600	11
12	No. 9	647.0	1938	62	110	600	9
13	No. 10	615.0	1936	64	110	600	8
14	No. 11	583.0	1937	63	110	600	11
15	No. 12	556.0	1938	62	110	600	9
16	No. 13	522.0	1938	62	110	600	11
17	No. 14 Main Chamber	493.3	1939	61	110	600	11
17	No. 14 Auxiliary Chamber	493.1	1922	78	80	320	11
18	No. 15 Main Chamber	482.9	1934	66	110	600	16
18	No. 15 Auxiliary Chamber	482.9	1934	66	110	360	16
19	No. 16	457.2	1937	63	110	600	9
20	No. 17	437.1	1939	61	110	600	8
21	No. 18	410.5	1937	63	110	600	10
22	No. 19	364.2	1957	43	110	1200	38
23	No. 20	343.2	1936	64	110	600	10
24	No. 21	324.9	1938	62	110	600	10
25	No. 22	301.2	1938	62	110	600	10
26	No. 24	273.4	1940	60	110	600	15
27	No. 25	241.4	1939	61	110	600	15
28	Price L&D Main Chamber	200.8	1990	10	110	1200	24
28	Price Aux. (under const.)	200.8	1992	8	110	600	24
	L&D 27 Main Chamber	185.1	1953	47	110	1200	21
	L&D 27 Auxiliary Chamber	185.1	1953	47	110	600	21
1	LaGrange L&D	80.2	1939	61	110	600	10
2	Peoria L&D	157.7	1939	61	110	600	11
3	Starved Rock L&D	231.0	1933	67	110	600	19
4	Marseilles L&D	244.6	1933	67	110	600	24
5	Dresden Island L&D	271.5	1933	67	110	600	22
6	Brandon Road L&D	286.0	1933	67	110	600	34
7	Lockport Lock	291.1	1933	67	110	600	40
8	T.J. O'Brien Lock	326.5	1960	40	110	1000	5

NAVIGATION STUDY OBJECTIVE 1

LOCK AND DAM INVENTORY

SHEET 1 OF 3

MISSISSIPPI RIVER: UPPER SAINT ANTHONY FALLS LOCK AND DAM THROUGH LOCK 27

ILLINOIS WATERWAY: NEW LAGRANGE LOCK AND DAM THROUGH THOMAS O'BRIEN LOCK AND DAM

MISSISSIPPI RIVER		Location	Lock Dimensions	Miles above Ohio	Traveling Downstream Lock on Left or Right Bank	Type of Lock Gate	# Roller Gates	# Tainter Gates
REACH 1 – NCS	USAF	Minneapolis, MN	56' x 400'	853.80	Right	Miter and Tainter	–	–
	LSAF	Minneapolis, MN	56' x 400'	853.40	Right	Miter and Tainter	–	4
	1	Minneapolis, MN	56' x 400'	847.60	Right	Miter Gate	–	–
	2	Hastings, MN	110' x 600'	815.20	Right	Miter Gate	–	20
	3	Red Wing, MN	110' x 600'	796.90	Right	Miter Gate	4	–
	4	Alma, WI	110' x 600'	752.80	Left	Miter Gate	6	22
	5	Minnesota City, MN	110' x 600'	738.10	Right	Miter Gate	6	28
	5A	Fountain City, WI	110' x 600'	728.50	Right	Miter Gate	5	5
	6	Trempealeau, WI	110' x 600'	714.30	Left	Miter Gate	5	10
	7	LaCrescent, MN	110' x 600'	702.50	Right	Miter Gate	5	11
	8	Genoa, WI	110' x 600'	679.20	Left	Miter Gate	5	10
	9	Eastman, WI	110' x 600'	647.90	Left	Miter Gate	5	8
	10	Guttenberg, IA	110' x 600'	615.10	Right	Miter Gate	4	8
REACH 2 – NCR	11	Dubuque, IA	110' x 600'	583.00	Right	Miter Gate	3	13
	12	Bellevue, IA	110' x 600'	556.70	Right	Miter Gate	3	7
	13	Fulton, IL	110' x 600'	522.50	Left	Miter Gate	3	10
	14	Le Claire,IA	110' x 600'	493.30	Right	Miter Gate	4	13
	15	Rock Island, IL	110' x 600'	482.90	Left	Miter Gate	11	–
	16	East Muscatine, IL	110' x 600'	457.20	Left	Miter Gate	4	15
	17	New Boston, IL	110' x 600'	437.10	Left	Miter Gate	3	8
	18	Gulfport, IL	110' x 600'	410.50	Left	Miter Gate	3	14
	19	Keokuk, IA	110' x 1200'	364.20	Right	Miter Gate\Vertical Lift	0	–
	20	Canton, MO	110' x 600'	343.20	Right	Miter Gate	3	40
	21	Quincy, IL	110' x 600'	324.90	Left	Miter Gate	3	10
	22	Saverton, MO	110' x 600'	301.20	Right	Miter Gate	3	10
REACH 3 – LMS	24	Clarksville, MO	110' x 600'	273.00	Right	Miter Gate	–	15
	25	Winfield, MO	110' x 600'	241.00	Right	Miter Gate	3	14
	26	Alton, IL	110' x 1200'	203.00	Left	Vertical Lift / Miter Gate	3	30
	27	Granite City, il	110' x 1200'	185.00	Left	Vertical Lift / Miter Gate	–	–
REACH 4 – ILLINOIS WATERWAY				Miles from Grafton				
	New La Grange	Versailles, IL	110' x 600'	80.00	Right	Miter Gate	–	1
	Peoria	Peoria, IL	110' x 600'	158.00	Left	Miter Gate	–	1
	Starved Rock	Ottawa, IL	110' x 600'	231.00	Right	Miter Gate	–	10
	Marseilles	Marseilles,IL	110' x 600'	245.00	Left	Miter Gate	–	11
	Dresden Island	Morris, IL	110' x 600'	272.00	Left	Miter Gate	–	9
	Brandon Road	Joliet, IL	110' x 600'	286.00	Right	Miter Gate	–	21
	Lockport	Lockport, IL	110' x 600'	291.00	Left	Miter Gate\Vertical Lift	–	–
	Thomas J. O'Brien	Chicago, IL	110' x 1000'	326.00	Right	Sector Gates	–	–

