ENV Report 53

Interim Report for the Upper Mississippi River - Illinois Waterway System Navigation Study

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Water Level Management Opportunities for Ecosystem Restoration on the Upper Mississippi River and Illinois Waterway

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Rock Island District
St. Paul District
St. Louis District

Water Level Management Opportunities for Ecosystem Restoration on the Upper Mississippi River and Illinois Waterway

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I. Introduction

A. Background

This study was conducted in support of the Restructured Upper Mississippi River and Illinois Waterway System Navigation Study (Restructured Navigation Study). The Restructured Navigation Study began, in 1993, as a multi-year study to investigate the feasibility of navigation improvements on the Upper Mississippi River (UMR) and the Illinois Waterway (IWW) over a 50-year planning period. The study area includes 854 miles of the Upper Mississippi River, with 29 locks and dams, between Minneapolis - St. Paul and the mouth of the Ohio River (Figure 1); and, 348 miles of the Illinois Waterway, with 8 locks and dams, that connect the city of Chicago and the Great Lakes with the Mississippi River just upstream of the Melvin Price Lock and Dam (Figure 1). The study area lies within portions of Illinois, Iowa, Minnesota, Missouri, and Wisconsin.

In 2000, the study was refocused to include consideration of environmentally sustainable development of the river system. This study change was made based on recommendations of the National Research Council (NRC) and based on input from a, Washington-level, Federal Agency Task Force. The current study strategy involves developing a framework for the comprehensive management of the Upper Mississippi River System. This includes navigation planning, ecosystem planning, ongoing operation and maintenance activities, and floodplain management.

The July 2002 Interim Report outlined the navigation improvement and ecosystem restoration measures that would be carried forward for evaluation. Ecosystem restoration measures included beneficial adjustments to system operation and maintenance, ecosystem restoration opportunities, and environmental enhancement opportunities related to the navigation system. Examples of these measures include traffic impact prevention and reduction, channel modifications, systemic fish passage and water level management, and backwater, secondary channel, and island rehabilitation.

A series of four regional stakeholder workshops were conducted during November 2002. The goal of the workshops was to review and confirm environmental objectives, and to formulate management actions to address the identified objectives, for the UMR-IWW. For all reaches of the UMR-IWW, modifications to the current methods of dam regulation were identified as a potential management action that could be used to obtain desired ecosystem benefits.

Historically, the Corps of Engineers has regulated the river for the single project purpose of maintaining a safe and reliable navigation channel. In this effort, we are examining opportunities to modify the current methods of river regulation to improve conditions of the river ecosystem. Additional authorities may be required.

Water Level Management initiatives are not new to the UMR-IWW. There are currently ongoing initiatives in all three UMR Corps Districts. To the extent possible, this effort attempted to maximize use of existing data developed for these initiatives, and sought to leverage the knowledge and expertise of the personnel and agencies currently involved in these ongoing efforts.

Figure 1. Upper Mississippi River and Illinois Waterway Navigation System

B. Purpose of this Report

The purpose of this report is to provide cost and benefit information for alternative water level management actions being evaluated for inclusion into the Environmental Alternatives of the Restructured Navigation Study. The management actions, considered herein, are designed to provide ecosystem restoration benefits on a pool-wide scale. Therefore the alternative management actions, discussed in this report, focus on changes in the way the dams are operated, as opposed to the isolation and management of individual off-channel areas. The prioritized water level management actions will be used in the development of alternatives to support the identified environmental sustainability goals and objectives. The scope of work for this effort is presented in Appendix A.

C. Organization of Report

Chapter II of this report presents information on the existing system of Navigation Dams and their operation, as well as historical water level management initiatives in the three Upper Mississippi River Districts. Chapter III discusses the alternative water level management strategies considered, including the anticipated benefits and impacts of each. Chapter IV discusses the reasons for prioritization of the water level management actions and the process by which the actions were prioritized within the three Upper Mississippi River Districts. Chapter V discusses the primary benefits and implementation costs for the prioritized actions, providing quantitative estimates where possible. Finally, Chapters VI and VII provide conclusions and recommendations resulting from this investigation.

Throughout the report, recommendations are presented where appropriate, and are shown in ***bold italic***. In addition, a compiled listing of recommendations is presented in Chapter VII.

D. Acknowledgements

This report represents the efforts and contributions of an interdisciplinary and interagency team. The authors would like to recognize and thank the following for their participation, ideas, provided literature sources, and for providing data support to this effort:

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II. Existing Condition

A. Physical Setting

The study area comprises the upper and middle portions of the Mississippi River and the entire Illinois Waterway (Figure 1). It extends from the confluence of the Mississippi River with the Ohio River (River Mile 0) to Upper St. Anthony Falls Lock in Minneapolis-St. Paul, Minnesota (River Mile 854.0). The regulated portion of the Upper Mississippi River (UMR) extends from north of Minneapolis, Minnesota to Mel Price Lock & Dam; and includes 28 dams with locks. The Illinois Waterway extends from its confluence with the Mississippi River at Grafton, Illinois (River Mile 0) to T. J. O'Brien Lock (River Mile 327.0) in Chicago, Illinois. There are eight dams with locks on the Illinois Waterway. The study area includes portions of Illinois, Iowa, Minnesota, Missouri, and Wisconsin.

The UMR ecosystem includes the river reaches described above, as well as the floodplain habitats that are important to large river floodplain ecosystems. The total acreage of the river-floodplain system exceeds 2.6 million acres of aquatic, wetland, forest, grassland, and agricultural habitats.

The total Illinois Waterway and Mississippi River Navigation System contains 37 lock and dam sites (43 locks), over 650 manufacturing facilities, terminals, and docks, and provides valuable habitat and recreational opportunities.

B. Current Water Regulation Practices

1. General

The purpose of the lock and dam systems on the UMR and IWW are to maintain a minimum channel depth of 9 feet (with suitable widths) for navigation. Each pool is operated using one or more control point locations at which the water surface is maintained within an operating band about a target, authorized, water surface elevation. The location of the locks and dams, the control point locations, the authorized water level elevations, operating limits, and gate configurations are summarized in Table 1 for the UMR and IWW.

The dams are operated as run-of-the-river structures. In other words, the dams do not actively store and release water (save a minor amount associated with hinge-point control, described below); rather, the dams are operated to discharge flow equal to that entering the pool from the upstream dam and local tributaries. As river flows increase, the dam gates are opened to pass the increased flow and to maintain the target water surface elevations. As river flows decrease, the dam gates are similarly closed.

During periods of high flow (when the dam is no longer needed to maintain a 9-foot channel), the dam gates are lifted clear of the water and taken "out of operation" to avoid backwater effects on adjacent floodplain areas. Under this condition ("open river condition"), the river rises and falls naturally with increasing and decreasing flows.

The dams on the UMR and IWW are operated using three primary methods characterized by the number and location of the control point(s): (1) dam-point control, where a single control point is located just upstream of the dam; (2) hinge-point control, where the primary control point is located at a point upstream along the length of the pool and with a secondary control point located at the dam; and (3) primary – secondary – tertiary control, which utilizes three control points. The three types of operation are, briefly, summarized below. Additional information on the regulation of the dams can be found in the individual Water Control Manuals for each project.

a. Dam-Point Control

Under dam-point control, a near constant pool elevation is maintained immediately upstream of the dam (the primary, and only, control point). As river flows rise and fall, the pool tilts about the dam (Figure 2). This method of regulation provides a high degree of control, as the control point is located at the dam itself, and results in fairly stable water levels through the lower portion of the navigation pool for low to moderate flows. This method of operation, however, required greater land acquisition at the time of construction than would have been required under Hinge-Point Control (described below). Dam-point control is the primary method of operation for the Rock Island Portion of the UMR (with the exception of Pools 16 and 20), Pool 7 in the St. Paul District, and the Illinois Waterway.

b. Hinge-Point Control

Under hinge-point control, a near constant pool elevation is maintained at the primary control point. The primary control point is located along the length of the pool, near the intersection of the project pool elevation and the pre-project ordinary high water line. As river flows rise and fall, the pool tilts, or "hinges", about this point such that under a rising river (increasing flow) the water surface upstream of the control point rises and the water surface downstream of the control point falls (Figure 3). This mode of operation continues until the maximum allowable drawdown at the dam is reached. At

Table 1. Summary of Dam Operations

Elevations are in feet and refer to m.s.l., datum of 1912

River	District	Lock & Dam	Dam Location (River Mile)	Type of Operation	Primary Control Point		Secondary Control Point		Tertiary Control Point		Pool Operating Limits	Dam Configuration							
					Location	Elevation	Location	Elevation	Location	Elevation		Roller Gates	Tainter Gates	Lift Gates	Overflow Dike Length (ft)	Ice Chute Width (ft)	Headgates	Wickets	Butterfly Valves
Upper Mississippi River	St. Paul	USAF	854.7	Uncontrolled, Overflow Weir	Dam	799.2					799.0 - 801.0	Run of the River Dam - Weir Crest 799.2							
		LSAF	853.4	Dam-Point Control	Dam	750.0					750	-	3 x 56'	-	-	-	-	-	-
		1	847.6	Uncontrolled, Overflow Weir	Dam	723.1[a] 725.2					722.8 - 725.1	Run of the River Dam - Weir Crest 723.1							
		2	815.2	Hinge-Point Control	South St. Paul, MN	687.2	Dam	686.5			686.5 - 687.2	-	19 x 30'	-	100	-	-	-	-
		3	796.9	Hinge-Point Control	Prescott, WI	675.0	Dam	674.0			674.0 - 675.0	4 x 80'	-	-	-	-	-	-	-
		4	752.8	Hinge-Point Control	Wabasha, MN	667.0	Dam	666.5			666.5 - 667.0	6 x 60'	22 x 35'	-	-	-	-	-	-
		5	738.1	Hinge-Point Control	Alma	660.0	Dam	659.5			659.5 - 660.0	6 x 60'	28 x 35'	-	-	-	-	-	-
		5A	728.5	Hinge-Point Control	L&D 5 TW	651.0	Dam	650.0			650.0 - 651.0	5 x 80'	5 x 35'	-	1,000	-	-	-	-
		6	714.3	Hinge-Point Control	Winona, MN	645.5	Dam	644.5			644.5 - 645.5	5 x 80'	10 x 35'	-	1,000	-	-	-	-
		7	702.5	Dam-Point Control	Dam	639.0					638.8 - 639.2	5 x 80'	11 x 35'	-	1,670	-	-	-	-
		8	679.2	Hinge-Point Control	La Crosse, WI	631.0	Dam	630.0			630.0 - 631.0	5 x 80'	10 x 35'	-	2,275	-	-	-	-
		9	647.9	Hinge-Point Control	Lansing, IA	620.0	Dam	619.0			619.0 - 620.0	5 x 80'	8 x 35'	-	1,350	-	-	-	-
		10	615.1	Primary – Secondary – Tertiary Control	Dam	611.0	Clayton, IA	611.8	Dam	610.0	610.0 - 611.0	4 x 80'	8 x 40'	-	1,200	-	-	-	-
	Rock Island	11	583.0	Dam-Point Control	Dam	603.0					602.6 - 603.1	3 x 100'	13 x 60'	-	-	-	-	-	-
		12	556.7	Dam-Point Control	Dam	592.0					591.6 - 592.1	3 x 100'	7 x 64.2'	-	1,200	-	-	-	-
		13	522.5	Dam-Point Control	Dam	583.0					582.6 - 583.1	3 x 100'	10 x 64.2'	-	1,650	-	-	-	-
		14	493.3	Dam-Point Control	Dam	572.0					571.6 - 572.1	4 x 100'	13 x 60'	-	-	-	-	-	-
		15	482.9	Dam-Point Control	Dam	561.0					560.6 - 561.1	11 x 100'	-	-	-	-	-	-	-
		16	457.2	Primary – Secondary – Tertiary Control	Dam	545.0	Fairport, IA	545.6	Dam	543.6	543.6 - 545.1	4 x 100'	15 x 40'	-	1,700	-	-	-	-
		17	437.1	Dam-Point Control	Dam	536.0					535.6 - 536.1	3 x 100'	8 x 64'	-	1,555	-	-	-	-
		18	410.5	Dam-Point Control	Dam	528.0					527.6 - 528.1	3 x 100'	14 x 60'	-	2,200	-	-	-	-
		19[b]	364.2	Dam-Point Control	Dam	518.2					517.2 - 518.2	-	-	119 x 32'	-	-	-	-	-
		20	343.2	Primary – Secondary – Tertiary Control	Keokuk, IA	480.4	Gregory Landing	479.0	Dam	475.5	475.5 - 481.0	3 x 100'	40 x 40'	-	-	-	-	-	-
		21	324.9	Dam-Point Control	Dam	470.0					469.6 - 470.1	3 x 100'	10 x 64.2'	-	1,400	-	-	-	-
		22	301.2	Dam-Point Control	Dam	459.5					459.1 - 459.6	3 x 100'	10 x 60'	-	1,600	-	-	-	-
	St. Louis	24	273.4	Hinge-Point Control	Louisiana, MO	448.8 - 499.5	Dam	445.5			445.5 - 449.0	-	15 x 80'	-	2,820	-	-	-	-
		25	241.4	Hinge-Point Control	Mosier Landing	434.0 - 437.0	Dam	429.7			429.7 - 434.0	3 x 100'	14 x 60'	-	2,566	-	-	-	-
		Mel Price	201.1	Hinge-Point Control	Grafton, IL	418.0 - 420.0	Alton	414.0			412.5 - 419.0	-	9 x 110'	-	2,000	-	-	-	-
Illinois Waterway	Rock Island	Lockport	291.0	Dam-Point Control	Dam	577.0					569.5 - 584.5	Hydropower Facility - Operated by MWRDGC							
		Brandon Road	286.0	Dam-Point Control	Dam	538.5					538.0 - 539.0	-	21 x 50'	-	-	30	8 x 15'		
		Dresden Island	271.5	Dam-Point Control	Dam	504.5					504.0 - 505.0	-	9 x 60'	-	35	30	-	-	-
		Marseilles	247.0	Dam-Point Control	Dam	482.8					482.8 - 483.0	-	8 x 60'	-	-	30	-	-	-
		Starved Rock	231.0	Dam-Point Control	Dam	458.8					458.0 - 459.0	-	10 x 60'	-	-	52	-	-	-
		Peoria	157.7	Dam-Point Control	Dam	440.0					440.0	-	1 x 84'	-	34	-	-	108	6
		LaGrange	80.2	Dam-Point Control	Dam	429.0					429.0	-	1 x 84'	-	136	-	-	109	12

[a] There are two project pool elevations for Lock & Dam 1. Elev 723.1 feet with the air bladder down, and Elev 725.1 feet with the bladder up.

[b] Dam 19 is owned and operated by Ameren UE.