NCS = SAINT PAUL DISTRICT
NCR = ROCK ISLAND DISTRICT
LMS = SAIN[illegible]UIS DISTRICT

SHEET 2 OF 3

PROJECT	MILES ABOVE MOUTH	CHANNEL LENGTH	CHANNEL DEPTH	CHANNEL WIDTH	COMMUNITY IN VICINITY	YEAR STARTED	YEAR OPENED	LOCKS WIDTH	LOCKS AVAILABLE LENGTH FOR FULL WIDTH	LOCKS LIFT AT FULL POOL LEVEL	LOCKS DEPTH ON SILLS UPPER	LOCKS DEPTH ON SILLS LOWER	GATE TYPE LEAF	GATE TYPE LIFT	GATE TYPE SECTOR	DAM TYPE	DAM LENGTH (FEET)	NUMBER OF GATES TAINTERS SUBMERSIBLE	NUMBER OF GATES TAINTERS REGULAR	HEAD	SLUICE	ROLLER	WICKET	WIER
MISSISSIPPI RIVER																								
BETWEEN OHIO AND																								
MISSOURI RIVERS																								
LOCK AND DAM NO. 27	185.1L	17.8	9	200	GRANITE CITY, IL.			110	1200	21	18	15				FIXED	3240							
								110	1200	21	18	15												
BETWEEN MISSOURI RIV.																								
& MINNEAPOLIS, MN.																								
LOCK AND DAM NO. 26	202.9L	38.5	9	200	ALTON, IL.			110	600	24	19	10				MOVABLE	1725							
								110	360	24	18	10												
LOCK AND DAM NO. 25	241.4R	32	9	200	CAP AU GRIS, MO.			110	600	15	19	12				MOVABLE	1298							
LOCK AND DAM NO. 24	273.4R	27.8	9	200	CLARKSVILLE, MO.			110	600	15	19	12				MOVABLE	4280							
LOCK AND DAM NO. 22	301.2R	23.7	9	NS	SAVERTON, MO.	12-Jan-34	22-Jul-38	110	600	10.5	18	14	6			MOVABLE	1024	1P	9P			3		1
LOCK AND DAM NO. 21	324.9L	18.3	9	NS	QUINCY, IL.	12-Jan-34	21-Jul-38	110	600	10.5	17	12	6			MOVABLE	1066	10P	8P			3		1
LOCK AND DAM NO. 20	343.2R	21.0	9	NS	CANTON, MO.	03-Nov-33	09-Jun-38	110	600	10	15	12	6			MOVABLE	2144	6N	32N&2P			3		
LOCK AND DAM NO. 19	364.1R	46.3	9	NS	KEOKUK, IA.		15-Nov-57	110	1200	38.2	15	13	2	2		FIXED	4434					0		
LOCK AND DAM NO. 18	410.5L	26.6	9	NS	BURLINGTON, IA.	08-Nov-33	08-Sep-37	110	600	10	17	14	6			MOVABLE	1350	14P				3		
LOCK AND DAM NO. 17	437.1L	20.1	9	NS	NEW BOSTON, IL.	25-Jul-35	14-May-39	110	600	8	16	13	6			MOVABLE	921	8P				3		1
LOCK AND DAM NO. 16	457.2L	25.7	9	NS	MUSCATINE, IA.	11-Dec-33	10-Jul-37	110	600	9	17	12	6			MOVABLE	1099	3P	12P			4		1
LOCK AND DAM NO. 15	482.9L	10.4	9	NS	ROCK ISLAND, IL.	09-Apr-31	07-Mar-34	110	600	16	27	11	4			MOVABLE	1203					11		
								110	360	16	27	11	4											
LOCK AND DAM NO. 14	493.3R	29.2	9	NS	LECLAIRE, IA.	25-Jul-35	14-Jun-39	110	600	11	21	14	4			MOVABLE	1343		13P			4		
	493.1R							80	320	11	18	11	4											
LOCK AND DAM NO. 13	522.5L	34.2	9	NS	CLINTON, IA.	25-Jul-35	13-May-39	110	600	11	19	13	6			MOVABLE	1066	10P				3		1
LOCK AND DAM NO. 12	556.7R	26.3	9	NS	BELLEVUE, IA.	11-Dec-33	04-May-39	110	600	9	17	13	6			MOVABLE	849	7P				3		1
LOCK AND DAM NO. 11	583.0R	32.1	9	NS	DUBUQUE, IA.	11-Dec-33	14-Sep-37	110	600	11	19	13	6			MOVABLE	1278	13P				4		
LOCK AND DAM NO. 10	615.1R	32.8	9	NS	GUTTENBERG, IA.	11-Dec-33	28-Nov-38	110	600	8	15	12	6			MOVABLE	763		6P			4		1
LOCK AND DAM NO. 9	647.9L	31.3	9	NS	LYNXVILLE, IA.	24-Apr-35	08-Jul-37	110	600	9	18	13	6			MOVABLE	811		8P			5		1
LOCK AND DAM NO. 8	679.2L	25.3	9	NS	GENOA, WI.	04-Mar-35	04-Apr-37	110	600	11	22	14	6			MOVABLE	897		10P			5		2
LOCK AND DAM NO. 7	702.5R	11.8	9	NS	DRESBACH, MN.	18-Apr-35	19-Apr-37	110	600	8	18	12	6			MOVABLE	940		10P			5		2(OUL)
LOCK AND DAM NO. 6	714.3L	14.2	9	NS	TREMPEALEAU, WI.	03-Feb-35	30-Jun-36	110	600	6.5	17	12.5	6			MOVABLE	893		10P			5		1
LOCK AND DAM NO. 5A	728.5R	9.6	9	NS	WINONA, MN.	15-Feb-35	08-Jul-36	110	600	5.5	18	13	6			MOVABLE	682		5P			5		1
LOCK AND DAM NO. 5	738.1R	14.7	9	NS	MINNEISKA, MN.	18-Jun-34	29-May-35	110	600	9	18	12	6			MOVABLE	1619		28N			6		(3OUL)
LOCK AND DAM NO. 4	752.8L	44.1	9	NS	ALMA, WI.	05-Jan-34	25-May-35	110	600	7	17	13	6			MOVABLE	1367		22N			6		
LOCK AND DAM NO. 3	796.9R	18.3	9	NS	RED WING, MN.	13-Apr-37	21-Apr-38	110	600	8	17	14	6			MOVABLE	365					4		
LOCK AND DAM NO. 2	815.2R	32.4	9	NS	HASTINGS, MN.		01-Jul-48	110	600	12.2	22.2	13	4			MOVABLE	822		9N&11P					1
						30-Nov-30	01-Jul-31	110	500	12	16	15	4											
LOCK AND DAM NO. 1	847.6R	5.7	9	NS	MINNEAPOLIS-		03-Jul-17	56	400	38	13	8	4			FIXED	574					0		1
					ST. PAUL, MN.		30-Sep-17	56	400	38	13	10	4											
ST. ANTHONY FALLS																								
LOWER LOCK AND DAM	853.3R	0.5	9	NS	MINNEAPOLIS, MN.			56	400	24.9	13.7	12.2	2		1 TAINT.	MOVABLE	188		3P					
ST. ANTHONY FALLS																								
UPPER LOCK AND DAM	853.9R	3.8	9	NS	MINNEAPOLIS, MN.		21-Sep-63	56	400	49.2	15.7	13.7	4		1 TAINT.	FIXED	3584							1

SHEET 3 OF 3

PROJECT	MILES ABOVE MOUTH	CHANNEL LENGTH	CHANNEL DEPTH	CHANNEL WIDTH	COMMUNITY IN VICINITY	YEAR STARTED	YEAR OPENED	LOCKS #OF CHAMBER	LOCKS WIDTH	LOCKS AVAILABLE LENGTH FOR FULL WIDTH	LOCKS LIFT AT FULL POOL LEVEL	DEPTH ON SILLS UPPER	DEPTH ON SILLS LOWER	GATE TYPE LEAF	GATE TYPE LIFT	GATE TYPE SECTOR	DAM TYPE	DAM LENGTH (FEET)	NUMBER OF GATES TAINTERS SUBMERSIBLE	TAINTERS REGULAR	HEAD	SLUICE	ROLLER	WICKET	WIER
ILLINOIS WATERWAY, IL.																									
LAGRANGE L/D	80.2R	77.5	9	300	BEARDSTOWN, IL.	01-Sep-36	30-Jul-39		110	600	10	16	13	4			MOVABLE	1066						135	
PEORIA L/D	157.7L	73.3	9	300	PEORIA, IL.	12-Sep-35	16-Dec-38		110	600	11	16	12	4			MOVABLE	536						134	
STARVED ROCK L/D	231.0R	13.6	9	300	UTICA, IL.	01-Apr-26	01-Jun-33		110	600	19	17	14	6			MOVABLE	1260	10P	10					1
MARSEILLES LOCK	244.6L	26.9	9	300	MARSEILLES, IL.	01-Nov-22	01-Jun-33		110	600	24	19	14	6											
MARSEILLES DAM	247.0R	24.6			MARSEILLES, IL.												MOVABLE	819	8P&3P						1
DRESDEN ISLAND L/D	271.5L	14.5	9	300	MORRIS, IL.	01-Jul-28	01-Jun-33		110	600	22	17	12	6			MOVABLE	1616	8P	14					2
BRANDON ROAD L/D	286.0R	5.1	9	300	JOLIET, IL.	01-Jul-27	01-Jun-33		110	600	34	16	14	6			MOVABLE	2373	22N	4	3				1
LOCKPORT LOCK	291.1L	36.1	9	300	LOCKPORT, IL.	01-Jul-23	01-Jun-33		110	600	40	12	15	2	2		NONE	0							
THOMAS J. O'BRIEN L/D	326.5R	6.9	9	300	CHICAGO, IL.		01-Jan-60		110	1000	2.5	14	14			4	MOVABLE	257			4				

SECTION E: COMPONENT CONDITION RATING SUMMARY AND SYSTEM CRITICALITY RANKING FROM OBJECTIVE 2A

Lock and dam components in this section are divided into two rankings: one a condition rating summary (based on the current conditon of components) and the second based on system criticality.

SECTION E: COMPONENT CONDITION RATING SUMMARY

The condition rating summary provides an assessment of the current condition of a number of components at each of the lock and dam sites in the study. The rating scheme is presented in a matrix form. A majority of components at a typical lock and dam site are included. Typical components include miter gates, roller gates, lock operating machinery, concrete, electrical system, etc. Periodic inspections were the main source of information for determining component condition. The rating criteria used is shown below.