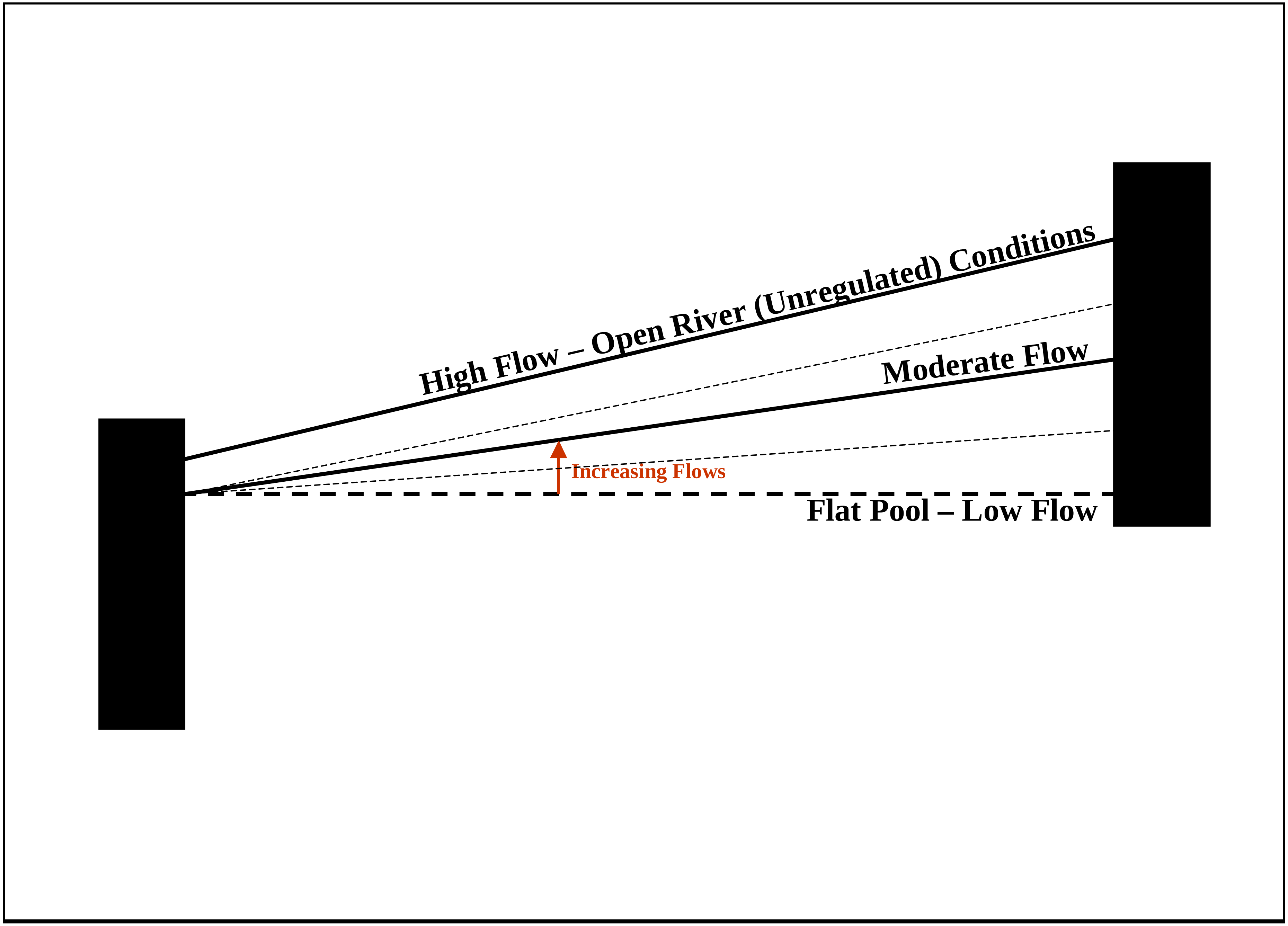


FIGURE 2. Overview of Dam Point Control

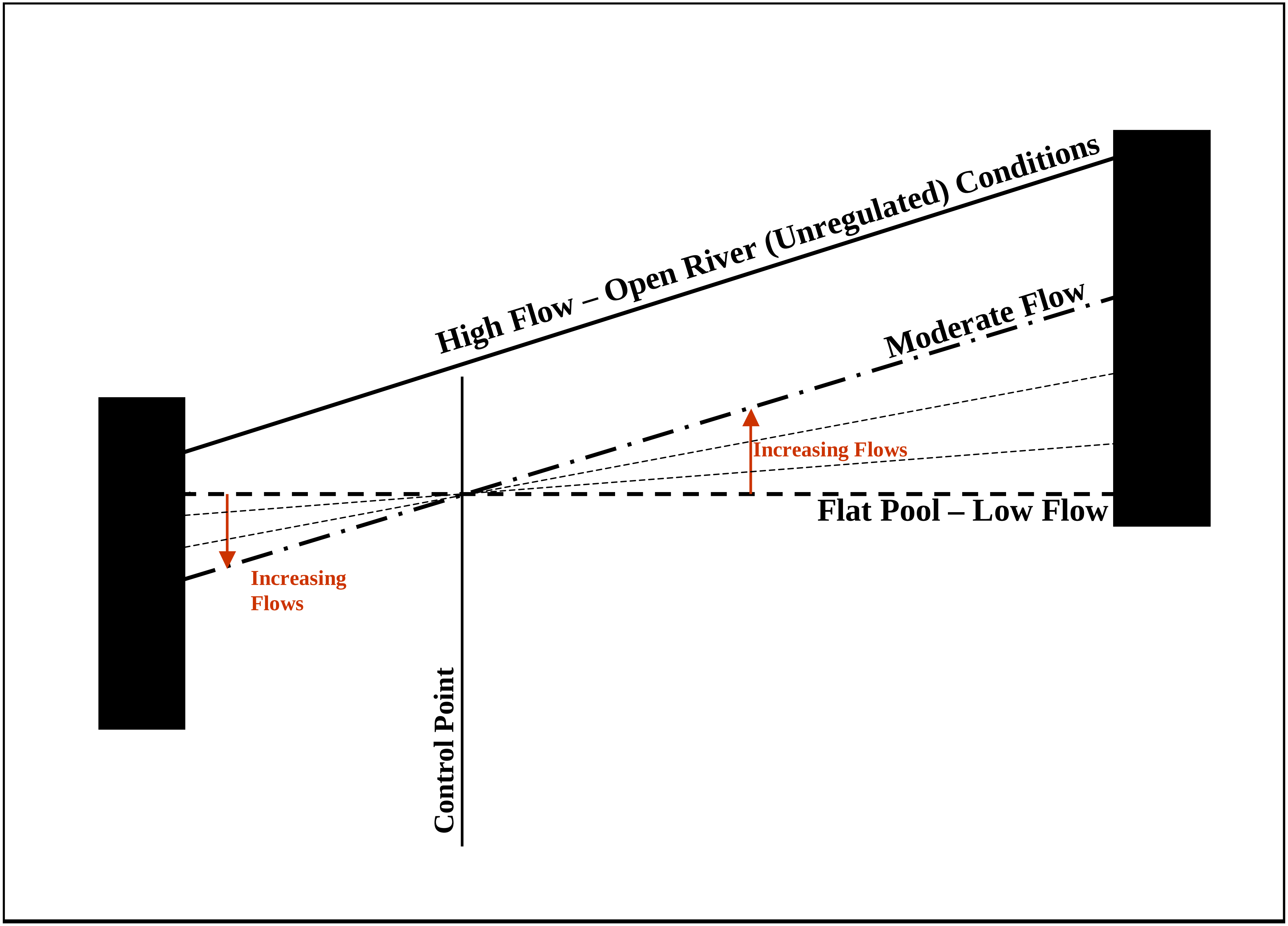


FIGURE 3. Overview of Hinge Point Control

this point, the maximum drawdown at the dam (the secondary control point) is maintained for rising flows until the dam is taken out of operation. The primary benefit of this regulation strategy is the need for less land acquisition at the time of project construction. Hinge-point control is the primary method of operation on the UMR in the St. Paul (with the exception of Pools 7 and 10) and St. Louis Districts.

C. Primary – Secondary – Tertiary Control

Pools 10, 16, and 20 utilize methods of operation involving 3 control points. For Pools 10 and 16, under low flow conditions, the primary control point is located at the dam. As flows increase, the control point moves upstream to a hinge point (the Secondary Control Point). As the flow continues to rise, and the maximum allowable drawdown at the dam is reached, the control point shifts back to the dam (the Tertiary Control Point). This method of operation was chosen to minimize land acquisition in these pools while not exceeding a maximum drawdown at the dam in order to maintain suitable channel dimensions for navigation.

Pool 20, under low flow conditions, has its primary control point at Dam 19's Tailwater. As flows increase, the control point moves downstream to a hinge point at Gregory Landing (the Secondary Control Point). As the flow continues to rise, and the maximum drawdown at Dam 20 is achieved, the control point shifts further downstream to Lock & Dam 20. This method of operation is designed to minimize the backwater impacts of Dam 20 on the hydropower plant at Dam 19 (which pre-dates the 9-foot channel project and Dam 20).

2. Upper Mississippi River Regulation Responsibilities

The U. S. Army Corps of Engineers is responsible for the operation and maintenance of the 9-foot channel projects on the UMR and IWW. Water regulation procedures have been developed for each project and are presented in a series of Water Control Manuals (USACE, varying dates of publication). The regulation plans and associated manuals are approved, as per 33 CFR 222.5, by the Division Commander.

a. St. Paul District

The St. Paul District is responsible for operation of 13 Dams on the UMR, from Upper St. Anthony Falls to Lock & Dam 10 (Figure 1). Daily regulation of Pools 2 through 10 is performed by the St. Paul's District's Water Control & Hydrology Section. Above Pool 2, there are two dams with uncontrolled overflow spillways (Upper St. Anthony Falls and Lock & Dam 1); and Lower St. Anthony Falls is regulated locally by the lockmaster due to the high frequency of gate operations required due to fluctuations associated with water used during the lockage process.

b. Rock Island District

The Rock Island District is responsible for operation of 11 Dams on the UMR, from Lock & Dam 11 to Lock & Dam 22 (Figure 1). The Rock Island District's Water

Control Section performs daily regulation of Pools 11-14, 16-18, and 20-22. Dam 15 is regulated locally by the lockmaster due to its interaction with two hydropower dams on Sylvan Slough and due to the (relatively) small pool size that responds quickly to changes made at Dam 14. Dam 19 is a private hydropower facility owned and operated by Ameren UE. The Rock Island District communicates with the hydropower plant daily, providing forecasted releases from Dam 18 and receiving forecasted releases from Dam 19.

c. St. Louis District

The St. Louis District is responsible for operation of 3 Dams on the UMR, from Lock & Dam 24 to Mel Price Lock & Dam (Figure 1). The St. Louis District's Potamology Section performs daily regulation of the 3 dams.

3. Illinois Waterway

The Rock Island District is responsible for operation of the Illinois Waterway (Figure 1). Of the 8 dams on the Illinois Waterway, only the lower 6 (Brandon Road to LaGrange) are regulated by the Corps of Engineers. The Metropolitan Sanitary District of Greater Chicago (MSDGC) is responsible for water control from the Lockport Dam to Lake Michigan.

The lower 6 dams are regulated locally by the individual lockmasters. This arrangement dates back to when the Illinois Waterway was under the responsibility of the Chicago District of the Corps of Engineers (control was transferred to the Rock Island District in 1981). Periodically there have been discussions about bringing the Illinois Waterway under centralized control by the Rock Island District's Water Control Section; however, currently the historical arrangement is still in place.

C. Impacts of Dam Regulation on the Hydrology of the UMR and IWW

Understanding how, and to what degree, the navigation dams on the Upper Mississippi River and Illinois Waterway have altered the natural hydrologic characteristics of the system is an important step in understanding the effects of impoundment and dam regulation on the river ecosystem. To this end, Theiling, et al, conducted an investigation to evaluate the effects that the dam regulation procedures, and other river development, have had on the hydrology of the Upper Mississippi River and Illinois Waterway (Theiling, unpublished). The authors used the Indicators of Hydrologic Alteration (IHA; Richter et al. 1996) in their study of the Upper Mississippi and Lower Illinois Rivers to assess ecologically relevant hydrologic parameters. The IHA has been applied in other parts of the Mississippi River region, including the Missouri River (Galat and Lipkin 2000), the Illinois River (Koel and Sparks 2002), and the Lower Mississippi River (Franklin et al. 2003). The approach of the IHA analysis is to: 1. Statistically characterize the temporal variability in hydrologic regimes using biologically relevant attributes of the annual hydrograph (Table 2), 2. Quantify hydrologic alterations associated with perturbations (such as channelization, dam operations, flow diversion, or watershed development), and 3. Quantify the natural range of hydrologic variation to determine to what extent the perturbed range of hydrologic variation has exceeded natural bounds and whether it can be manipulated to more closely approximate the natural condition.

Table 2. Indicators of Hydrologic Alteration (IHA) analytical parameters (after The Nature Conservancy 1997).

IHA Statistic Group	Regime Characteristics	Hydrologic Parameters
Magnitude of monthly water conditions	Magnitude Timing	Mean value for each calendar month
Magnitude and duration of annual extreme water conditions	Magnitude Duration Frequency	Annual 1-day minima Annual minima, 3-day mean Annual minima, 7-day mean Annual minima, 30-day mean Annual minima, 90-day mean Annual 1-day maxima Annual maxima, 3-day mean Annual maxima, 7-day mean Annual maxima, 30-day mean Annual maxima, 90-day mean Number of zero flow days Base Flow
Timing of annual extreme water conditions	Timing	Julian date of each annual 1-day minimum Julian date of each annual 1-day minimum
Frequency and duration of high and low pulses	Magnitude Frequency Duration	Number of low pulses Mean duration of low pulses Number of high pulses Mean duration of high pulses
Rate and frequency of water condition changes	Frequency Rate of change	Rise rate Fall rate Number of reversals

Recognizing that development of the Upper Mississippi and Lower Illinois Rivers did not greatly affect total discharge (Chen and Simons 1986, Sparks 1995), the authors used the IHA analyses to assess water surface elevations. They examined pre- and post development hydrologic regimes at six long-term water surface elevation gages distributed throughout the Upper Mississippi River, and one on the Lower Illinois River. They further applied the IHA Range of Variation Analysis (RVA) to calculate indexes of hydrologic alteration. The authors cite several examples of biological response to development of the Upper Mississippi and Lower Illinois Rivers and discuss the implications for river management and restoration measures. Koel and Sparks (2002), for example correlated greater annual production of native fish species with years that exhibit more natural-like hydrology and greater production of exotic species in years with more altered hydrology. Buesing, Theiling, and Wilcox (2004) used the IHA to assess hydrologic implications of dam removal in the Upper Mississippi River St. Paul District. IHA tools can also be used to assess the extent to which the many hydrologic management scenarios considered in this report and other Upper Mississippi River initiatives may affect simulate the natural hydrology.

RECOMMENDATION: Consideration should be given to extending the application of the Indicators of Hydrologic Alteration analysis, to all portions of the UMR and IWW, to assist in guiding application of potential water level management actions.

D. Historical Water Level Management Initiatives

Water Level Management initiatives, to provide ecosystem benefits, are not new to the UMR-IWW. There are currently ongoing initiatives in all three UMR Corps Districts. A goal of this effort was to utilize the lessons learned from, and to maximize the use of existing data developed for, the initiatives. The following sections provide a brief overview of the historical and ongoing water level management initiatives within the UMR Corps Districts.

1. St. Paul District

a. Interagency Coordination

The Water Level Management Task Force of the River Resources Forum is the primary proponent of alternative water level management strategies, for ecosystem restoration, with which the St. Paul District coordinates. The River Resources Forum includes government representatives from the Iowa, Minnesota and Wisconsin Departments of Natural Resources; the National Park Service; the U.S. Army Corps of Engineers, St. Paul District; the U.S. Coast Guard; and the U.S. Fish and Wildlife Service. Its mission is to facilitate coordination among river resource management agencies on a wide variety of issues.

The River Resources Forum serves as an advisory body to the St. Paul District, Corps of Engineers, for implementation of GREAT I study recommendations and coordination of river related issues. The Water Level Management Task Force (WLMTF) is a technical advisory group established by the River Resources Forum to provide direction for evaluation of alternative water level management strategies and technical review of study components. For the pilot drawdown of Pool 8, the WLMTF assumed lead roles in the areas of public information, education, and coordination.

b. Small Scale Drawdowns

Small-scale drawdowns (less than 25 acres) were conducted in Pools 5 and 9 in 1997, 1998 and 1999. These drawdowns served as demonstration projects to provide additional information about the drying of sediments and vegetation response to drawdowns on the UMR.

c. Growing Season Drawdown - Pool 8

Pilot drawdowns of Pool 8 were completed during the summers of 2001 and 2002. A *Problem Appraisal Study For Water Level Management* (Water Level Management Task Force, 1996), completed in November 1996, concluded that partial pool drawdowns of Upper Mississippi River navigation pools have the potential for providing substantial habitat restoration benefits. Important considerations in selecting Pool 8 for the pilot drawdown were the relatively lower dredging requirements needed to maintain the navigation channel, the existing habitat conditions within Pool 8 and the potential habitat benefits, the potential effects on recreational users, and public input.

Under normal regulation, Pool 8 is operated using hinge-point control with the primary control point at LaCrosse, WI (Elev. 531.0), and the secondary control point at the dam (Elev. 530.0). The attempted increase in drawdown in Pool 8 was 1.5 feet (to elevation 628.5 at the dam), subject to maintaining a minimum pool elevation of 630.5 at the La Crosse gage. This minimum elevation at LaCrosse was selected to limit the extent of the drawdown in upper Pool 8. This operating constraint limited the drawdown to river discharges above 28,000 cfs. Advanced maintenance dredging was required to maintain the navigation channel during the drawdown. A total of 120,000 cubic yards of material was dredged to facilitate the drawdown, at a cost of $737,300. The St. Paul District hopes to recover a significant portion of this cost through reduced dredging requirements in the subsequent years.

For 45 days in 2001 and 90 days in 2002, the St. Paul District successfully lowered the water level in pool 8. This action exposed about 2,000 acres of river bottom to air and sunlight for the first time in decades. Once exposed, more than 50 plant species, including arrowhead, rice cutgrass, nutgrass, bulrush, and cattail sprouted from the seed bank in exposed areas (Figure 4; Kevin Kenow, U.S. Geological Survey, Upper Midwest Environmental Sciences Center, La Crosse, Wisconsin, personal communication). These native plants, once established, may serve to reduce both plant bed and bankline erosion by buffering waves and currents. The plant growth also creates high value wetland habitat that furnishes high-quality food for wildlife such as tundra swans, which favor arrowhead tubers.

Due to the positive vegetative response to the pilot drawdowns in Pool 8, the Water Level Management Task Force (WLMTF) has been evaluating where, and to what extent, additional water level reductions can be done.

d. “Minor” Growing Season Drawdowns in Pools 6 and 9

In 2003, the St. Paul District intended to conduct “minor” drawdowns in Navigation Pools 6 and 9. The drawdowns would be similar to that in Pool 8, however, the goal was to perform no advanced maintenance dredging in advance of the drawdown and therefore limit the magnitude of the drawdown as well as the range of acceptable flow conditions under which the drawdown could be maintained without closure of the navigation channel.

Prior to implementation of the drawdowns, both actions were postponed until 2004. In Pool 6, recreational interests voiced concerns over potential impacts to recreational use (primarily concerning river access) in the lower portion of Pool 6. The St. Paul District is currently working to address this concern prior to the 2004 growing season. In Pool 9, the drawdown was delayed until 2004 due to the time required to complete the compliance process for cultural resources protection in the State of Iowa.

Figure 4. Vegetative Conditions in Pool 8 at Start of Drawdown (Top) and 1 Month into Drawdown (Bottom).

e. Winter Operation

Prior to 1995, a winter operating band of +/- 0.3 feet about the target water surface elevation at the La Crosse gage was used. These expanded limits allowed for time to free up a frozen-in gate. Since 1995, the St. Paul District has operated on the high side of this operating band, limiting the band to 0.0 to 0.3 feet above the target water surface elevation. The historical use of expanded limits was discontinued to improve water quality conditions in backwater areas by increasing the volume of water and mass of dissolved oxygen at ice-over. Oxygen depletion, which occurs in many backwaters during winter, would be less extensive due to the greater mass of dissolved oxygen in the slightly higher water column. Reduced magnitude, spatial extent, and frequency of winter oxygen depletion would increase the availability of suitable overwintering habitat for lentic fishes (Bodensteiner and Sheehan 1988, Bodensteiner et al. 1990, Knights et al. 1995, Raibley et al. 1997, and Johnson et al. 1998). Increased habitat could improve overwinter survival and condition of fish, possibly having some positive population-level effects.

The slightly higher and slightly more stable winter water levels could also benefit furbearers such as beaver and muskrat, whose dens and foraging areas are subject to disturbances from changes in winter water levels.

2. Rock Island District

a. Interagency Coordination

The Fish & Wildlife Interagency Committee's Water Level Management Subgroup (comprised of representatives from the U.S. Fish and Wildlife Service, the Iowa DNR, and Illinois DNR; with support from the Upper Midwest Environmental Sciences Center and participation by local representatives of Non-Government Organizations) is the primary proponent of alternative water level management strategies, for ecosystem restoration, with which the Rock Island District coordinates. The Fish and Wildlife Interagency Committee (FWIC) is a field staff-level coordination forum sanctioned by the State and Federal agencies that participated in the Great River Environmental Action Team (GREAT) process of the late Seventies and the Master Plan process of the early Eighties.

The FWIC currently has two standing subcommittees: the Water Level Management Subcommittee and the 404 Team. The Water Level Management Subcommittee works with Rock Island District staff to seek opportunities for modified river regulation that would provide benefits to fish and wildlife. This subcommittee supported the planning and implementation of an experimental drawdown in Pool 13, and is currently seeking other opportunities for both pool-wide and small-scale drawdowns. The 404 team was formed to support development of targeted research on the effects of dredged material disposal on fish, vegetation, and invertebrates.

In recent years, the Rock Island District has met on several occasions with The Nature Conservancy to discuss alternative water level management strategies and tools to reduce and/or eliminate non-natural stage fluctuations on the Illinois Waterway.

b. Winter Operation

The authorized limits for most pools on the Rock Island District Portion of the UMR expand from 0.5 foot during the navigation season to 1.0 foot (expanding to allow lower pool elevations) during the non-navigation season. Prior to 1987, expanded limits were utilized during winter months to allow for fewer gate settings. However, since 1987, in coordination with the Fish and Wildlife Service, the normal 0.5 foot pool limits have been maintained throughout the entire year to improve water quality and aquatic habitat in backwater areas, which historically suffered from low dissolved oxygen levels, or which could become isolated, during periods of ice cover.

c. Growing Season Drawdown – Pool 13

At the request of the Fish and Wildlife Interagency Committee (FWIC) the Rock Island District attempted temporary drawdowns of Navigation Pool 13 during the summers of 1998, 2001, and 2003 to benefit environmental resources. The FWIC requested that the District conduct a 1-foot drawdown below the normal operating band for a continuous 30-day period between June 15 and August 15.

In order to avoid closure of the navigation channel, or the need for additional dredging, maintenance of the drawdown was limited to when the flow was between 50,000 and 110,000 cubic feet per second (cfs). Below 50,000 cfs the reliability of the navigation channel would be threatened, above 110,000 cfs open river conditions would prevail. Based on historical flow records, it was estimated that a continuous 30-day drawdown could be achieved in approximately one out of three years.

The drawdown was expected to increase moist soil plant production, promote sediment oxidation and compaction, and expand the photic zone for submersed vegetation, thereby providing conditions beneficial to fish and wildlife resources in the lower portion of Pool 13. Staff of the Rock Island District and the Upper Midwest Environmental Sciences Center (UMESC, formerly the Environmental Management Technical Center) estimated that approximately 440 acres in the lower pool would be dewatered by a 1-foot drawdown at the dam. Additional acreage could indirectly benefit from this action.

The effects of the drawdown were monitored by the state and federal resource agencies. Before and during the drawdown period, sampling was conducted to measure larval fish production in the impact area and photo points were monitored to measure vegetative response.

In each of the three years, the drawdown attempts were discontinued due to river flows outside of the 50,000 - 110,000 cfs range (in 2001 and 2003 the flows fell too low; in 1998 the flows rose too high). Therefore, none of the attempts were successful in achieving the primary objective of a 30-day drawdown. Due to the short duration of the drawdown attempts, insufficient monitoring was accomplished to determine if the secondary objectives of sediment compaction or oxidation were met.

3. St. Louis District

a. Interagency Coordination

During the 1994 annual spring coordination meeting between the Corps of Engineers, Missouri Department of Conservation (MODOC), Illinois Department of Conservation and the U.S. Fish and Wildlife Service, water level management was a major focus of discussion. The water control managers asked the river and wildlife biologists to clarify their environmental pool management goals with a suggested pool water level management schedule. In response to this request, a set of parameters and a period of time desired were provided by the Missouri Department of Conservation. Since the parameters and the time period were both possible and within the water control management authority, the water management schedule was immediately implemented.

b. Growing Season Drawdowns

Environmental Pool Management (EPM), first implemented in 1994, attempts to create thousands of acres of critical wetland vegetation in the navigation pools, while still maintaining a safe and dependable navigation channel. A successful environmental pool management year is to keep the already drawn down pools (due to high flows and the hinge-point method of operation, discussed above), continued drawn down 0.5 to 2.0 feet for at least 30 days. This pool drawdown occurs between May and August, with the May-June period being the most desirable for non-persistent vegetation propagation (Figure 5). The target drawdowns are usually: 0.5-1.0 feet at Lock and Dam 24; 1.0-2.0 feet at Lock and Dam 25; and 0.5-1.0 feet at Mel Price Lock and Dam. Drawdown targets greater than these have not been attempted due to potential negative impacts on recreational use of the river.

The Missouri Department of Conservation provides monitoring during the drawdown periods in each of the pools. In 1994, it was estimated that more than 2,000 acres of vegetation were created as a result of the drawdowns that year. It was based on this measurable success that the decision was made to continue the growing season drawdowns in subsequent years. From 1999 to 2002, Southern Illinois University performed detailed monitoring in Pool 25 to measure ecosystem responses to EPM. Results of their analysis are presented in an April 2003 report to the St. Louis District (Garvey et al, 2003).

Garvey et al. (2003) found that vegetation response varied with hydrologic conditions in each year monitored. In 1999, an extended drawdown resulted in a large magnitude response by smartweeds, chufa (primarily red-root sedge, and millet. A brief drawdown in 2000 resulted in very minimal emergent plant response. Moderate drawdowns in 2001 resulted in a moderate emergent plant response. The species assemblage differed between 1999 and 2001 with a later drawdown resulting in less smartweed. Seed biomass was similar in both years however. Fish sampling indicated that the young-of-year of spring and summer spawning species were abundant in emergent residual or the current year’s emergent vegetation. Fishes were most abundant in years with greater abundance of emergent vegetation. Extended drawdowns isolating vegetated backwaters for extended periods resulted in poor water quality (<3 ppm) and

Figure 5. Vegetative growth in dewatered areas of Pool 25, summer of 2001.

low fish diversity of tolerant species like mosquito fish. Diverse habitat patches in channel border habitats had the greatest fish diversity. Spring migrating waterfowl appeared to respond to the previous year's vegetation production as well as climatological and regional factors. Water quality was generally within tolerance limits of most fishes except for a particularly isolated site that had chronically low dissolved oxygen. Zooplankton abundance was generally higher in vegetated plots. Macroinvertebrate communities were highly variable and associated with hydrologic and vegetation dynamics. There were generally fewer large, long-lived species in the variable lower pool reaches. Because annual hydrology varied through the study, the results demonstrated different ecological responses under different hydrologic conditions; similar to that known in moist soil wildlife management areas. This implies that if managers have broader management limits allowed by dam or mid pool operating regulations, they can manage for specific results in different years.

During implementation, an important component of EPM is the close coordination with resource managers in the field. As with any natural process, the vegetative response will vary from year to year, and the resource managers provide valuable insight into annual vegetative response.

RECOMMENDATION: Existing coordinating bodies should be engaged to support the prioritization, implementation, and monitoring of water level management actions resulting from implementation of the recommendations of the Restructured Navigation Study. Greater coordination between the three UMR Corps Districts and coordinating bodies should be pursued to prioritize resource allocation and monitoring.

RECOMMENDATION: Ongoing water level management initiatives should continue to be pursued, and not rely upon the outcomes of the Restructured Navigation Study. If the study results in authorization of a systemic ecosystem restoration program, the ongoing water level management initiatives should be integrated into the adaptive management strategy of that program.

RECOMMENDATION: Water level management has been test applied in all three UMR Corps Districts over the past decade, in a variety of different pools, with varying degrees of success. The study team believes that the benefits of these actions has been proven sufficient to recommend that the three UMR Corps Districts move beyond the concept of pilot projects and test applications to making water level management, for ecosystem restoration, an integrated part of the Corps' water management procedures; and that the Corps should pursue whatever authorities may be necessary to accomplish this.

III. Alternative Water Level Management Actions

Changes to the hydrologic regime on the UMRS can have many effects on the river ecosystem and on water uses, both positive and negative. In this investigation, six primary water level management actions were considered:

- Lowering the Pool Level Below the Existing Operating Band (Pool Drawdowns)
- Raising the Pool Level Above the Existing Operating Band (Pool Raise)
- Changing From Hinge-Point Control to Dam-Point Control
- Modification to the Distribution of Flow Across the Dam
- Reduction in Pool Level Fluctuations
- Inducing Water Level Fluctuations During Winter

In addition to these six basic management actions, each management action has the potential to produce different benefits and impacts depending upon the timing of implementation, the duration of implementation, and the magnitude of the change. The sections below provide descriptions of the management actions, expected ecological benefits, and impacts resulting from implementation of the management actions. Information contained in the following sections were drawn from the input of team members (identified in Section I.D) and from existing Water Level Management literature, most notably the 1996 *Problem Appraisal Study For Water Level Management* (Water Level Management Task Force, 1996), completed by the St. Paul District.

A. Lowering the Pool Level Below the Existing Operating Band (Pool Drawdowns)

1. Description of Action

This management action involves a reduction in the target operating level for the navigation pool, as measured at the dam. As discussed above, fourteen of the thirty-six navigation dams on the UMR and IWW are operated using “hinge-point” or “primary-secondary-tertiary” control. Under these modes of operation, a drawdown at the dam automatically occurs as part of the normal operation, under certain flow conditions. The purpose of this management action is to either extend the period of time that the pool is drawn down or to increase the magnitude of the drawdown in these pools. For the pools operated under “dam-point control”, this action involves a water level reduction at the primary control point located at the dam.

This distinction is important in that the pools operated using “dam-point control” have historically not been maintained (through dredging) to accommodate *any* drawdown, nor has the infrastructure along the lower portion of the pool necessarily been constructed or maintained to accommodate water levels below the normal pool elevation. Therefore, impacts to other users of the river and advanced maintenance dredging requirements (in order to maintain project channel dimensions during the drawdown) tend to be greater in these pools.

2. Supported Environmental Objectives

The primary objectives of this alternative are: 1) the exposure of substrate to compact and oxidize sediments to increase water clarity and nutrient assimilation, respectively, and 2) the extension of the photic zone through improved water clarity as well as extending the areal extent of the photic zone where water depths are reduced, but not exposed to increase the production, extent, and diversity of aquatic plants. An increase in the abundance of emergent and submersed aquatic plants would improve habitat conditions and provide a valuable source of food for a variety of organisms including young-of-year and small fish, migratory birds, wading birds, furbearers, reptiles, and amphibians. Upon reflooding, the flooded vegetation would provide valuable habitat for small fish and spawning habitat for fish the following spring. Further, an increase in the abundance of emergent and submersed aquatic plants would help to dissipate wind energy, resulting in less sediment resuspension in the near-shore zone and reduced bank erosion. In addition, drawdowns could be used as a tool to control undesirable or exotic species. For example, a drawdown could be timed to interrupt carp spawning or to strand zebra mussels in order to induce mortality.

The species composition of new vegetation would depend on a variety of factors including the plant propagules (seeds, tubers, and rhizomes) present in the sediment, the seasonal timing of the drawdown, the degree of sediment dewatering that occurs, weather conditions, etc. In addition, drawdowns in areas that currently have submersed aquatic or moist soil plants may result in short term mortality of these plants in exchange for new growth of emergent aquatic plants depending upon conditions during the drawdown and frequency of occurrence of drawdowns.

Consolidation of sediments during a drawdown may help to limit sediment resuspension by wave action and bioturbation, and create beneficial conditions for establishment of submersed aquatic plants (Cross 1988 - 1993). In addition, the expanded vegetation would help to reduce sediment resuspension by wave action and promote the settling of suspended materials in the river, leading to improved water clarity (Sparks et al. 1990). Benthic macroinvertebrates will rapidly recolonize in the dewatered areas following refilling (Theiling 1995; Garvey et al. 2003).

3. Potential Impacts of Action

a. Impacts to Ecosystem Resources and Water Quality

During the drawdown, there would be increased mobilization of sediments, resulting in increased suspended solids draining from backwater areas through advective flow and wind (Water Level Management Task Force 1996). These sediment flows could exert some dissolved oxygen demand on the backwater and channel areas.

Exposed sediments would consolidate during the drawdown, oxidize, and change chemically (Richardson 2002). The degree to which the sediments would dewater, consolidate, and oxidize would depend on the frequency and duration of rewetting caused by rainfall and increases in river discharge during the drawdown period.

Many backwaters isolated and rendered shallow by drawdown would be subject to high summer water temperature, dissolved oxygen depletion, and possibly unionized ammonia toxicity. The reduced water volume in backwaters would result in wider swings in day-to-night water temperature, pH, dissolved oxygen, and possibly unionized ammonia. These conditions would be stressful to aquatic life, and fish may be forced out of some backwater areas during the warmer parts of the summer (Water Level Management Task Force 1996).

Upon reflooding, drawdown zone sediments may release phosphorus, triggering an algae bloom if conditions allow. Flooded standing vegetation releases considerable dissolved organic matter that causes both flocculation and settling of suspended solids, and can exert a substantial oxygen demand when water temperatures are warmer. Fall reflooding of vegetation in drawdown zones should not result in significant dissolved oxygen depletion because of the greater solubility of oxygen during cool water periods (Water Level Management Task Force 1996).