The condition rating indices can be used for several purposes including providing a calibration for the BETA values being derived in Objective 2A. The ratings can also be used to provide an initial determination of components that may need repair or replacement in either the immediate future or at some later time. To maintain consistency between the four Reaches, the following rating criteria was used:

RATING	EXPLANATION
1	Severe deterioration, failure either has occurred or is imminent and reconstruction is needed
2	Poor condition, component exhibits operational problems, highly visible deterioration evident, frequent and extensive maintenance is required to keep component operational
3	Fair Condition, some deterioration and operational problems may exist, increased frequency of maintenance and repairs
4	Good Condition, no noticeable deterioration or operational problems, only normal maintenance is required to keep component operational
5	New or Rehabilitated component, excellent condition, only normal maintenance is required to keep component operational

UMR – IWW NAVIGATION STUDY

CURRENT CONDITION ASSESSMENT AND CONDITION RATING SUMMARY

MAJOR COMPONENTS AND RANKINGS

Component Rating Key: 1 lowest rating 5 highest rating NA = Not Applicable

NCS = Saint Paul District

NCR = Rock Island District

LMS = Saint Louis District

DAM

DAM GATE SYSTEMS

MISSISSIPPI RIVER		Location	GATE MACHINERY	SLIDE GATES	HEAD GATES	SLUICE GATES	ROLLER GATES	TAINTER GATES	WICKET GATES	BUTTERFLY VALVES	DAM GATE ANCHORAGE
REACH 1 – NCS	USAF	Minneapolis, MN	NA	NA	NA	NA	NA	NA	NA	NA	NA
	LSAF	Minneapolis, MN	4	NA	NA	NA	NA	4	NA	NA	4
	1	Minneapolis, MN	NA	NA	NA	NA	NA	NA	NA	NA	NA
	2	Hastings, MN	5	NA	NA	NA	NA	3	NA	NA	4
	3	Red Wing, MN	3	NA	NA	NA	3	NA	NA	NA	NA
	4	Alma, WI	2	NA	NA	NA	3	3	NA	NA	3
	5	Minnesota City, MN	2	NA	NA	NA	3	3	NA	NA	3
	5A	Fountain City, WI	3	NA	NA	NA	3	3	NA	NA	3
	6	Trempealeau, WI	3	NA	NA	NA	3	3	NA	NA	3
	7	LaCrescent, MN	3	NA	NA	NA	3	3	NA	NA	3
	8	Genoa, WI	3	NA	NA	NA	3	3	NA	NA	3
	9	Eastman, WI	3	NA	NA	NA	3	3	NA	NA	3
	10	Guttenberg, IA	3	NA	NA	NA	3	3	NA	NA	3
REACH 2 – NCR	11	Dubuque, IA	3	NA	NA	NA	3	3	NA	NA	4
	12	Bellevue, IA	3	NA	NA	NA	3	3	NA	NA	4
	13	Fulton, IL	3	NA	NA	NA	3	3	NA	NA	4
	14	Le Claire, IA	3	NA	NA	NA	3	3	NA	NA	4
	15	Rock Island, IL	3	NA	NA	NA	3	NA	NA	NA	4
	16	East Muscatine, IL	4	NA	NA	NA	3	3	NA	NA	4
	17	New Boston, IL	4	NA	NA	NA	3	3	NA	NA	4
	18	Gulfport, IL	4	NA	NA	NA	3	3	NA	NA	4
	19	Keokuk, IA	NON-FEDERAL	NA	NA	NA	NA	3 NON-FED	NA	NA	4
	20	Canton, MO	4	NA	NA	NA	3	3	NA	NA	4
	21	Quincy, IL	3	NA	NA	NA	3	3	NA	NA	4
	22	Saverton, MO	3	NA	NA	NA	3	3	NA	NA	4
REACH 3 – LMS	24	Clarksville, MO	3	NA	NA	NA	NA	2	NA	3	
	25	Winfield, MO	3	NA	NA	NA	3	3	NA	3	
	26	Alton, IL	5	NA	NA	NA	NA	3	NA	5	
	27	Granite City, Il	NA	NA	NA	NA	NA	NA	NA	NA	
ILLINOIS WATERWAY											
New La Grange		Versailles, IL	5	NA	NA	NA	NA	5	2	4	5
Peoria		Peoria, IL	5	NA	NA	NA	NA	5	2	3	5
Starved Rock		Ottawa, IL	4	NA	NA	NA	NA	3	NA	NA	4
Marseilles		Marseilles, IL	5	NA	NA	NA	NA	5	NA	NA	5
Dresden Island		Morris, IL	3	NA	NA	NA	NA	3	NA	NA	4
Brandon Road		Joliet, IL	5	NA	5	NA	NA	5	NA	NA	4
Lockport		Lockport, IL	NON-FEDERAL DAM		NA	NA	NA	NA	NA	NA	NA
Thomas J. O'Brien		Chicago, IL	3	3	NA	NA	NA	NA	NA	NA	NA

UMR – IWW NAVIGATION STUDY

CURRENT CONDITION ASSESSMENT AND CONDITION RATING SUMMARY

MAJOR COMPONENTS AND RANKINGS

Component Rating Key: 1 lowest rating 5 highest rating NA = Not Applicable

SPD = Saint Paul District

RID = Rock Island District

STL = Saint Louis District

DAM

		DAM ELECTRICAL SYSTEMS			DAM STRUCTURES						
MISSISSIPPI RIVER		POWER SUPPLY	ELECTRICAL CONTROLS	POWER DISTRIBUTION	SURFACE CONCRETE	SERVICE BRIDGE	SHEET PILE STRUCTURES	OVERFLOW SPILLWAYS	ABUTMENTS	NON-OVERFLOW EMBANKMENTS	STILLING BASINS
REACH 1 – NCS	USAF	NA	NA	NA	NA	NA	3	NA	NA		NA
	LSAF	2	2	1	4	4	4	NA	4		2
	1	NA	NA	NA	3	NA	NA	3	NA		NA
	2	5	5	5	4	5	NA	NA	4		3
	3	5	5	1	3	4	4	NA	3		3
	4	5	5	1	3	2	NA	NA	3		3
	5	1	5	1	3	2	NA	NA	3		3
	5A	1	5	1	3	4	NA	4	3		3
	6	1	5	1	3	3	NA	4	3		3
	7	1	5	1	3	3	NA	2	3		3
	8	1	5	1	3	3	NA	4	3		3
	9	1	5	1	3	3	NA	4	3		3
	10	1	5	1	3	3	NA	2	4		3
REACH 2 – NCR	11	3	3	3	3	4	NA	NA	3	3	3
	12	3	3	3	3	4	4	3	3	4	3
	13	5	5	5	3	4	4	3	3	3	3
	14	3	3	4	3	4	NA	NA	3	4	3
	15	5	5	5	4	4	NA	NA	3	NA	3
	16	5	5	5	4	4	NA	3	3	3	3
	17	5	4	5	4	4	4	3	3	3	3
	18	5	5	4	4	4	4	2	3	3	3
	19	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	20	4	5	4	3	4	NA	NA	3	NA	3
	21	5	5	5	3	4	4	3	3	3	3
	22	5	5	5	3	4	4	3	3	3	3
REACH 3 – LMS	24	3	2	3	2	4	3	4	3	1	4
	25	3	1	2	4	4	3	3	1	1	4
	26	5	5	5	4	4	5	4	4	5	3
	27	2	1	1	NA	NA	1	4	NA	4	NA
ILLINOIS WATERWAY											
New La Grange		4	4	4	5	5	3	NA	NA	3	4
Peoria		4	4	4	5	5	3	NA	NA	3	4
Starved Rock		4	3	4	4	3	NA	NA	4	NA	3
Marseilles		4	4	4	5	5	NA	NA	4	NA	4
Dresden Island		4	3	4	3	3	NA	NA	3	NA	3
Brandon Road		4	4	4	3	3	NA	3	3	3	3
Lockport		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Thomas J. O'Brien		3	3	3	4	NA	3	NA	NA	4	4