Consolidation and oxidation processes should increase the critical shear strength of the sediment during drawdown. Upon reflooding, the bottom sediment should be more resistant to resuspension by waves and bioturbation than before the drawdown, resulting in improved water clarity. More extensive vegetation should also contribute to greater water clarity through reduced wave resuspension of sediments (Water Level Management Task Force 1996).

b. Impacts to Commercial Navigation

Disruptions to the normal flow of traffic have the potential to increase the overall costs of shipping. The following is a description of the potential effects of drawdowns on Commercial Navigation:

i. Maintenance of the 9 ft Navigation Channel

Advanced dredging would likely be required to maintain a reliable navigation channel during a drawdown. The amount of advanced maintenance dredging would vary with the magnitude of the drawdown. If the new, deeper channel conditions were to be maintained for drawdowns in subsequent years, additional annual maintenance dredging may be required due to potentially increased trapping efficiency in chronic dredging areas. The additional dredging requirement could potentially be mitigated through the construction, or modification, of wingdam structures in the reach. In addition, during the drawdown period, the existing wingdam structures may become more effective at training flows to the main channel thereby reducing shoaling during these periods (Water Level Management Task Force 1996).

ii. Sill Depth of Lock

The depth at the entrance of the lock chambers must be sufficient to allow fully-loaded barges safe and efficient access to the chamber. As the barge enters the lock chamber, water is displaced which must flow around and underneath the barge, and out of the chamber. Insufficient flow area between the sill and the bottom of the barge will result in increased forces that resist the barges' entrance into, and exit from, the lock (sometimes referred to as the "piston" effect) that increases the entry and exit times for the transiting tow and may result in the tow striking the miter gates. Recommendations regarding minimum clearance over the sill to prevent such conditions are presented in the ERDC Technical Report, "Effects of Lock Sill and Chamber Depths on Transit Time of Shallow Draft Navigation" (Maynord, 2000).

iii. Depths near Terminals

Terminals are locations along the river where barges may tie-off, load, and unload materials. A drawdown has the potential to limit or prevent access to these existing facilities. Localized dredging could be an option to improve access during a drawdown; however, the Corps currently has no authority to conduct such dredging. In addition, the tie-off points may need to be altered depending upon the degree of drawdown implemented. The locations of terminals on the Upper Mississippi River and Illinois Waterway are listed in the Inland River Guide (Spencer, 2002a).

iv. Depths in Fleeting Areas

Depending on bathymetry and degree of drawdown, fleeting area locations may become less accessible. During a drawdown new fleeting areas could be identified and authorized for use. Locations of fleeting areas are listed in the Inland River Guide (Spencer, 2002b).

v. Safe Approach Conditions at locks and bridges

The lowering of pool elevations alters the distribution and velocity of flow in the navigation channel. Wingdams that were formerly submerged may become emergent, and more effective, training more flow towards the center of the channel. Changes in the distribution and magnitude of channel velocities can cause maneuvering difficulties for tows as they are approaching locks and bridges. Lock locations that currently experience outdraft problems may require increased use of helper boats to assist tows in making their approach to the lock.

vi. Depths over Bendway Weirs

Currently there are no bendway weirs in the pooled portion of the UMR. However, construction of a bendway weir above L&D 24 is currently being discussed. Bendway weirs are typically built to a depth of 15 feet below minimum pool and are designed for navigation to pass over the top of the structure. A drawdown could result in reduced depths over the structure creating hazardous conditions for transiting tows.

vii. Rock Substrate in the Navigable Channel

Areas of the navigation channel that have rock substrate are extremely costly or impossible to deepen sufficiently to provide suitable channel dimensions during periods of drawdown. Most, if not all, of the rock cuts likely to be impacted by drawdowns are located in the Rock Island District. This is due to the current (St. Louis District) and historical (St. Paul District) drawdowns that are/were a part of the operation plan for the other Districts. During construction of the 9-foot channel project, the rock cut areas (in the Rock Island District) were cut to 11 ft below the flat pool elevation; with Pool 15 cut to only 10.5 ft in certain locations. Deeper cuts were seldom done because rock cutting is very expensive and deeper cuts were unnecessary given the dam-point method of operation utilized by the Rock Island District. If a drawdown is implemented, adequate depth above the rock substrate is a serious issue for navigation in certain locations. In the Rock Island District, frequent problem areas for barge navigation due to rock substrate on the UMR and Illinois Waterway (excluding the canal system above Lockport Lock, RM 291) are:

River	Pool	Location	Approx. River Mile
UMR	14	Smith Chain	496
	15	Lock 14 Lower	493
	15	Campbell's Island	491
	15	Bettendorf	487
	16	Crescent Bridge	481
	16	Credit Island	480
	16	Horse Island	476
	18	Edward's River	431
	20	Lock 19 Lower	364
	24	Lock 22 Lower	301
IWW	Brandon Road	Ruby St. to Lockport Lower	288.9 – 291
	Dresden Island	Brandon Road Lock Lower	284 – 285.8
	Dresden Island	Treats Island Cut	280.1
	Marseilles	Dresden Island Lower Approach	270.4 – 271.3
	Marseilles	North Kickapoo Creek	250
	Marseilles	South Kickapoo Creek	248.9 – 249.5
	Marseilles	Ballards Island Lower	247.5 – 247.6
	Marseilles	Marseilles Canal	244.6 – 247
	Starved Rock	Marseilles Lower Approach	244 – 244.5
	Starved Rock	Milliken Creek	242.4 – 244
	Starved Rock	Bulls Island Cut	241.2 – 241.5
	Starved Rock	Poor Farm Cut	235 – 236.6
	Peoria	Starved Rock Lower Approach	229.8 – 230.8

c. Impacts to Recreation

Drawdowns will have noticeable effects on recreation, primarily associated with reduced ramp and dock access, reduced backwater access, and potential safety concerns due to lower water levels. The extent of the impact would be related to the size of the drawdown and the flow of the river during the drawdown period. Greater effects would occur with larger drawdowns, and under periods of lower flow.

Recreational craft navigating the main channel would be less sensitive to drawdowns than commercial craft, since most draft to 3.5 feet or less. Drawdown impacts at marinas would likely be more serious than those at ramps, since trailered boats can more easily be transported to substitute launching areas, while marina boats have stationary slips. Crowding at open ramps could create access availability problems in some areas. A drawdown would result in reduced boating access to backwater areas. The extent of the effect will be greater with larger drawdown alternatives.

Lower water levels could also increase safety hazards if underwater objects (such as stumps or wingdams) were closer to the water surface or exposed. These hazards currently exist under present conditions, and would likely be exacerbated under drawdown conditions.

Long-term benefits to recreationists would be expected, to the extent that improvements to fish and wildlife resources are realized (Water Level Management Task Force 1996).

d. Impacts to Hydropower

Hydropower facilities generate power from the difference in water level upstream and downstream of the dam (the operating head). Pool drawdowns would result in less operating head for power generation at hydropower facilities. Hydropower facilities in the study area are located at:

<u>Upper Mississippi River</u>:

- St. Anthony Falls, NSP – 12,000 KW
- Lock & Dam 1, Ford Hydro Plant – Capacity 14,400 KW
- Lock & Dam 2, City of Hastings – 4,400 KW
- Lock and Dam 15, Corps of Engineers - Capacity approximately 250 KW
- Arsenal Island Hydroelectric Plant (Sylvan Slough, RM 484) – Capacity 2,800 KW
- MidAmerican Energy Hydroelectric Plant (Sylvan Slough, RM 484.6) – Capacity 3,700 KW
- Dam 19, Ameren UE Hydroelectric Plant – Capacity 135,000 KW

<u>Illinois Waterway</u>:

- Starved Rock Lock & Dam Power Project, City of Peru – Capacity 2,142 KW
- Lockport Powerhouse – Capacity 6,000 KW

e. Impacts to Adjacent Landowners

The Government may not have to acquire any additional real estate rights to draw the pool down. Non-government riparian owners may claim that their property value or the property itself is being adversely affected due to aesthetic effects, lost recreational opportunities, or bank slumping. These would have to be evaluated on a case-by-case basis. Conversely, long-term improvements in habitat quality could result in increased property values for riparian owners.

f. Other Impacts

Drawing down the pool would have visual effects that would likely be viewed negatively by most of the general public. Exposed river bottom, decaying vegetation, and in some locations, dead fish would be aesthetically unpleasing. Drawdowns may produce an odor from the exposed sediments, decaying vegetation, and decaying fish that would likely be locally offensive, with the effects generally lasting less than a week, and varying greatly with temperature and wind conditions.

A drawdown of the pool could adversely affect cultural resources. In areas where a drawdown would lower the pool below the normal, seasonal low-water levels, cultural sites may be subject to: increased erosion from wave action; increased biochemical deterioration of deposits due to exposure to sunlight and oxygen; and human impacts related to vandalism, looting, and recreational use of areas (Dunn, 1996).

RECOMMENDATION: Implementation planning for pool drawdowns should include a monitoring and mitigation plan for cultural resource sites that may be exposed to mechanical, biochemical and/or human destruction.

4. Constraints to Implementation

a. Operational/Structural

Execution of a drawdown would require additional effort by water control personnel and dam personnel in the form of more frequent gate changes and additional monitoring of river elevations.

b. Hydrologic

Natural fluctuations in river discharge may prohibit drawdowns. Periods of high flow produce river stages that are naturally higher than the project pool elevations, and which cannot be controlled through the operation of the navigation dam. When the tailwater elevation (plus swellhead through the dam) is in excess of the desired drawn down pool elevation, a drawdown cannot be accomplished.

Additionally, very low river discharges may prohibit a drawdown due to insufficient depth available at the next upstream dam’s lower miter gate sill.

c. Legal

Implementation of a drawdown may be inconsistent with the project’s single authorized purpose of navigation and may therefore require additional authority. In addition, implementation would require review of, and compliance with, applicable laws and regulations. Wilcox and Willis (Wilcox, 1993) provide an overview of the major constraints on river regulation practices, including legal constraints. Applicable laws and regulations include:

- The Rivers and Harbors Act of 1930, which authorized the construction and operation of the Upper Mississippi River Nine-Foot Channel Project and the Illinois Waterway to provide for a channel depth of nine feet at low water with widths suitable for long haul, common carrier service.
- Code of Federal Regulations 33 CFR 222.5 (ER 1110-2-240) which covers policy and procedures for water control management.
- The National Environmental Policy Act
- The Clean Water Act
- The Federal Water Project Recreation Act (1965)
- The Federal Power Act of June 10, 1920
- The Fish & Wildlife Coordination Act (16 U.S.C. 661)
- The National Historic Preservation Act
- The Endangered Species Act

In addition, consideration must be given to existing interagency agreements, including the 1963 cooperative agreement between the Department of the Army and The Department of the Interior on the land and water areas of the Upper Mississippi River nine foot channel project, which made all privileges granted subject to navigation and flood control purposes, including changing water surface elevations.

5. Authorization(s) Required for Implementation

Historically, implementation of drawdowns (in excess of the current regulation limits) on the Upper Mississippi River have been conducted as temporary deviations to the approved regulation plan, as approved by the Division Commander (per 33 CFR 222.5). The Digest of Water Resources Policies and Authorities (EP 1165-2-1, Feb. 15, 1989) states that "Revised water control plans to add a new objective not included in the project authorization, other then municipal and industrial water supply, water quality, fish and wildlife, instream flows and recreation not significantly affecting operation of the project for authorized purposes, require congressional authorization." Based on this document, congressional authorization may be required to implement this management action for the benefit of fish and wildlife, to the extent that such management actions render navigation hazardous or otherwise significantly affect the operation of the project for its authorized purpose of navigation.

The Water Resources Development Act of 1988 (Public Law 100-676) provides for public review and comment prior to any change in reservoir operation that would significantly affect any project purpose.

B. Raising the Pool Level Above the Existing Operating Band (Pool Raise)

1. Description of Action

This management action involves an increase in the target operating level for the navigation pool, as measured at the dam. The management action could be implemented either in winter to benefit overwintering fish or in spring during years with low flows to benefit species that make use of flooded habitats.

2. Supported Environmental Objectives

An intentional pool raise during the winter would provide for increased overwintering depths for fish, as well as provide greater dissolve oxygen levels and increased water temperatures in backwater areas. This would provide for increased overwintering fish habitat that would improve survival and condition of the fish, potentially having positive population-level effects.

An intentional pool raise in the spring during years with minimal spring runoff could be employed as a management measure to increase productivity of riverine life through a controlled "flood pulse." The pool level could be raised to provide flooded terrestrial vegetation used by northern pike and walleyes for spawning. The pool level could be maintained at a higher and gradually declining level into early June, providing good habitat conditions for young-of-year fish, waterfowl broods, and wading birds. This water level management could have a minor but positive effect on abundance of fish and other organisms dependent on flooded vegetation habitats in the spring. The intentional pool raise could be stopped abruptly in late May to strand carp eggs and limit recruitment of carp.

3. Potential Impacts of Action

a. Impacts to Ecosystem Resources and Water Quality

Pool raises have the potential to inundate low-lying terrestrial floodplain areas producing mortality of trees and other vegetation, as well as flooding furbearer dens.

During a winter pool raise, water quality conditions can be expected to be better in backwater areas due to the increased volume of water and mass of dissolved oxygen at ice-over. Oxygen depletion, which occurs in many backwaters during winter, would be less extensive due to the greater mass of dissolved oxygen in the slightly higher water column. Additionally, water temperatures in backwaters would be slightly increased.

During a spring pool raise, water temperatures in backwater areas would generally be reduced. In addition, connectivity between the channel and backwater areas may be increased, resulting in greater exchange of oxygen and nutrients and greater mobilization of sediments. A spring pool raise may additionally result in a reduction in the areas suitable for production of submersed aquatic plants due to greater depths and light extinction.

b. Impacts to Commercial Navigation

A seasonal pool raise is likely to have no negative effect on maintenance of the navigation channel, commercial navigation, or transportation infrastructure. The higher water levels may benefit commercial navigation by providing additional depths in the navigation channel and at loading facilities.

c. Impacts to Recreation

A seasonal pool raise would benefit boaters to the extent that the higher water improves access to off-channel areas and provides deeper depths at recreational facilities. Long-term benefits to recreational users would be expected as a result of improvements to fish and wildlife resources. Extended implementation of this management action may require modification to existing recreation infrastructure, including boat ramps, marinas, and docks to accommodate the increased water levels.

d. Impacts to Hydropower

A seasonal increase in the pool level would result in higher pool elevations that would generally be favorable to hydropower production. Changes in the tailwater elevations at the next upstream dam would likely be minor to negligible, resulting in no appreciable impact to hydropower facilities at the next upstream dam.

e. Impacts to Adjacent Landowners

Seasonal pool raises would not have any adverse real estate ramifications as long as the water levels did not exceed the limits of Federal fee title or easement boundaries. An intentional raise above project pool levels that exceeded the existing flowage easement boundaries, and which was sufficient to constitute a legal “taking”, would require the acquisition of additional real estate rights of use, either through flowage easements, fee title acquisition, or through agreements with individual landowners. In addition to the cost of the real estate rights, there would be surveying and administrative costs associated with such acquisition.

4. Constraints to Implementation

a. Operational/Structural

As shown in Figure 1, 20 of the 36 dams on the UMR and IWW have uncontrolled overflow spillway sections with crest elevations at, or near, the project pool elevation. Any attempt to raise the pool level would result in increasing amounts of flow over the uncontrolled spillway section until such time that sufficient flow was passing over the uncontrolled spillway to prevent further pool raises. A seasonal raise in the project pool level would therefore require modifications to the overflow spillway section (if present) and perhaps to the dam gates themselves. Additional efforts required of the lock and dam staff could be substantial if temporary modifications (such as removable flashboards) were used along the crest of the overflow spillway and on the top of the dam gates.

b. Legal

The legal requirements for this action are similar to those described in Section III.A.4. In addition, implementation would be subject to acquisition of real estate interests on those lands for which a taking is determined to have occurred; as well as compensation for damages to adjacent landowners impacted by seepage, blocked gravity drainage, and increased pumping costs.

5. Authorization(s) Required for Implementation

Implementation of this management action would likely require new congressional authority for the acquisition of additional fee title lands and flowage easements, as well as for compensation of damages to adjacent landowners.

C. Changing From Hinge-Point Control to Dam-Point Control

1. Description of Action

Under this management action, the pool would be operated under dam-point control for a portion, or all, of the year. By its definition, this alternative management action is only applicable to those pools that are currently operated under hinge-point control or by primary-secondary-tertiary control.

2. Supported Environmental Objectives

Year-round implementation of this management action would result in an increase in the extent of shallow aquatic and wetland habitats, improve spawning conditions for northern pike and walleyes, increase depths in backwater and side-channel areas, and provide a more natural response to changes in the hydrologic regime.

During winter, water quality conditions would be expected to improve in backwater areas due to the increased volume of water and mass of dissolved oxygen at ice-over. Oxygen depletion, which occurs in many backwaters during winter, would be less extensive due to the greater mass of dissolved oxygen in the slightly higher water column. A reduction in the magnitude, spatial extent, and frequency of winter oxygen depletion in river backwaters would increase the availability of suitable overwintering habitat for lentic fishes. Increased habitat could improve overwintering benefits to the survival and condition of fish, possibly having some positive population-level effects.

The slightly higher and slightly more stable winter water levels could also benefit furbearers such as beaver and muskrat, whose dens and foraging areas are subject to changes in winter water levels.

During spring, the reduction in water levels that occurs on the lower part of the pools would be eliminated, preventing negative effects on the life cycles of numerous species and providing for a more natural flood pulse response.

3. Potential Impacts of Action

a. Impacts to Ecosystem Resources and Water Quality

A change in the control point location to the dam, and the associated rise in water levels in the lower portion of the pool, would have the short-term effect of continuously inundating what were previously floodplain terrestrial areas. The terrestrial vegetation would be killed, and organic materials would be leached from the soil and decaying vegetation into the water. This effect would occur during the first month or two following change in pool regulation, but would probably be undetectable. The rate of water exchange in some backwater areas would be slightly reduced by the somewhat higher pool water surface, probably resulting in slightly greater algal densities during the summer. The higher water levels would have the positive effect of reducing the extent and frequency of winter oxygen depletion in shallow backwater areas. The reduced magnitude and frequency of water level fluctuations associated with a change in control point to the dam would also reduce the rate of water exchange in shallow and single-inlet backwaters by reducing the "tidal" exchanges that occur during changes in water level.

Relocation of the control point to the dam would cause the lower portion of the pool (below the hinge point) to be continuously inundated. This change would force the floodplain-terrestrial ecotone landward, resulting in a vegetation response in the zone affected. Part of the areas that presently support submersed aquatic plants would become too deep and revert to open water without plants. Emergent aquatic plants would become established in areas that presently support floodplain terrestrial vegetation. The rise in water level may kill a band of floodplain forest trees in the lower portion of the pool.

A change to control at the dam would also change the littoral processes of wind and wave action, shoreline erosion, and sediment transport. Islands in the lower part of the pool may be subjected to increased wave attack and erosion.

The reduced water level fluctuations in the lower portion of the pool, associated with the change to dam control, would have some minor long-term benefit in reducing the frequency of disturbance in littoral areas.

b. Impacts to Commercial Navigation

This action is likely to have no negative effect on maintenance of the navigation channel, commercial navigation, or transportation infrastructure. The slightly higher water levels may benefit commercial navigation by providing additional depths in the navigation channel and at loading facilities.

c. Impacts to Recreation

Changing the primary control point from a hinge-point to the dam would benefit boaters to the extent that the higher water improves access to off-channel areas and recreational facilities. Long-term benefits to recreational users would be expected as a result of improvements to fish and wildlife resources. Extended implementation of this management action may require modification to existing recreation infrastructure, including boat ramps, marinas, and docks to accommodate the increased water levels.

d. Impacts to Hydropower

Changing from hinge-point to dam-point control would result in higher, and more consistent, pool elevations under certain flow conditions (that portion of the flow range for which the pool would normally be drawn down under hinge-point operation). This would generally be favorable to hydropower production. Changes in the tailwater elevations at the next upstream dam would likely be minor to negligible, resulting in no appreciable impact to hydropower facilities at the next upstream dam.

e. Impacts to Adjacent Landowners

Changing from hinge-point to dam-point control would cause increases in water levels along the length of the pool. This would not require the acquisition of any additional real estate interests (in fee title or through flowage easements) as long as the water levels did not exceed the limits of Federal fee title or easement boundaries. A raise above project pool levels that exceeded the existing flowage easement boundaries, and which was sufficient to constitute a legal "taking", would require the acquisition of additional real estate rights of use, either through flowage easements, fee title acquisition, or through agreements with individual landowners. In addition to the cost of the real estate rights, there would be surveying and administrative costs associated with such acquisition.

4. Constraints to Implementation

a. Operational/Structural

If enacted as a permanent change (as opposed to seasonal), the higher water levels may temporarily reduce channel maintenance requirements due to the greater depths available in the lower portion of the pool. However, the change in pool operation would reduce the gradient in the pool that, over time, could result in less scour and increased channel maintenance requirements. Therefore, as the river adjusted to the new conditions, channel maintenance requirements could stabilize similar to present-day conditions or be increased. It is unlikely that long-term channel maintenance requirements would decrease under this alternative.

b. Legal

The legal requirements for this action are similar to those described in Section III.A.4. In addition, implementation would be subject to acquisition of real estate interests on those lands for which a taking is determined to have occurred; as well as compensation for any damages to adjacent landowners.

5. Authorization(s) Required for Implementation

Implementation of this management action would likely require new congressional authority for the acquisition of additional fee title lands and flowage easements, as well as for compensation of any damages to adjacent landowners.

D. Modification to the Distribution of Flow Across the Dam

1. Description of Action

Under this management action, flows through the dam gates could be redistributed along the length of the dam in an attempt to maximize tailwater habitat conditions. Modifying the distribution of flows across the dam gates also has the potential to be used in conjunction with a fish passage structure to provide attracting flows. The distribution of flow across the dam gates is constrained, as there are limits to the amount of flow that can be passed through a particular gate to prevent scour below the dam and vibration within the dam structure.

2. Supported Environmental Objectives

The combination of depth, velocity (and associated turbulence) and substrate type is a key factor in tailwater habitat. Fish concentrate in the tailwater areas because of the barrier to upriver movement imposed by the dam, and because of the diversity of habitat present. Some species, notably walleye and sauger, spawn in tailwater areas and provide a popular sport fishery. Changing the distribution of flow through the dam gates could increase the spatial extent and temporal occurrence of specific habitat conditions needed by spawning saugers, walleye, sturgeon, and paddlefish.

The velocity pattern in the tailwater could also be adjusted to provide an attracting flow adjacent to a new fish passage structure or perhaps to increase the number of fish that would be attracted into the lock for locking through to the upper pool.

3. Potential Impacts of Action

a. Impacts to Ecosystem Resources and Water Quality

Modifying the distribution of flow through the dam gates would alter the distribution and quality of habitats immediately below the dam. This modification would, as with any modification to the velocity and depth regime, benefit certain species over others. This management action would have no long-term impacts to water quality. In the short-term, some scour and transport of materials from below the dam may occur.

b. Impacts to Commercial Navigation

Modifying the distribution of flow through the dam gates has the potential to produce increased outdraft conditions above or below the lock, which could worsen approach conditions and therefore require additional use of helper boats and/or result in increased approach times. Likewise, it is possible that modifying the pattern of releases through the dam gates could have positive effects on navigability in the lock approaches.

c. Impacts to Recreation

Modifying the distribution of flow through the dam gates would have negligible effects on recreation. This change could have minor affects (to the betterment or detriment) on fishing conditions in the tailwater areas. Long-term benefits to recreational users would be expected, to the extent that improvements to fish and wildlife resources are realized.

d. Impacts to Hydropower

Modifying the distribution of flow through the dam gates would have no impact on hydropower generation.

e. Impacts to Adjacent Landowners

Modifying the distribution of flow through the dam gates would have no impact on adjacent landowners.

4. Constraints to Implementation

a. Operational/Structural

Variations in the distribution of flow through the dam gates may be possible; however, past problems with large scour holes developing downstream of the dam would limit the amount of flow that could be passed through an individual gate for a given flow condition. This is necessary to prevent scour from undermining the foundation of the dam. In addition, certain combinations of gate openings have the potential to produce structural vibrations in the dam.

The amount of allowable change from the existing pattern of releases from dam gates would vary with each dam, depending on the number of gates, condition of the scour protection at the base of the dam, etc.

b. Legal

There are no identified legal constraints to implementing this management action.

5. Authorization(s) Required for Implementation

The Corps of Engineers currently has the authority to implement this management action. Further evaluation would be required to determine specific objectives for velocity patterns in tailwater areas. Two-dimensional hydraulic modeling could be employed to examine alternatives for achieving objectives for velocity patterns and habitat conditions in tailwater areas, and to insure that unacceptable scour conditions below the dam, nor structural vibrations, are created.

E. Reduction in Pool Level Fluctuations

1. Description of Action

This management action involves reducing the magnitude of pool and/or tailwater fluctuations through modification of the dam structure, more intense management of the dam gates (i.e., more frequent gate changes), or through improved forecasting of future river conditions and regulation procedures. Short-term water level fluctuations, that is, water levels changes of 0.5 feet or more over the course of several hours to several days, stress plants and animals.

Non-natural, short-term water level fluctuations result from: increased stormflows entering the river from developed (urban) areas via local runoff or tributary streams; fluctuating hydropower releases; and dam operation procedures. Additionally, water levels in the upstream portions of the Illinois River Basin fluctuate in response to flood control operations in the Chicago Metropolitan area. Flow pulses due to drawdowns of Lockport Pool in advance of forecast rainfall, along with any stormwater generated by the storms, translate through the downstream pools until its effects are attenuated, causing downstream water levels to fluctuate.

Some sources of fluctuations are beyond the scope of this effort (as well as the scope of the Restructured Navigation Study), as they involve watershed level effects and the operation of hydropower facilities that the Corps of Engineers do not operate. Therefore, the focus of this effort (in regards to reducing pool level fluctuations) is on reducing short-term water level fluctuations impacted by the operation of the mainstem navigation dams.

2. Supported Environmental Objectives

Reducing the magnitude and frequency of water level fluctuations would have some positive effects on vegetation, small fish, and furbearers in littoral areas. The frequency of watering/dewatering shallow areas would be reduced, allowing development of vegetation and associated aquatic life with reduced frequency of disturbance. The greatest positive effect might be with increased survival of young-of-year fish, which make use of shallow littoral habitats as nursery areas.

3. Potential Impacts of Action

a. Impacts to Ecosystem Resources and Water Quality

Reducing the magnitude and frequency of water level fluctuations would not have any significant effects on water quality. Water exchange between the flowing channels and embayments and single-inlet backwater areas would be reduced, perhaps allowing greater development of algal blooms.

b. Impacts to Commercial Navigation

A reduction in pool level fluctuations would have no impact on maintenance of the 9-foot navigation channel, or on commercial navigation infrastructure.

c. Impacts to Recreation

A reduction in pool level fluctuations would have negligible effects on recreation. Control of water levels has been identified as an issue of concern among boaters on the UMRS (Carlson et al., 1995), and "smoothing out" the changes would be seen as an improvement; however, water level changes caused by changes in river flow would still be predominant. Long-term benefits to recreational users would be expected, to the extent that improvements to fish and wildlife resources are realized.

d. Impacts to Hydropower

A reduction in pool level fluctuations would have no impact on hydropower generation under moderate to high flow conditions. Under low flow conditions, it has been the historical practice of the hydropower plant at Pool 19 (owned and operated by Ameren UE) to store and release water behind the dam to maximize hydropower generation. By agreement with the Corps of Engineers, these daily to twice-daily fluctuations are limited to 2.0 feet in Dam 19's tailwater (pool fluctuations of approximately 0.5 feet), provided that a minimum stage of 2.0 feet is maintained below Dam 19 (Figure 6). A mandated reduction in water level fluctuations during low flow conditions would negatively impact hydropower generation at this facility.

e. Impacts to Adjacent Landowners

A reduction in pool level fluctuations would have no impact on adjacent landowners.

4. Constraints to Implementation

a. Operational/Structural

One method of reducing short-term pool fluctuations involves more intense management of dam operations, including increasing the number of daily gate changes. Increasing the number of daily gate adjustments would require water control personnel to perform addition monitoring and coordination with the projects. It would also require additional effort on the part of the lock and dam personnel to make the additional gate adjustments. Generally, lock and dam staffing levels are barely sufficient for current operational needs during the navigation season. More frequent gate adjustments would likely require an increase in lock and dam staff levels and/or automation of gate mechanisms and controls.

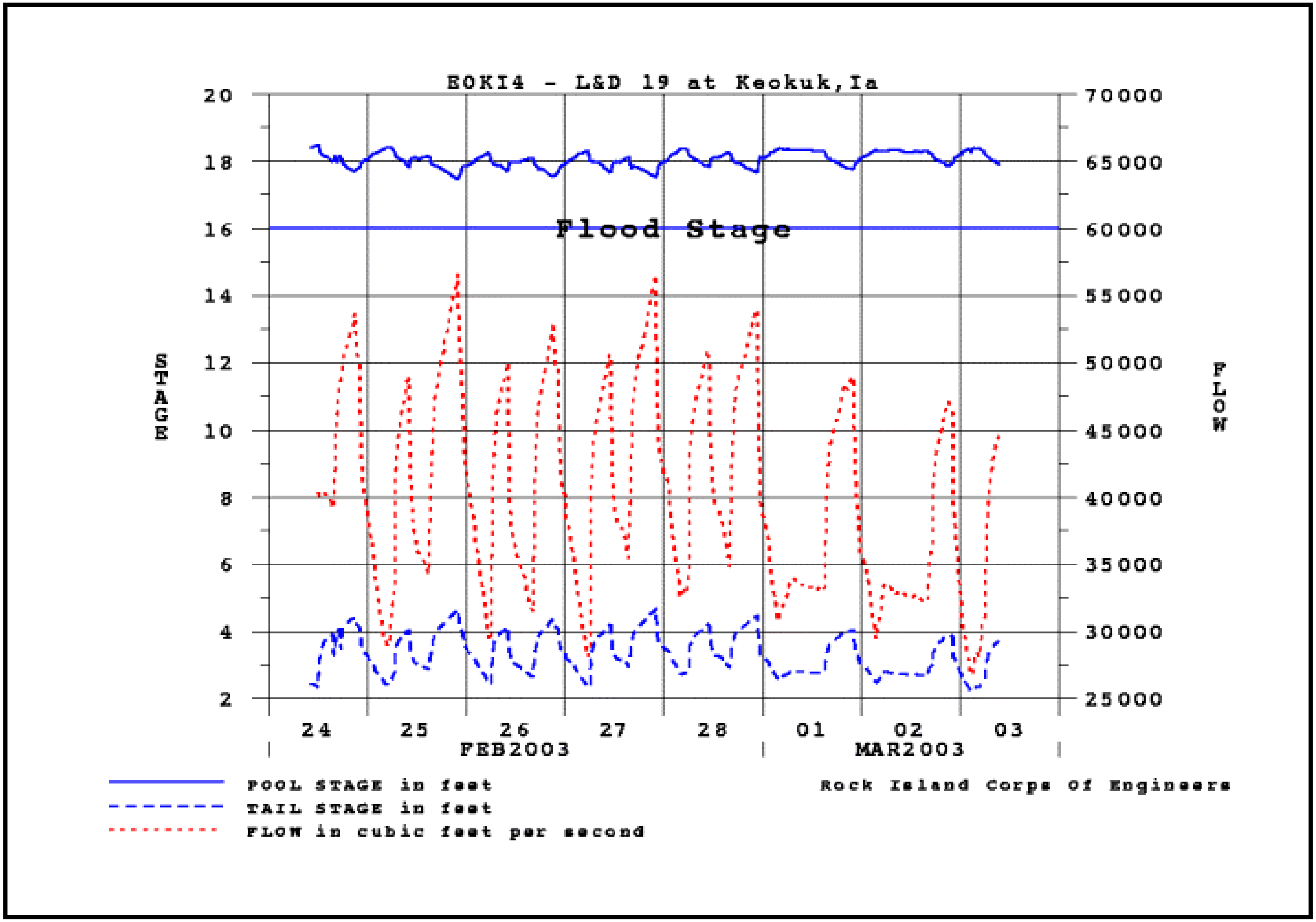


FIGURE 6. Water Level and Flow Fluctuations Below Dam 19.

b. Legal

The Corps of Engineers has no existing legal authority to mandate a reduction in the magnitude or frequency of fluctuations resulting from the operation of Dam 19 (by Ameren UE) or the flood control operations above Lockport Dam, by the Metropolitan Sanitary District of Greater Chicago (MSDGC).

5. Authorization(s) Required for Implementation

The Corps of Engineers has existing authority to implement this management action at the Corps owned facilities (exceptions noted in Section III.E.4.b, above).

F. Inducing Water Level Fluctuations During Winter

1. Description of Action

This management action involves the intentional creation of pool level fluctuations during the winter months to increase the volume of fresh water exchange with off-channel areas. The fluctuations would be minor and fall within the existing, authorized, operating bands of the projects.

2. Supported Environmental Objectives

Inducing minor pool level fluctuations during the winter has the potential to increase the fresh water exchange between the main channel and off-channel areas in the lower portion of the navigation pool. This action would help to increase the dissolve oxygen levels in backwater areas, thereby improving overwintering conditions for fish.

3. Potential Impacts of Action

a. Impacts to Ecosystem Resources and Water Quality

Inducing minor (within operating band) water level fluctuations during the winter has the potential to disturb furbearer dens in the lower portion of the navigation pool. This action is expected to have no adverse impacts on water quality.

b. Impacts to Commercial Navigation

Inducing minor (within operating band) water level fluctuations during the winter would have no impact on maintenance of the 9-foot navigation channel, or on commercial navigation infrastructure.

c. Impacts to Recreation

Inducing minor (within operating band) water level fluctuations during the winter would have minimal impact on recreational use. If the amplitude of the induced fluctuations were great enough, it could cause the ice to break up, producing unsafe ice conditions.

d. Impacts to Hydropower

Inducing minor (within operating band) water level fluctuations during the winter would have negligible impact on hydropower generation.

e. Impacts to Adjacent Landowners

Inducing minor (within operating band) water level fluctuations during the winter would have no impact on adjacent landowners.

4. Constraints to Implementation

a. Operational/Structural

Intentionally producing short-term pool fluctuations would require water control personnel to perform additional monitoring and coordination with the projects. It would also require additional effort on the part of the lock and dam personnel to make additional gate adjustments. More frequent gate adjustments may require an increase in lock and dam winter staffing levels during second and third shifts, and/or automation of gate mechanisms and controls.

b. Legal

There are no identified legal constraints to implementing this management action.

5. Authorization(s) Required for Implementation

The Corps of Engineers has existing authority to implement this management action.

G. Interrelationships Between Alternative Water Level Management Actions

It is important to note that the six primary water level management actions are not necessarily mutually exclusive, with some combinations providing complimentary benefits. The following sections discuss several such complimentary combinations.

1. Pool Drawdowns and Changing the Pool Control Point From Mid-Pool to the Dam

Modifying the operation of a pool from hinge-point to dam-point, yet providing for drawdown opportunities during the growing season, provides tremendous flexibility in managing the pool for the benefit of the environment. Elimination of water level reductions in winter and spring would serve to improve winter survival and spawning success of fish, and provide a more natural spring flood pulse to the system. Growing season drawdowns could then be conducted to simulate historical low-flow summer periods to increase the extent and diversity of emergent vegetation. Upon reflooding, the emergent vegetation would provide valuable habitat conditions and serve as a valuable food source for a diverse range of species.

2. Changing the Pool Control Point From Mid-Pool to the Dam and Reduction in Pool Level Fluctuations

Modifying the operation of a pool from hinge-point to dam-point would eliminate the water level reductions inherent to hinge-pool operation, thereby greatly reducing pool level fluctuations, and their associated disturbances, in the lower portion of the navigation pool.

IV. Prioritization of Water Level Management Actions

A. Purpose

The number of potential combinations of management actions and navigation pools is nearly infinite when one considers the various magnitudes, durations, and timings of the management actions that could be considered. Therefore, it was desirable to undergo a prioritization effort to reduce the number of possible combinations of management actions and navigation pools to a reasonable number of "prioritized" actions that could be evaluated in greater detail as part of this effort. The prioritization processes used were designed to identify those combinations of management actions and pools that produce the most benefits for the least cost (i.e., are efficient), and which are most likely to be successfully implemented (i.e., are feasible). This type of prioritization process has been utilized historically to select the pools for implementation of pilot water level management experiments. To the extent that these earlier prioritization processes supported the goals of this effort, the results of the previous screening efforts were utilized.