UMR – IWW NAVIGATION STUDY

CURRENT CONDITION ASSESSMENT AND CONDITION RATING SUMMARY

MAJOR COMPONENTS AND RANKINGS

Component Rating Key: 1 lowest rating 5 highest rating NA = Not Applicable

SPD = Saint Paul District

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DAM

MISSISSIPPI RIVER		PILE FOUNDATION	MASS CONCRETE	UNDER-SEEPAGE	GRAVITY STRUCTURE	SCOUR PROTECTION	
REACH 1 – NCS	USAF		NA	4	NA	4	
	LSAF		4	4	NA	4	
	1	4		4	4	4	
	2	4		4	4	4	
	3	4		3	4	3	
	4	4		4	4	4	
	5	4		4	4	4	
	5A	4		4	4	4	
	6	4		4	4	4	
	7	4		4	4	4	
	8	4		4	4	4	
	9	4		4	4	4	
	10	4		4	4	4	
REACH 2 – NCR	11	4	4	4	#	3	
	12	4	4	4	#	3	
	13	4	3	4	#	3	
	14	NA	4	NA	#	NA	# RATED WITH SURFACE CONCRETE AND MASS CONCRETE
	15	NA	4	NA	#	NA	
	16	4	4	4	#	4	
	17	4	4	4	#	4	
	18	4	4	4	#	4	
	19	NA	NA	NA	NA	NA	DAM 19 IS NON FEDERAL
	20	4	3	4	#	4	
	21	4	4	4	#	4	
	22	NA	4	NA	#	NA	
REACH 3 – LMS	24	4	1	3	NA	4	
	25	2	3	2	NA	4	
	26	3	5	3	NA	5	
	27	NA	NA	NA	NA	NA	
ILLINOIS WATERWAY							
New La Grange		4	5	3	#	4	
Peoria		4	5	3	#	4	
Starved Rock		NA	4	NA	#	NA	# RATED WITH SURFACE CONCRETE AND MASS CONCRETE
Marseilles		NA	5	NA	#	4	
Dresden Island		NA	4	NA	#	NA	
Brandon Road		NA	4	NA	#	NA	
Lockport		NA	NA	NA	#	NA	LOCKPORT DAM IS NON-FEDERAL
Thomas J. O'Brien		NA	4	3	#	NA	

UMR – IWW NAVIGATION STUDY

CURRENT CONDITION ASSESSMENT AND CONDITION RATING SUMMARY

MAJOR COMPONENTS AND RANKINGS

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LOCK

MISSISSIPPI RIVER		MITER GATES	MITER GATE MACHINERY	LIFT GATES	LIFT GATE MACHINERY	SECTOR GATES	SECTOR GATE MACHINERY	LOCK GATE ANCHORAGE	TAINTER VALVES	TAINTER VALVE MACHINERY	CULVERTS
REACH 1 – NCS	USAF	4	3	4	3	NA	NA		4	4	4
	LSAF	4	3	4	3	NA	NA		4	4	4
	1	4	3	NA	NA	NA	NA	3	3	3	4
	2	4	5	NA	NA	NA	NA	3	5	5	4
	3	4	5	NA	NA	NA	NA	4	5	5	4
	4	4	5	NA	NA	NA	NA	4	5	5	4
	5	4	5	NA	NA	NA	NA	4	5	5	4
	5A	4	5	NA	NA	NA	NA	3	3	5	4
	6	4	5	NA	NA	NA	NA	3	3	5	4
	7	4	3	NA	NA	NA	NA	3	3	3	4
	8	4	3	NA	NA	NA	NA	4	5	3	4
	9	4	3	NA	NA	NA	NA	4	5	3	4
	10	4	3	NA	NA	NA	NA	4	5	3	4
REACH 2 – NCR	11	2	3	NA	NA	NA	NA	3	3	2	4
	12	2	3	NA	NA	NA	NA	3	3	2	4
	13	2	5	NA	NA	NA	NA	3	3	5	4
	14	2	3	NA	NA	NA	NA	3	3	2	4
	15	3	5	NA	NA	NA	NA	3	3	5	4
	16	3	5	NA	NA	NA	NA	3	3	5	4
	17	3	5	NA	NA	NA	NA	3	3	5	4
	18	3	5	NA	NA	NA	NA	3	3	5	4
	19	4	4	NA	NA	NA	NA	3	3	4	4
	20	3	5	NA	NA	NA	NA	3	3	5	4
	21	3	5	NA	NA	NA	NA	3	3	5	4
	22	3	5	NA	NA	NA	NA	3	3	5	4
REACH 3 – LMS	24	1	2	NA	NA	NA	NA NA	4	1	3	4
	25	1	2	NA	NA	NA	NA	4	1	2	3
	26	3	4	3	2	NA	NA	3	4	2	5
	27	2	1	1	2	NA	NA	4	3	3	4
ILLINOIS WATERWAY											
New La Grange		3	4	NA	NA	NA	NA	3	3	4	4
Peoria		3	4	NA	NA	NA	NA	3	3	4	4
Starved Rock		3	4	NA	NA	NA	NA	3	3	3	4
Marseilles		5, 3	3	NA	NA	NA	NA	3	3	3	4
Dresden Island		5, 3	3	NA	NA	NA	NA	3	3	3	4
Brandon Road		5, 3	4	NA	NA	NA	NA	3	3	3	4
Lockport		5	4	3	5	NA	NA	4	3	3	4
Thomas J. O'Brien		NA	NA	NA	NA	4	3	4	3	3	4