The prioritization process is not intended to exclude any pool or management action from possible future consideration, but rather to help focus the workgroup's efforts to those combinations of management actions and navigation pools that appeared to be the most efficient and feasible. An important component of the Restructured Navigation Study is the concept of *adaptive management*. Under adaptive management, continuous monitoring of the ecosystem's health, and the performance of management actions taken, is conducted to increase the river managers' knowledge of the system and to guide future decision-making.

B. Prioritization Procedures

Prioritization of the potential water level management actions was conducted independently by each of the three Corps Districts.

1. St. Paul District

In 1997, the Technical Subgroup of the Water Level Management Task Force conducted a screening exercise to identify those navigation pools that would be the best candidates for pool drawdowns. The prioritization methodology and results are presented in Appendix B.

No management actions, aside from pool drawdowns, were identified for more detailed analysis in the St. Paul District.

2. Rock Island District

As part of this effort, the Rock Island District conducted a prioritization of potential water level management actions for Pools 11-22 on the UMR and the Illinois Waterway. The prioritization process utilized criteria established during a meeting (conducted for this effort) with the U.S. Fish and Wildlife Service, the Illinois Department of Natural Resources, the Iowa Department of Natural Resources, the Minnesota Department of Natural Resources, and The Nature Conservancy. The prioritization methodology and results are presented in Appendix C.

3. St. Louis District

Similar to the Rock Island District, the St. Louis District utilized the prioritization criteria established during the interagency meeting, discussed above, to prioritize pools for potential implementation of water level management actions for the St. Louis District's portion of the Upper Mississippi River (Pools 24 through Mel Price). The prioritization methodology and results are presented in Appendix D.

C. Results

Based on the prioritization process described above, the following list of prioritized management actions was selected for further analysis of benefit and cost information:

- <u>Growing Season Drawdowns</u>: Pools 5, 7, 8, 9, 11, 13, 16, 18, 19, 24, 25, and 26

- <u>Modifying the Dam Operation From Hinge-Point to Dam-Point Control</u>: Pools 16, 24, 25, 26

- <u>Modifying the Distribution of Flow Across the Dam</u>: As Needed to Provide Attracting Flows for Fish Passage

- <u>Minimizing Short-term Fluctuations</u>: LaGrange, Peoria, Starved Rock, Marseilles, Dresden Island, Brandon Road, and Lockport Pools on the Illinois Waterway.

RECOMMENDATION: For those pools in which pool-wide, growing season, drawdowns do not appear to be feasible and/or efficient, consideration should be given to identifying isolated or single outlet backwaters within those pools in which small-scale drawdowns could be implemented through the use of portable pumps and temporary closing dams.

V. Benefits and Implementation Costs of the Prioritized Actions

The following section describes the primary benefits and implementation costs for the prioritized water level management actions. Where possible, the benefits and costs have been quantified for use in the Restructured Navigation Study. Due to fiscal and time limitation available for this study, this evaluation was limited to the use of existing information or information which could readily be developed from existing data sources.

A. Growing Season Drawdowns – St. Paul and Rock Island Districts

For the purpose of this analysis, the growing season was assumed to extend from May 1 to August 31. While the growing season varies along the system, this time period was considered to be representative of the system for the limited purpose for which it was used. Specifically, this time period was used to evaluate drawdown success rates and to characterize the seasonal variations in water levels and flows. The optimal timing of a drawdown in a given pool may vary from these dates, including extending into September, and could change from year to year depending upon weather and river conditions.

1. Primary Benefits and Costs

The primary measure of benefits associated with growing season drawdowns is the area (e.g., number of acres) exposed by the drawdown, the duration of the drawdown, and the vegetation response (acres and species composition). The magnitude of the water level change is greatest immediately upstream of the dam, and decreases with distance from the dam. As a result, the majority of the area exposed by a drawdown is located in the lower half of the navigation pool. Additionally, for the same reduction in water level at the dam, varying amounts of land will be dewatered depending upon the amount of flow in the river; with the greatest amount of land exposed during low-flow conditions. For the purposes of estimating benefits (acres exposed), the median controlled river condition (see Section V.A.2.b, below, for definition) was used to estimate the "typical" benefits that could be expected. The actual area exposed will need to be evaluated with each attempt. The duration of drawdowns will depend on annual hydrologic conditions, and will also be estimated as above but measured each year. Vegetation response can be estimated based on predicted results, but remote sensing and ground truthing will be required to document actual response.

The primary costs associated with growing season drawdowns are those related to advanced maintenance dredging required to maintain a safe and reliable navigation channel during the drawdown, impacts to commercial navigation infrastructure, impacts to recreation, and impacts to hydropower production. As stated above, the effects of the drawdown on water levels within the pool is greatest under low-flow conditions. Therefore, the 95% duration, controlled river condition was utilized to estimate costs associated with the drawdown (see Section V.A.2.b, below, for definition). It is anticipated that there would be a substantial first cost for dredging to provide navigable channel depths during drawdowns, but that future costs would likely be lower if increased depths were periodically maintained. The validity of this assumption needs to be tested, but in lieu of the testing, first costs were extrapolated over the repeated measures.

2. Evaluation of Primary Benefits and Costs

a. Hydrologic Chance of Success

During high-flow conditions, the river naturally produces water surface elevations sufficient to maintain a nine-foot navigation channel without the influence of the dam. During these conditions, the dam gates are lifted clear of the water and "open river" conditions exist. During "open river" conditions there is a minor water surface differential across the dam due to the small amount of obstruction produced by the dam piers. This water surface differential is know as the "swellhead" and is similar to the effect that can be observed at bridge piers. This swellhead is typically less than a foot, but is as high as 2.1 feet at Lock & Dam 14.

Figure 7 shows the tailwater elevation-duration curve, during the growing season, for Dam 16. The swellhead at Dam 16 is 0.5 feet. As shown in the figure, approximately 15% of the time the tailwater elevation, plus the swellhead, exceeds the normal (flat) pool elevation. During these conditions, the normal pool elevation could not be maintained due to the river naturally producing water levels higher than the target pool elevation (as discussed above, under these conditions the dam gates are raised out of the water and open-river conditions exist). During a drawdown, the target operating water surface elevation at the dam is lowered. As the magnitude of the desired drawdown increases, the percent of time that the pool could not be maintained at the desired elevation increases. For example, for a two-foot drawdown (to elevation 543.0), the percentage of time that the tailwater elevation plus the 0.5-foot swellhead exceeds the target pool level is 25% (Figure 7). The significance of this is that as the desired magnitude of the drawdown increases, the likelihood that it can be maintained (simply due to flow considerations) decreases due to the river naturally exceeding the target water surface elevation more frequently.

To estimate the probability that a drawdown of a given magnitude could be maintained for a minimum of 60 days, a year-by-year analysis was conducted to determine the percentage of years that a continuous, 60-day, drawdown could have been maintained. This analysis was based on the recorded tailwater elevations and known swellhead at each project. The computed probabilities of success are shown in Table 3.

b. Water Surface Profiles

Drawdowns would expose varying amounts of substrate depending upon the depth of drawdown and the river discharge. The area exposed by a drawdown could range from nearly zero at high river discharges to thousands of acres at low flows. To

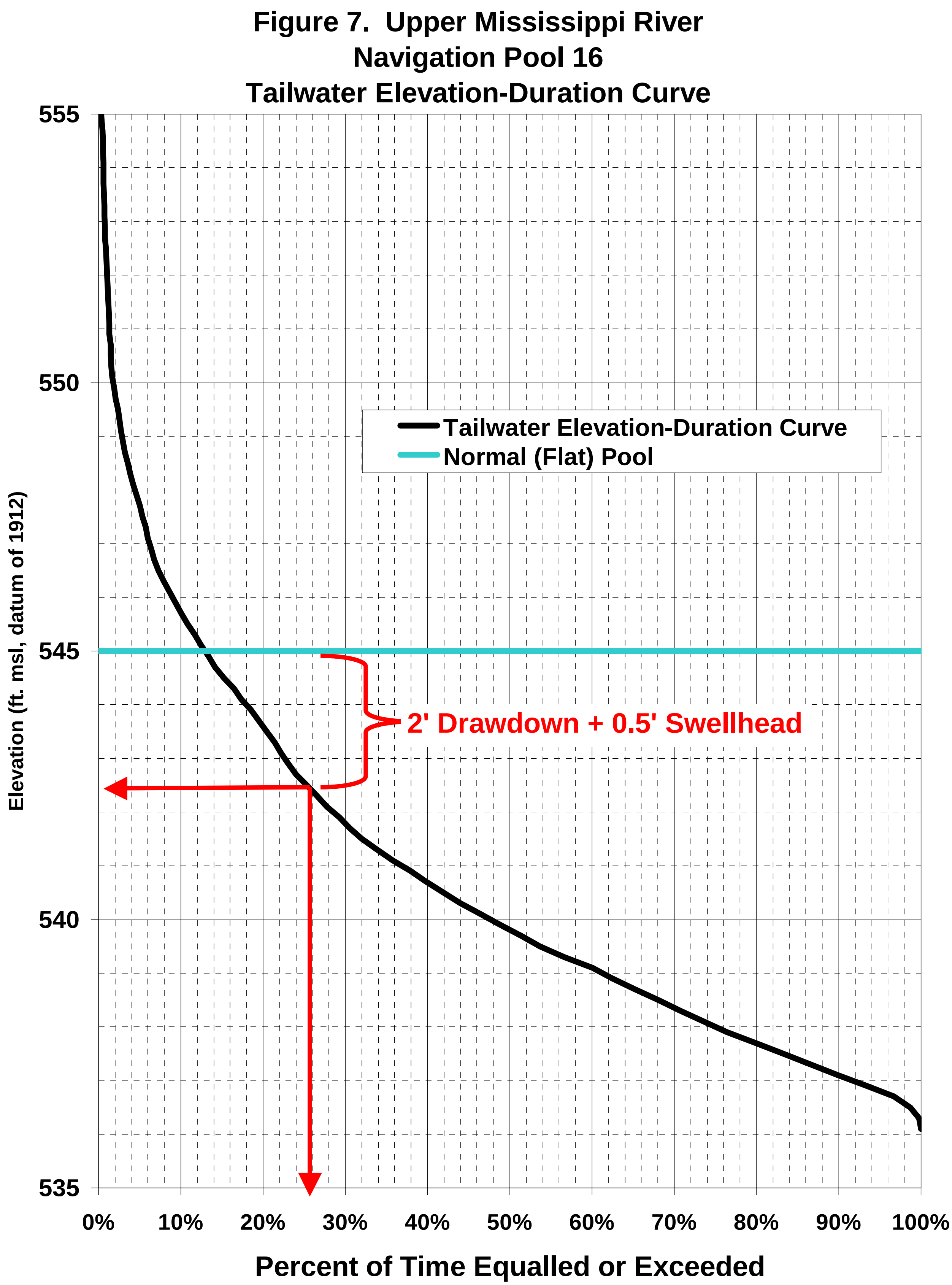


Figure 7. Upper Mississippi River
Navigation Pool 16
Tailwater Elevation-Duration Curve
555
550
545
540
535
Elevation (ft. msl, datum of 1912)
Tailwater Elevation-Duration Curve
Normal (Flat) Pool
2' Drawdown + 0.5' Swellhead
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Equalled or Exceeded

TABLE 3. Summary of Costs and Benefits Associated with Drawdowns in the St. Paul and Rock Island Districts

Pool	Drawdown[1] Magnitude	Drawdown Success Rate	Acres Exposed	Incremental Acres Exposed	Dredging Required (yd^3)	Dredging Cost	Incremental Cost	Cost per Acre	Incremental Cost per Acre
5	1	95%	1,100	1,100	135,811	$643,175	$643,175	$585	$585
	2	81%	2,200	1,100	287,236	$1,365,093	$721,918	$620	$656
	3	55%	4,000	1,800	448,088	$2,137,217	$772,124	$534	$429
	4	38%	5,500	1,500	610,333	$2,935,132	$797,915	$534	$532
7	1	98%	1,206	1,206	0	$0	$0	$0	$0
	2	74%	2,331	1,125	215,000	$1,280,000	$1,280,000	$549	$1,138
	3	40%	3,385	1,054	475,000	$2,800,000	$1,520,000	$827	$1,442
8	1	74%	1,300	1,300	2,000	$88,000	$88,000	$68	$68
	2	50%	3,090	1,790	120,253	$475,000	$387,000	$154	$216
	3	33%	5,215	2,125	300,000	$1,185,000	$710,000	$227	$334
9	1	71%	4,751	4,751	0	$0	$0	$0	$0
	2	57%	6,932	2,181	75,000	$375,000	$375,000	$54	$172
	3	40%	9,497	2,565	165,000	$825,000	$450,000	$87	$175
11	1	91%	399	399	0	$0	$0	$0	$0
	2	86%	883	484	49,368	$399,400	$399,400	$452	$825
	3	86%	1,606	723	109,076	$762,441	$363,041	$475	$502
	4	64%	2,744	1,137	162,800	$976,800	$214,359	$356	$188
13	1	86%	1,560	1,560	35,200	$316,800	$316,800	$203	$203
	2	86%	2,822	1,262	131,032	$1,021,093	$704,293	$362	$558
	3	68%	4,519	1,697	229,768	$1,581,487	$560,394	$350	$330
	4	55%	6,821	2,303	325,600	$1,953,600	$372,113	$286	$162
16	1	55%	157	157	13,200	$118,800	$118,800	$757	$757
	2	55%	307	150	75,636	$601,121	$482,321	$1,955	$3,206
	3	50%	504	197	148,808	$1,031,148	$430,027	$2,045	$2,185
	4	23%	680	176	215,600	$1,293,600	$262,452	$1,901	$1,489
18	1	50%	484	484	26,400	$237,600	$237,600	$491	$491
	2	50%	761	277	133,848	$1,053,830	$816,230	$1,385	$2,949
	3	36%	1,054	293	247,500	$1,711,875	$658,045	$1,624	$2,243
	4	18%	1,305	251	356,400	$2,138,400	$426,525	$1,639	$1,702
19	1	100%	790	790	4,400	$39,600	$39,600	$50	$50
	2	100%	1,627	836	50,380	$403,500	$363,900	$248	$435
	3	100%	2,752	1,126	103,649	$721,547	$318,047	$262	$283
	4	100%	3,685	933	152,533	$915,198	$193,651	$248	$208

[1] "Drawdown" refers to a reduction in the target operating level for the navgation pool, as measured at the dam.

estimate the benefits and costs associated with growing season drawdowns, two representative flow conditions were used. The first represents the median flow for the conditions under which the drawdown could be maintained (see discussion in section V.A.2.a, above). This "typical" flow condition was used to compute the expected acreage exposed by the various drawdown scenarios.

The second flow condition evaluated was the 95% duration flow (the flow which is equaled or exceeded 95% of the time), which was used to represent the impact of the drawdown under low-flow conditions. This low-flow condition was used to estimate advanced dredging requirements and to evaluate the potential impacts on barge terminals and recreational facilities. The two flow conditions are depicted graphically on Figure 8.