UMR – IWW NAVIGATION STUDY

CURRENT CONDITION ASSESSMENT AND CONDITION RATING SUMMARY

MAJOR COMPONENTS AND RANKINGS

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LOCK

LOCK ELECTRICAL SYSTEM

MISSISSIPPI RIVER	POWER SUPPLY	MOTOR CONTROLS	POWER DISTRIBUTION	RELIEF WELLS	LOCK FLOOR	CONCRETE JOINTS	SURFACE CONCRETE	PILE FOUNDATIONS	GUIDEWALLS	GUARDWALLS
REACH 1 – NCS USAF	3	3	3		4	2	2	NA	4	4
LSAF	3	2	2		4	2	2	NA	4	NA
1	4	1	4		4	4	4	NA	3	NA
2	1	1	1		4	5	5	4	4	NA
3	5	5	5		4	5	5	4	4	NA
4	5	5	5	5	4	5	5	4	3	NA
5	2	5	3	5	4	5	5	4	2	NA
5A	2	5	3		4	2	2	4	3	NA
6	2	5	3		4	2	2	4	4	NA
7	2	1	1		4	2	2	4	2	NA
8	2	1	1		4	5	5	4	4	NA
9	2	1	1		4	5	5	4	2	NA
10	2	1	1		4	5	5	4	4	NA
REACH 2 – NCR 11	3	3	3	3	4	3	2	4	3	3
12	5	3	3	3	4	3	2	4	3	NA
13	5	5	5	3	4	5	5	4	4	NA
14	3	3	3	NA	4	3	2	NA	3	3
15	5	5	5	NA	4	4	4	NA	4	NA
16	5	5	4	4	4	5	4	4	4	3
17	4	5	5	3	4	3	3	4	4	NA
18	5	5	5	4	3	5	4	4	4	NA
19	5	3	4	NA	4	4	4	NA	4	NA
20	4	4	4	3	4	3	3	4	4	4
21	5	4	4	3	4	1	3	4	4	3
22	4	4	4	NA	4	4	4	NA	4	3
REACH 3 – LMS 24	3	2	3	NA	3	2	2	NA	2	4
25	3	1	2	NA	1	2	4	3	2	4
26	5	3	5	NA	5	3	4	3	5	4
27	2	1	1	NA	3	2	3	NA	4	3
ILLINOIS WATERWAY										
New La Grange	4	4	4	4	4	3	4	4	4	NA
Peoria	4	4	4	4	4	5	5	4	4	NA
Starved Rock	4	4	4	NA	4	4	4	NA	3	NA
Marseilles	5	4	4	NA	4	4	3	NA	3	NA
Dresden Island	4	4	4	3	4	4	3	NA	3	NA
Brandon Road	4	4	4	NA	4	5	5	NA	4	4
Lockport	5	4	5	NA	4	5	5	NA	4	NA
Thomas J. O'Brien	5	4	4	3	4	4	4	4	2	NA

UMR – IWW NAVIGATION STUDY

CURRENT CONDITION ASSESSMENT AND CONDITION RATING SUMMARY

MAJOR COMPONENTS AND RANKINGS

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LOCK

MISSISSIPPI RIVER		MASS CONCRETE	UNDER–SEEPAGE	GRAVITY STRUCTURE	SCOUR PROTECTION
REACH 1 – NCS	USAF		4	4	4
	LSAF		4	4	4
	1		4	4	4
	2		4	4	4
	3		4	4	4
	4		4	4	4
	5		4	4	4
	5A		4	4	4
	6		4	4	4
	7		4	4	4
	8		4	4	4
	9		4	4	4
	10		4	4	4
REACH 2 – NCR	11	3	4	4	4
	12	3	4	4	4
	13	4	4	4	4
	14	3	5	4	NA
	15	4	5	4	NA
	16	4	2	4	2
	17	4	4	4	4
	18	4	2	4	4
	19	4	5	4	NA
	20	4	4	4	4
	21	4	4	4	4
	22	4	5	4	NA
REACH 3 – LMS	24	2	NA	2	NA
	25	4	1	NA	3
	26	5	5	NA	4
	27	3	NA	2	NA
ILLINOIS WATERWAY					
New La Grange		4	4	4	4
Peoria		4	4	4	4
Starved Rock		4	5	4	NA
Marseilles		4	5	4	NA
Dresden Island		3	5	4	4
Brandon Road		4	5	4	NA
Lockport		4	5	4	NA
Thomas J. O'Brien		4	4	4	4

UMR – IWW NAVIGATION STUDY

CURRENT CONDITION ASSESSMENT AND CONDITION RATING S

MAJOR COMPONENTS AND RANKINGS

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CHANNEL

				CHANNEL RETAINING STRUCTURES					
MISSISSIPPI RIVER		NAVIGATION CHANNEL	RETAINING LEVEES/DIKES	CONCRETE CHANNEL WALLS	WING DAMS	CLOSURE DAMS	JETTIES	UPPER APPROACH	LOWER APPROACH
REACH 1 – NCS	USAF			NA				3	4
	LSAF			NA				4	4
	1			NA				4	4
	2	4		NA				3	4
	3	3		NA				2	3
	4	2		NA				3	4
	5			NA				3	4
	5A			NA				3	4
	6			NA				3	4
	7			NA				3	4
	8			NA				3	4
	9			NA				3	4
	10			NA				3	4
REACH 2 – NCR	11			NA					
	12			NA					
	13			NA					
	14			NA					
	15			NA					
	16			NA					
	17			NA					
	18			NA					
	19			NA					
	20			NA					
	21			NA					
	22			NA					
				NA					
REACH 3 – LMS	24		4	NA		1			
				NA					
	25		2	NA		1			
				NA					
	26		5	NA		NA			
				NA					
	27		4	NA		NA			
ILLINOIS WATERWAY									
New La Grange				NA					
Peoria				NA					
Starved Rock				NA					
Marseilles				NA					
Dresden Island				NA		4			
Brandon Road				3		4			
Lockport				2		4			
Thomas J. O'Brien				NA					

SECTION E: SYSTEM CRITICALITY RANKING FROM OBJECTIVE 2A

The second part of this section comes from Objective 2A of the Navigation Study. Components within the system were ranked for their importance and criticality from a system wide perspective. The ranking does not consider the condition of components. Components were judged simply for the effect they have on the operation of the lock and the navigation system as a whole. The primary purpose of developing a "criticality" rating list was to judge components that a Beta reliability factor would need to be calculated for.

If a component is rated poorly in the condition survey list from Objective 1, the Objective 2A list can be referred to for establishing the importance of that component from a system wide perspective. For example, surface concrete can be deteriorating at a lock site and be judged poorly in the condition survey. However, the Objective 2A ranking list shows this is insignificant in the operation of the overall navigation system.

UMR-IWW NAVIGATION STUDY

Engineering Plan - Objective 2a
COMPONENT RANKING

Ranking

The component ranking for each of the four categories is a relative scale of 1 to 3 with 1 being the low end and 3 being the high end. The assignment of the category rankings will be based on data collected by the districts and engineering judgment of the Objective 2 committee. These rankings are to serve as a screening of the submitted navigation components to determine which components are significant from an overall UMR-IWW navigation system standpoint and which components are not. This information will then be used to determine which components will have detailed investigative reliability/condition models developed and which components can be investigated in more limited detail as a part of the Objective 2a - Future Rehabilitation work effort.

Ranking	Description
1	Low, No, Minor
2	Medium, Average
3	High, Yes, Major

Definition of Category

O&M/ Major Rehab: Indicates whether the item would be repaired through O&M funds or through a major rehabilitation effort.

Discipline: Identifies the discipline responsible to carry out analysis of the component.

System No.: Number of sites or locations where this component is present within the UMR-IWW system.

Critical Component: From a site specific standpoint, if this component were to perform unsatisfactorily, would navigation traffic be directly and immediately affected considering likely failure scenarios?

System Cost: From an overall system standpoint, does the total number of this component reflect a significant rehabilitation replacement cost on the UMR-IWW system?

System Consequences: From an overall system standpoint, if this component were to perform unsatisfactorily, would navigation be impacted significantly?

Likelihood of Problems: From a system standpoint, is it likely that the item will need repairs based on past performance or suspected degradation?

Rank: The relative rank of the component base on the sum of the rankings in the previous four categories.

Method of Analysis: The methodology used to establish the future investment needs.

Prioritization Recommendations

To establish a priority list for objective 2a, the Component Ranking Table was developed. To limit the list to a workable number of items, it is recommended that those components whose ranking is twelve or greater be considered. Also, only the components listed as Major Rehab items will be considered. The components listed as O&M items should not be included on this list because they will be included in baseline cost developed in Objective 1. The components that satisfy the these two criteria have been denoted with a asterisk in the rank column.

UMR-IWW NAVIGATION STUDY
Engineering Plan - Objective 2a
COMPONENT RANKING

Component	O&M/ Major Rehab	Discipline	System No.	Critical Comp.	System Cost	System Conseq.	Likelihood of Problems	Ranking	Method of Analysis
CHANNEL									
Channel Stability									
Bank Stabilization Measures	O&M	Hydraulics	1	2	1	2	2	8	Objective 1
Scour Protection	Major Rehab	Hydraulics	3	2	2	3	3	13 *	reliability
Navigation Channel Depth/Width/Alignment	O&M	Hydraulics	3	3	3	3	3	15	Objective 1
Channel Retaining Structures									
Retaining Levees/Dikes	Major Rehab	Hydraulics	1	3	2	3	2	11	contigency
Concrete Channel Walls	Major Rehab	Structures	1	3	2	3	3	12 *	reliability
Channel Training Structures									
Wing Dams/Jetties	Major Rehab	Hydraulics	3	2	2	3	3	13 *	reliability
Closure Dikes	Major Rehab	Hydraulics	3	2	2	3	2	12 *	reliability
Channel Lock Approach Conditions									
Upper Approach	Major Rehab	Hydraulics	3	3	2	2	2	12	efficiency
Lower Approach	Major Rehab	Hydraulics	3	3	2	2	2	12	efficiency