Water surface profiles for the "typical" and low-flow river conditions were computed using existing, one-dimensional, steady flow models (HEC-2 and HEC-RAS, depending upon Corps District). Water surface profiles were generated for the baseline condition (current regulation conditions) and for drawn down conditions in each pool. The computed water surface profiles are shown in Appendix E.

c. Acres Exposed by Drawdown Alternatives

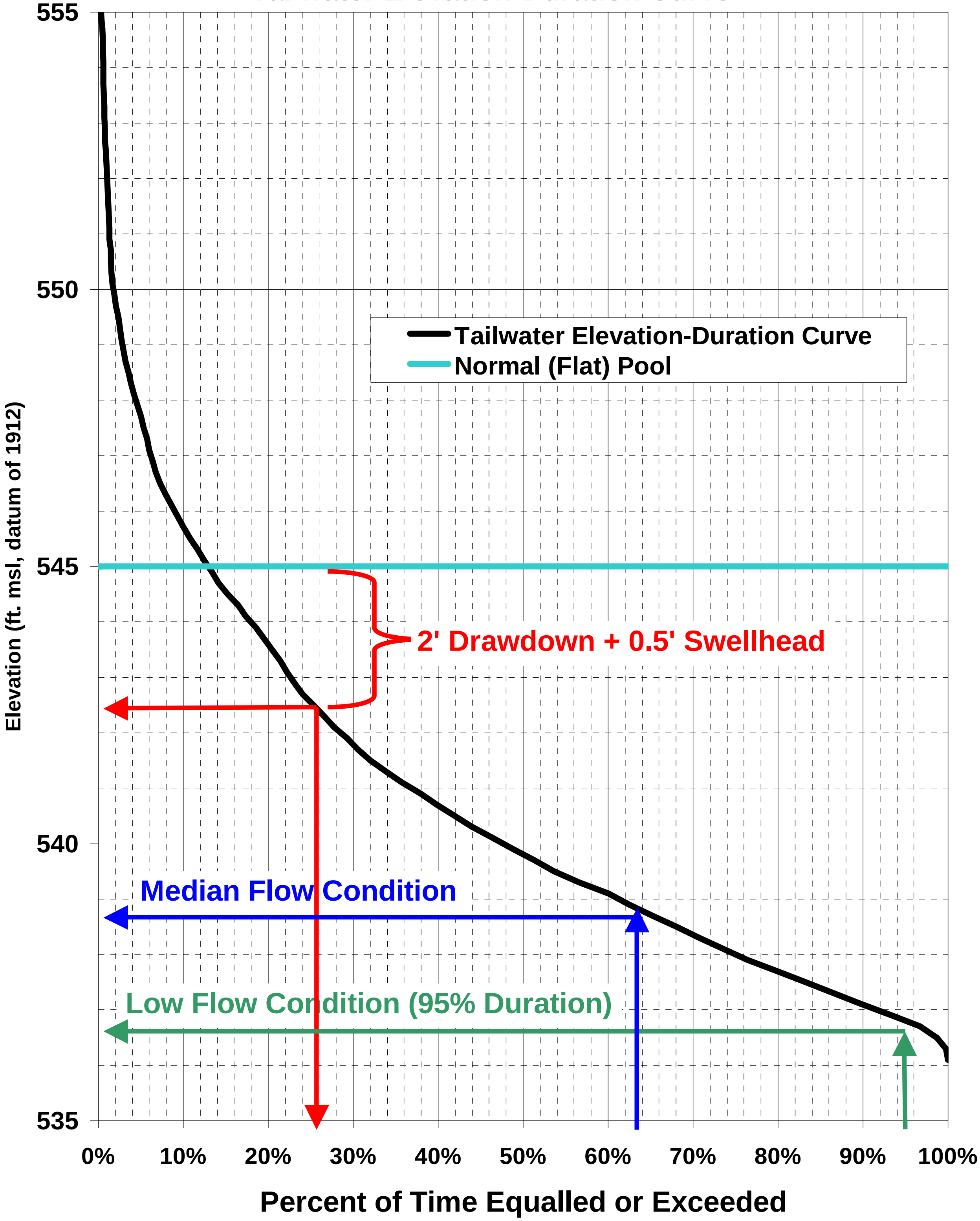
Two methods were utilized to estimate the number of acres exposed by drawdowns (of varying magnitudes) in the selected pools. For those pools that had existing GIS bathymetric data coverages available (developed as part of the Long Term Resource Monitoring Program by UMESC), the acreage exposed was computed, using ARC-GIS, by intersecting the computed water surface profiles with the GIS bathymetric database. Detailed bathymetric information was available for Pools 5, 7, 8, 9, 13, and 26. Figures 9 through 12 show example results of this analysis for drawdowns of 1 to 4 feet in Pool 13. In addition to estimates of acreage exposed, changes in the depth-distribution within the pools can be computed from the GIS database. Figure 13 shows changes in various depth ranges, within Pool 13, for drawdowns of 1 to 4 feet.

RECOMMENDATION: Collection of detailed bathymetric data should continue to be a priority of the Long Term Resource Monitoring Program, with emphasis on collecting data for those pools selected for possible implementation of pool-wide water level management actions.

For the remaining pools, the estimated number of acres dewatered by drawdowns was estimated using the one-dimensional model results. At each cross-section, the width of bankline exposed, for each drawdown magnitude, was computed. Using these widths of exposure, and the known spacing between model cross-sections, an end-area calculation was performed to develop the pool-wide estimates of acreages exposed.

The ability of this method to produce acreage estimates comparable to the GIS estimates from the first method was tested for Pool 13. Estimates using both methods were developed and compared. Based on this comparison, it appeared that the second method (utilizing the one-dimensional model results) yielded estimates that were higher than the GIS estimates. The estimates for each of the drawdown magnitudes were uniformly higher by a (roughly) constant amount. This may be due to the model showing dewatering at elevations that are not considered aquatic by UMESC (particularly in the

Figure 8. Upper Mississippi River
Navigation Pool 16
Tailwater Elevation-Duration Curve



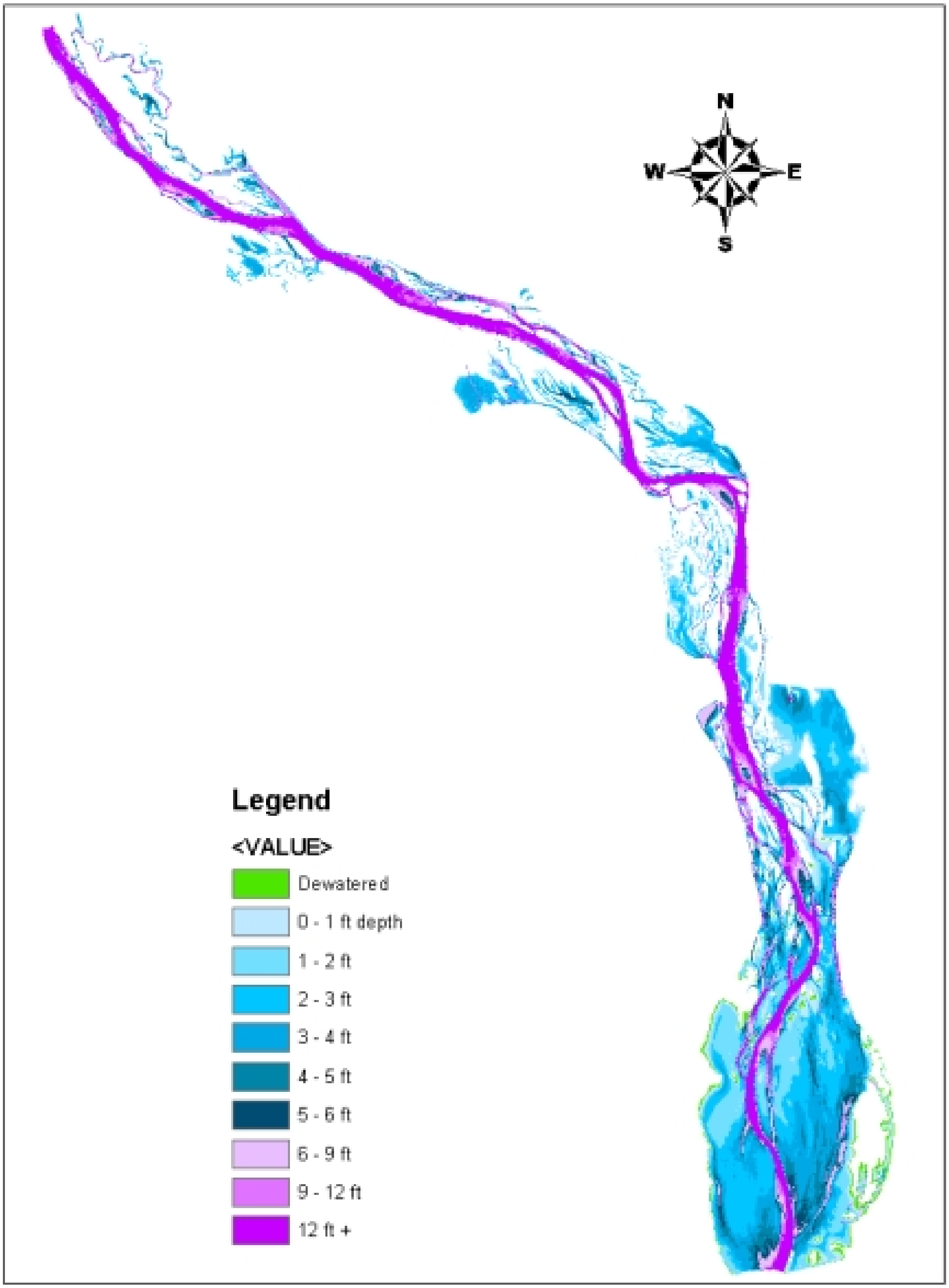


Figure 9. Depths in Pool 13 with a 1-Foot Drawdown, Under Median Flow Conditions.

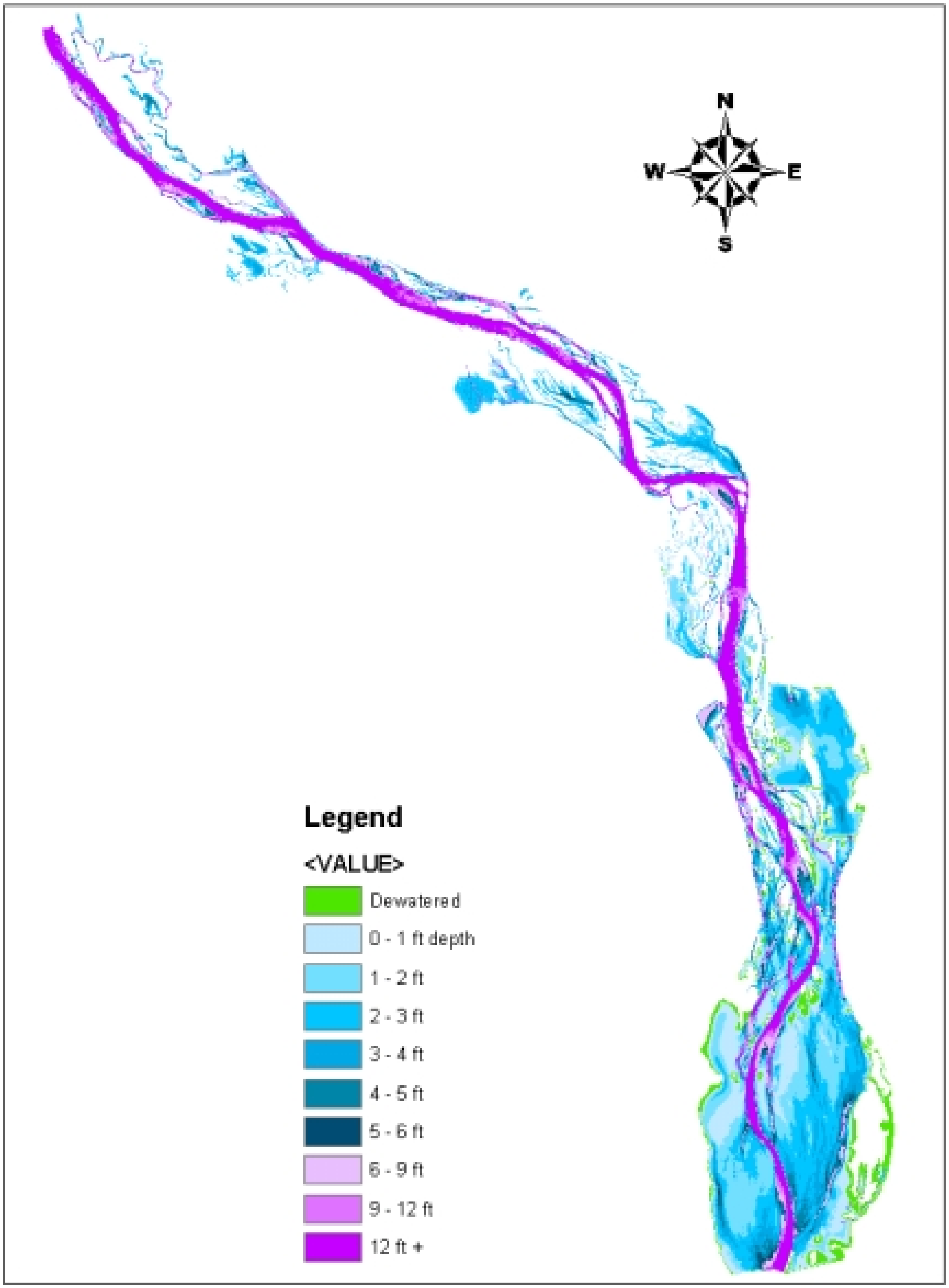


Figure 10. Depths in Pool 13 with a 2-Foot Drawdown, Under Median Flow Conditions.

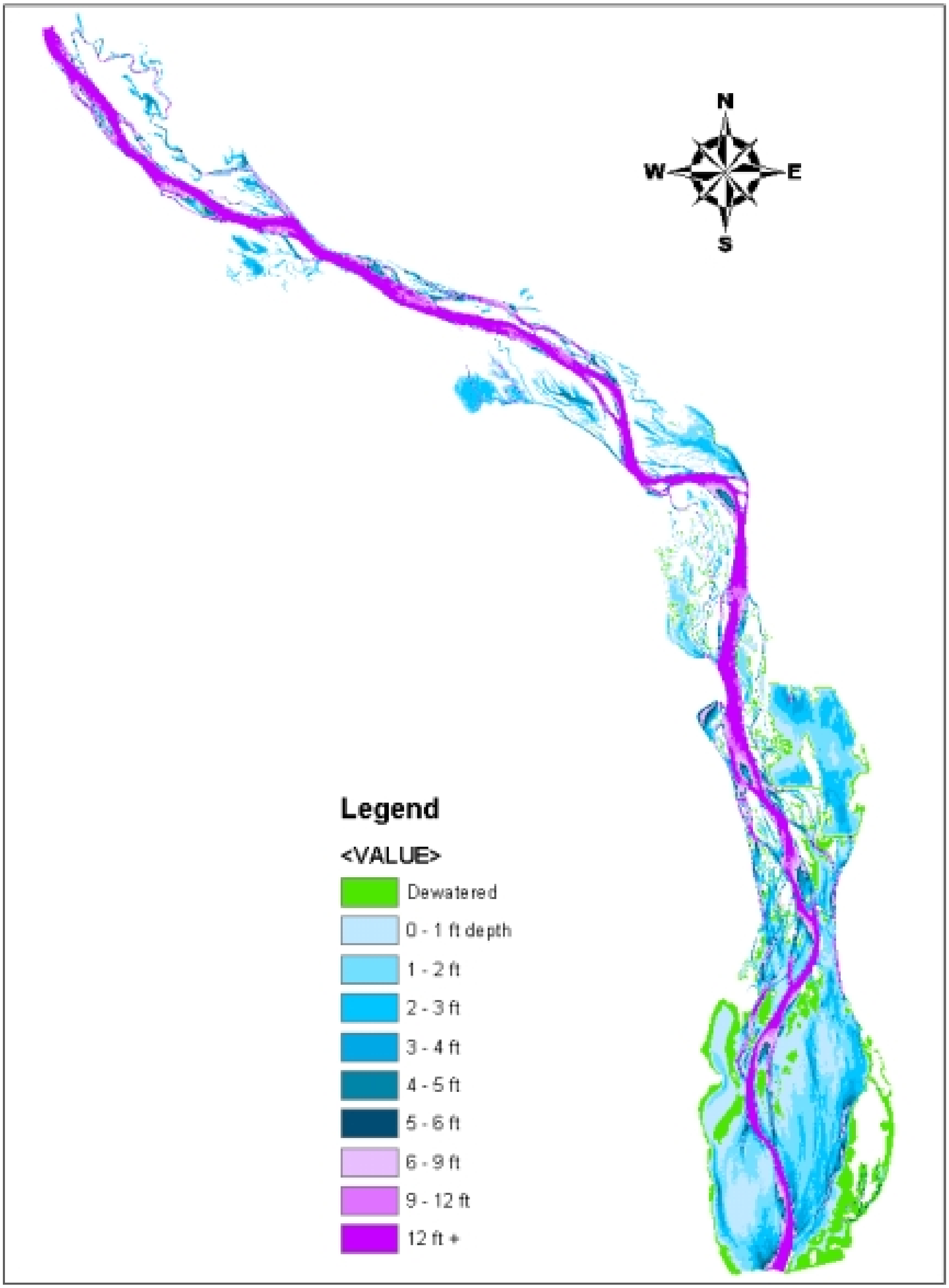


Figure 11. Depths in Pool 13 with a 3-Foot Drawdown, Under Median Flow Conditions.