Component	O&M/ Major Rehab	Discipline	System No.	Critical Component	System Cost	System Conseq.	Likelihood of Problems	Ranking	Method of Analysis
LOCK									
Lock Gate Systems									
Miter Gates, Vertical Framed	Major Rehab	Structures	3	3	3	3	3	15 *	reliability
Miter Gates, Horiz. Framed	Major Rehab	Structures	3	3	3	3	3	15 *	reliability
Lift Gates	Major Rehab	Structures	1	3	2	3	3	12*	reliability
Sector Gates	Major Rehab	Structures	1	3	1	1	3	9	contigency
Miter Gate Machinery	Major Rehab	Mechan.	3	3	3	3	3	15 *	surviver curves
Gate Motors	Major Rehab	Mechan.	3	3	1	3	3	13 *	surviver curves
Lift Gate Machinery	Major Rehab	Mechan.	1	3	1	3	3	11	contigency
Sector Gate Machinery	Major Rehab	Mechan.	1	3	1	1	2	8	contigency
Lock Gate Anchorage	Major Rehab	Structures	3	3	3	3	3	15 *	reliability
Lock Filling/ Emptying System									
Culverts	Major Rehab	Structures	3	2	1	1	1	8	contigency
Tainter Valves	Major Rehab	Structures	3	3	3	2	3	14 *	reliability
Tainter Valve Machinery	Major Rehab	Mechan.	3	3	3	2	3	14 *	surviver curves
Valve Motors	Major Rehab	Mechan.	3	2	1	2	3	11	contigency
Slide Valves	Major Rehab	Mechan.	2	2	2	2	3	11	contigency
Slide Valve Machinery	Major Rehab	Mechan.	2	3	3	2	3	13 *	surviver curves

Component, cont.	O&M/ Major Rehab	Discipline	System No.	Critical Comp.	System Cost	System Conseq.	Likelihood of Problems	Ranking	Method of Analysis
Lock Structure									
Relief Wells	Major Rehab	Geotech.	2	2	3	1	2	10	contigency
Sheet Pile Structures	Major Rehab	Geotech.	1	3	2	2	3	11	contigency
Concrete Horizontal Surfaces	Major Rehab	Geotech.	3	1	2	1	3	10	contigency
Lock Appurtenances	Major Rehab	Structures	3	1	1	1	2	8	contigency
Ice/Debris Facilities	Major Rehab	Structures	1	2	1	1	2	7	contigency
Guidewalls Stability	Major Rehab	Geotech.	3	3	3	3	3	15 *	reliability
Guardwalls	Major Rehab	Geotech.	2	1	1	1	1	6	contigency
Mass Concrete	Major Rehab	Geotech.	3	3	3	3	2	14 *	reliability
Lockwall Stability	Major Rehab	Geotech.	3	3	3	3	2	14 *	reliability
Concrete Joints	Major Rehab	Geotech.	3	1	1	1	3	9	contigency
Underseepage Control	Major Rehab	Geotech.	3	3	3	3	3	15 *	reliability
Tow Haulage Unit	O&M	Mechan.	3	2	3	2	3	13	Objective 1

Component	O&M/ Major Rehab	Discipline	System No.	Critical Comp.	System Cost	System Conseq.	Likelihood of Problems	Ranking	Method of Analysis
DAM									
Dam Gate Systems									
Gate Machinery	Major Rehab	Mechan.	3	2	3	1	2	11	contigency
Gate Motors	Major Rehab	Mechan.	3	1	2	1	2	9	contigency
Slide Gates	Major Rehab	Structures	1	1	1	1	2	6	contigency
Head Gates	Major Rehab	Structures	1	1	1	1	2	6	contigency
Sluice Gates	Major Rehab	Structures	1	1	1	1	2	6	contigency
Roller Gates	Major Rehab	Structures	3	2	3	2	3	13 *	reliability
Tainter Gates	Major Rehab	Structures	3	2	3	2	3	13 *	reliability
Wicket Gates	Major Rehab	Structures	1	3	1	2	3	10	contigency
Butterfly Valves	Major Rehab	Structures	1	1	1	1	2	6	contigency
Dam Gate Anchorage	Major Rehab	Structures	3	3	3	3	2	14 *	reliability
Dam Structures									
Concrete Horizontal Surfaces	Major Rehab	Geotech.	3	1	1	1	2	8	contigency
Mass Concrete	Major Rehab	Geotech.	3	3	3	3	2	14 *	reliability
Service Bridge	Major Rehab	Structures	3	2	2	2	2	11	contigency
Dam Appurtenances	O&M	Structures	3	1	1	1	2	8	Objective 1
Sheet Pile Structures	Major Rehab	Geotech.	1	3	2	2	2	10	contigency
Overflow Spillways	Major Rehab	Geotech.	3	3	3	3	3	15 *	reliability
Ice/Debris Facilities	Major Rehab	Structures	1	2	1	1	2	7	contigency
Pier Stability	Major Rehab	Geotech.	3	3	3	3	2	14 *	reliability
Underseepage Control	Major Rehab	Geotech.	3	3	3	3	2	14 *	reliability
Non-overflow Embankments	Major Rehab	Geotech.	3	2	3	3	3	14 *	reliability
Stilling Basins	Major Rehab	Structures	3	2	2	2	2	11	contigency

Component	O&M/ Major Rehab	Discipline	System No.	Critical Comp.	System Cost	System Conseq.	Likelihood of Problems	Ranking	Method of Analysis
Electrical Systems									
Main Transmittion/ Service Entrance	Major Rehab	Electrical	3	2	2	2	1	10	contigency
Generator / EM feed	Major Rehab	Electrical	3	2	2	2	2	11	contigency
Transfer Switch	Major Rehab	Electrical	3	2	2	3	1	11	contigency
Moter Control Center	Major Rehab	Electrical	3	3	3	3	1	13 *	to be determined
Circuit Breakers	Major Rehab	Electrical	3	2	2	2	1	10	contigency
Starters/Contactors	Major Rehab	Electrical	3	1	2	2	3	11	reliability
Control Switches	Major Rehab	Electrical	3	1	2	2	3	11	reliability
Auxilliary Transformers	Major Rehab	Electrical	3	1	2	2	2	10	contigency
Power Cables	Major Rehab	Electrical	3	1	3	2	2	11	contigency
Power Connections	Major Rehab	Electrical	3	1	2	1	1	8	contigency
Peripheral Devices	Major Rehab	Electrical	3	1	1	1	3	9	contigency
Control Cables	Major Rehab	Electrical	3	2	3	1	3	12 *	to be determined
Control Connections	Major Rehab	Electrical	3	2	2	1	2	11	contigency
Lighting	Major Rehab	Electrical	3	1	2	1	2	9	contigency