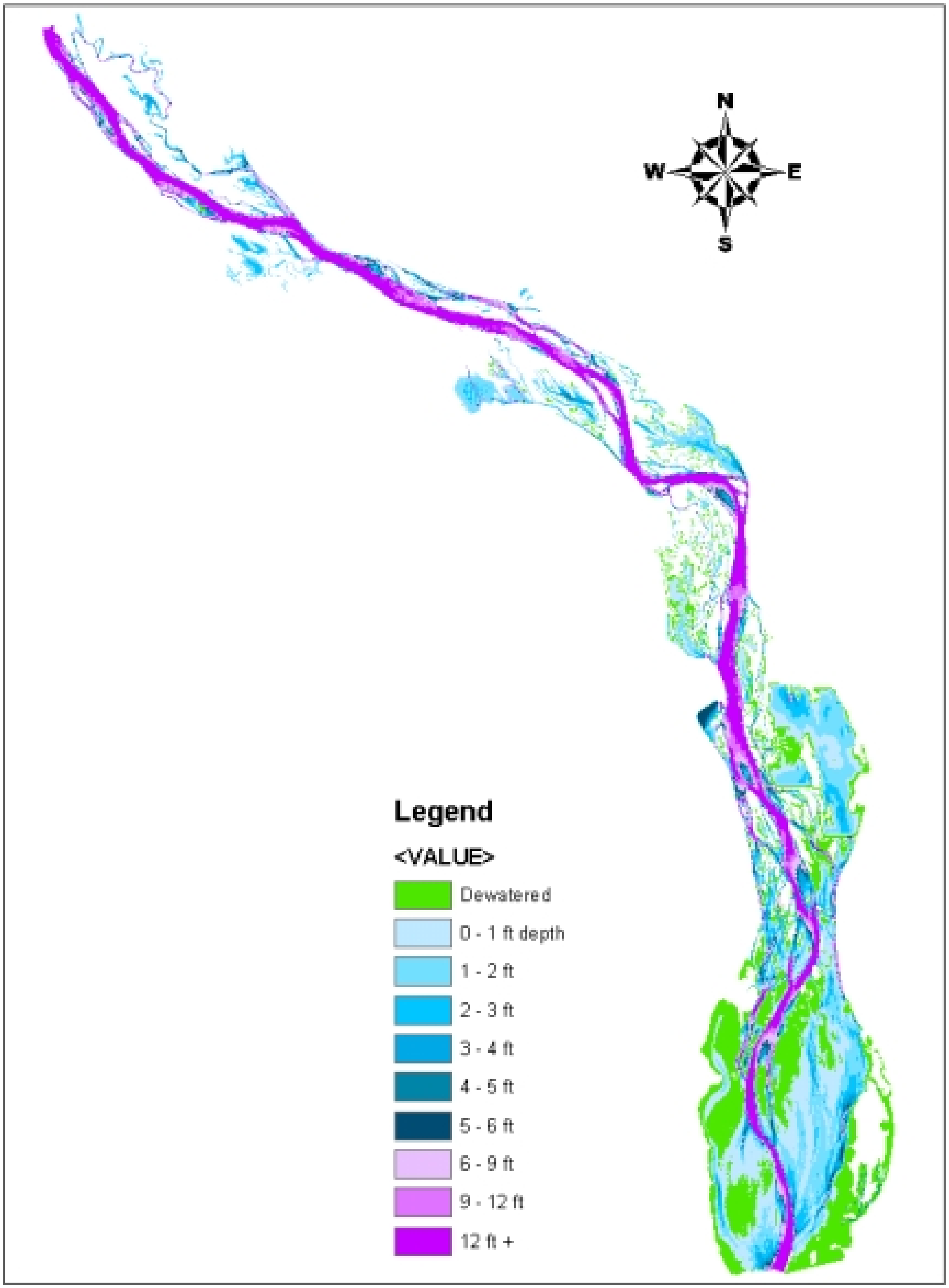
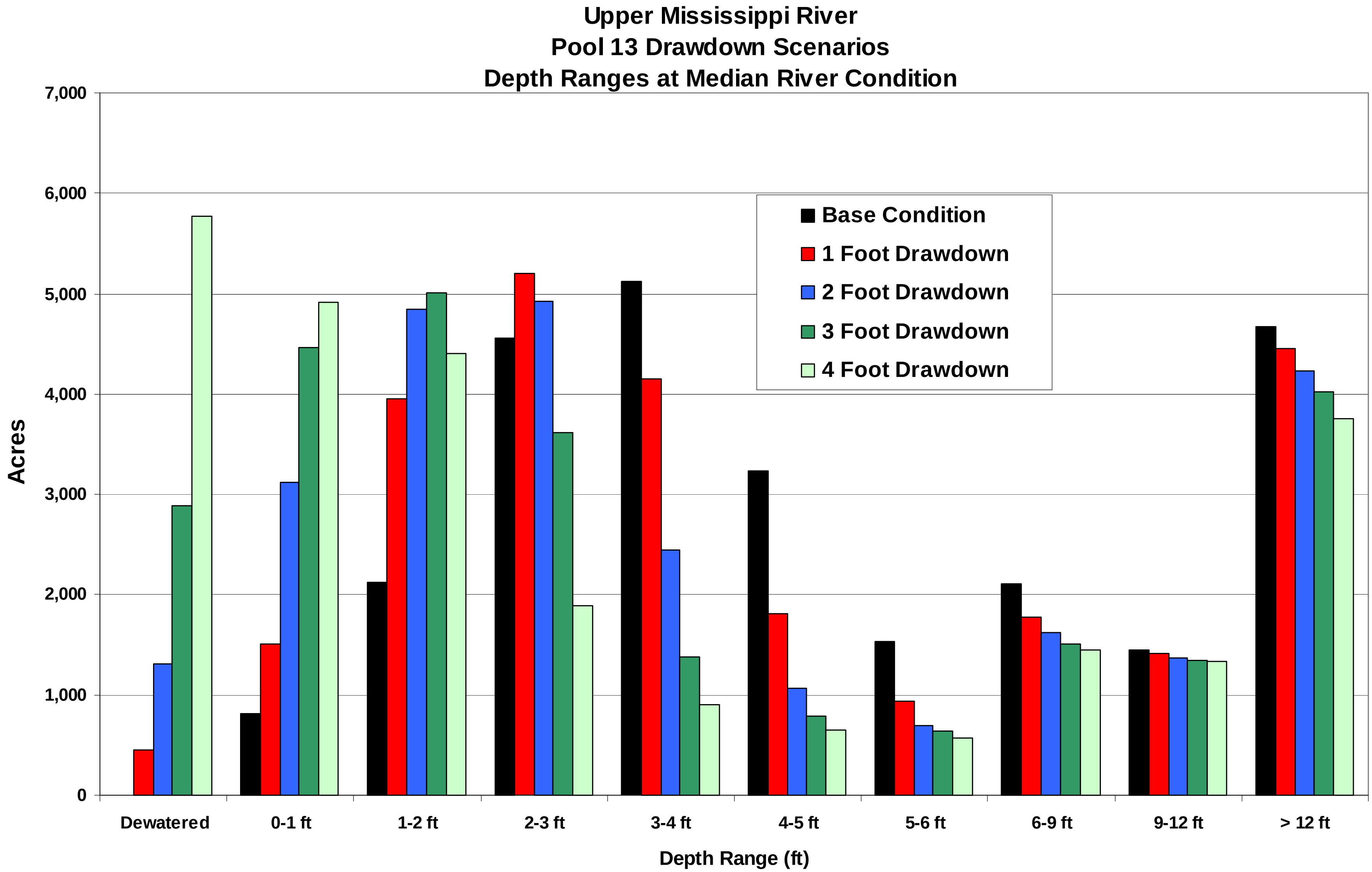


Figure 12. Depths in Pool 13 with a 4-Foot Drawdown, Under Median Flow Conditions.

Figure 13.



Upper Mississippi River
Pool 13 Drawdown Scenarios
Depth Ranges at Median River Condition
Acres
Depth Range (ft)
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
Dewatered
0-1 ft
1-2 ft
2-3 ft
3-4 ft
4-5 ft
5-6 ft
6-9 ft
9-12 ft
> 12 ft
Base Condition
1 Foot Drawdown
2 Foot Drawdown
3 Foot Drawdown
4 Foot Drawdown

middle and upper portions of the pools), and are therefore not included in the bathymetric coverage. Based on the results of this analysis, it was felt that the results obtained through use of the one-dimensional model results were acceptable.

The estimated numbers of acres exposed, for each pool and drawdown magnitude, are shown in Table 3.

d. Advanced Maintenance Dredging Requirements

Advanced maintenance dredging would likely be required to maintain a reliable navigation channel during a drawdown. The amount of advanced maintenance dredging would vary with the magnitude of the drawdown. Assuming that the new, deeper channel conditions were to be maintained for drawdowns in subsequent years, additional annual maintenance dredging may be required due to potentially increased trapping efficiency in chronic dredging areas. The magnitude of this potential, additional maintenance requirement is unknown. A literature search identified no suitable method for estimating this quantity. Additional, future, maintenance dredging requirements could potentially be reduced through the construction, or modification, of wingdam structures in the reach.

Advanced maintenance dredging requirements were estimated for each drawdown magnitude, and pool, through review of current channel conditions as well as historical dredging quantities and trends. Dredging costs were estimated using historical unit costs and the assumed method(s) of dredging and location of placement.

The estimated advanced dredging requirements, for each pool and drawdown magnitude, are shown in Table 3.

RECOMMENDATION: Implementation of pool-wide drawdowns should be based upon the current state of vegetation within the pools and hydrologic conditions. Acquisition of channel dimensions suitable for maintaining navigation during a drawdown, through advanced dredging, should be pursued in lieu of scheduled closures of the navigation channel. Advanced maintenance dredging would allow for drawdowns in any year, at any time during the growing season, in which flow conditions are suitable, providing for a high degree of flexibility. Scheduled closures, on the other hand, risk causing large disruptions to other river uses and face unknown hydrologic conditions, which may prevent successful implementation.

e. Drawdown Impacts to Commercial Navigation Infrastructure

Pool drawdowns will result in a reduction in available depths at barge facilities and in fleeting areas. Depending upon the available depths, the magnitude of the drawdown, and the current river discharge, use of these facilities may be impacted.

In order to estimate the number of barge facilities potentially impacted, the available depths at the barge terminals were compared to the low-flow, computed water surface profiles for the various drawdown scenarios. Information on the location and available depths at the barge facilities was extracted from a GIS database obtained from the Navigation Data Center, and updated with the aide of the Inland Waterway Guide booklet (Spencer, 2002a). The criteria selected as the threshold value for when impacts would (or would not) occur, was a minimum depth of 9 feet under low-water conditions.

For each facility contained within the database, a determination was made as to whether 9 feet of depth would be available under low-flow conditions for each of the drawdown scenarios. The results of this analysis are presented in Appendix F, and are summarized in Table 4, below.

TABLE 4. Summary of Potential Impacts to Barge Facilities

Pool	Number of Facilities Evaluated	Number of Barge Facilities Likely to Be Impacted by a Drawdown of:			
		1-Foot	2 Foot	3-Foot	4-Foot
5	1	0	0	0	1
7	0	0	0	0	
8	5	2	2	2	
9	3	0	1	1	
11	3	1	1	1	1
13	0	0	0	0	0
16	12	4	7	9	9
18	4	1	1	1	2
19	17	2	4	8	11

Impacts to barge terminals could be minimized through advanced dredging to provide additional depth. However, the Corps currently has no authority or funding to conduct such dredging.

Assuming that advanced notice of the drawdown is made available, the towing industry should be able to adjust their fleeting activities in order to minimize impacts of the drawdown. Fleeting areas may need to be adjusted riverward or relocated.

f. Drawdown Impacts to Recreation

Accurate assessment of the impacts of the pool drawdowns on recreation is extremely difficult. While impacts to river access from marinas and boat ramps can be inferred from site-specific analysis of fleet composition, bathymetric conditions, and water surface profiles, impacts to recreational boating are also related to the recreational activities the boaters engage in once they've left these access areas (e.g., access to off-channel areas for fishing vs. pleasure cruising). Actual impacts from a drawdown alternative are likely to be highly individual in nature. However, some generalized conclusions regarding impacts to recreational users can be made.

Potential impacts to boat ramps and marinas were evaluated by reviewing the median and low-flow computed water surface profiles for the various drawdown scenarios. The two criteria used to identify boat ramps and marinas which are likely to be impacted by the drawdowns were: (1) if the drawn down pool, under median flow conditions, was below flat pool at the facility location; or, (2) if the drawn down pool, under low-flow conditions, was 1 foot or more below the flat pool elevation at the facility location. Using these criteria, the potential for impact was evaluated for each recreation facility. The results of this analysis are shown in Appendix G, and are summarized in Table 5, below.

TABLE 5. Summary of Potential Impacts to Recreational Facilities

Pool	Number of Facilities	Number of Recreational Facilities Likely to Be Impacted by a Drawdown of:			
		1-Foot	2 Foot	3-Foot	4-Foot
5	11	5	11	11	11
7	12	7	12	12	
8	36	14	36	36	
9	16	4	16	16	
11	18	5	18	18	18
13	19	9	14	19	19
16	16	1	8	11	11
18	13	3	9	10	12
19	18	7	12	17	18

As shown in Table 4, even one-foot drawdowns are likely to impact a large number of recreational facilities. Impacts to the recreational facilities are likely to progress from reductions in use (by larger boats) under one- or two-foot drawdowns, to greatly restricted use or potential closure during a three- or four-foot drawdown. Impacts to boat ramps could be partially offset through the use of ramps located further upstream in the pool, or through recreational users moving to other pools. Impacts to recreational facilities could be minimized through advanced dredging to provide additional depth. Based on historical dredging to improve access at recreational areas in Pool 8, the cost per site is estimated as $25,000. However, the Corps currently has no authority or funding to conduct such dredging.

Shoreline recreational use is likely to be impacted in the form of reducing fishing opportunities and aesthetically unpleasing river views and odors during the initial week(s) of the drawdown, which may impact use of campgrounds and day-use facilities. During the experimental drawdowns conducted in Pool 13, numerous complaints from campers were received at the Corps-run recreational facilities. Many of the campground users visit from outside the immediate geographic area and, at least during the initial years of implementation, were caught unaware by the changes in water level regulation.

RECOMMENDATION: The Corps should develop procedures to effectively share information concerning the goals and anticipated impacts of pool-wide drawdowns with the public in order to increase public knowledge and to allow for other users to prepare for the modified river regulation. The current procedures being used for the proposed drawdown in Pool 5 could be used as a starting point for the development of such procedures.

g. Drawdown Impacts to Hydropower Production

The only prioritized pool in which implementation of a growing season drawdown would impact hydropower generation is Pool 19. Dam 19 is owned and operated by Ameren UE, and has a maximum generating capacity of 135,000 KW. Implementation of a drawdown in Pool 19 could only occur through cooperation with Ameren UE. During a drawdown, hydropower generation would be negatively impacted due to the reduction in available operating head. The median operating head during the growing season is 34.5 feet.

h. Other Impacts

Water supply intakes within the prioritized pools would generally be unaffected by the magnitude of drawdowns considered. The elevations of the water supply intakes are not public information and were not, despite repeated information requests, disclosed to the Corps for this study. If growing season drawdowns are authorized by Congress following completion of the Restructured Navigation Study, a detailed analysis of potential impacts to water supply should be undertaken as part of the project design process.

3. Summary of Benefits and Costs

Table 3 summarizes the drawdown success rates, expected benefits (acres exposed), maintenance dredging requirements, and dredging costs per acre for the range of drawdowns considered for the prioritized pools. In addition, incremental benefits, dredging quantities, and costs per acre are presented in one-foot drawdown increments.

B. Growing Season Drawdowns – St. Louis District

Due to the hinged operation of the navigation pools within the St. Louis District, one and two-foot drawdowns are possible, in some years, without any additional dredging. Within these pools, advance maintenance dredging would allow for the drawdowns to be maintained more frequently, and for longer periods of time. Based on historical flow records, and past experience regarding vegetative response to drawdowns, Table 6, below, presents the average annual acres of vegetation that are expected to occur without additional maintenance dredging.

Table 6. Average Annual Acres of Vegetation Without Additional Dredging.

	Probability of a 1' Drawdown	***Acres of vegetation for 1' DD***	***Probability of a 2' drawdown***	***Acres of vegetation for 2' DD***	***Average annual acres of vegetation***
L&D#24	75 %	1,020	22 %	2,000	1,368
L&D#25	86 %	1,000	75 %	1,760	1,542
Mel Price	86 %	1,000	42 %	2,100	1,634

If advanced dredging is used to increase the probability of a successful drawdown, by extending the flow range under which the drawdown could be maintained without negatively impacting the Corps' ability to provide a safe and dependable navigation channel, the probabilities for maintaining one and two-foot drawdowns could be increased. Table 7, below, summarizes the potential for success and expected, average, annual acres of vegetation that could be obtained with additional dredging.

Table 7. Average Annual Acres of Vegetation With Additional Dredging.

	Probability of a 1' Drawdown	***Acres of vegetation for 1' Drawdown***	***Probability of a 2' drawdown***	***Acres of vegetation for 2' Drawdown***	***Average annual acres of vegetation***
L&D#24	80	1,020	47	2,000	1,540
L&D#25	90	1,000	80	1,760	1,596
Mel Price	95	1,000	75	2,100	1,910

The incremental additional annual average acres of vegetation, as well as an average cost for dredging, are listed in Table 8, below.

Table 8. Incremental Average Annual Acres of Vegetation.

	Average annual acres of vegetation	***Total cost***	***Cost per acre***
L&D#24	172	$100,000	$581
L&D#25	54	$100,000	$1,852
Mel Price	306	$100,000	$327

As shown above, it does not appear that additional dredging would greatly increase the amount of vegetation in pool 25. However, Pool 24 and Mel Price Pool would provide substantial additional vegetation with additional dredging.

C. Changing the Pool Control Point From Mid-Pool to the Dam

1. Primary Benefits and Costs

The primary benefit associated with this management action is the elimination of drawdowns during the winter and spring that are caused by the hinged-operation of the dam. Elimination of these drawdowns during winter would provide more consistent and increased water depths in off-channel areas, resulting in higher dissolved oxygen levels and increased temperatures, providing for improved overwintering habitat conditions for fish. Elimination of the spring drawdown would eliminate disruptions to the lifecycles of numerous species that require a flood pulse in the spring for successful reproduction.

The primary costs associated with this alternative are related to the acquisition of real estate interests for areas subject to increased inundation by the change in dam operation and any impacts to adjacent landowners.

2. Evaluation of Primary Benefits and Costs

a. Navigation Pool 16

i. Estimation of Benefits

Figure 14 shows Pool 16's elevation-duration curve for December through February. As shown in the figure, the hinged operation, and the existing operating band, result in pool elevations below the normal (flat) pool elevation 56% of the time. Operating under dam-point control would result in removal of the reduced water levels produced by the hinged operation. The average increase in depth resulting from the change would be approximately 0.4 feet, ranging from zero to 1.4 feet depending upon hydrologic conditions.

ii. Estimation of Costs

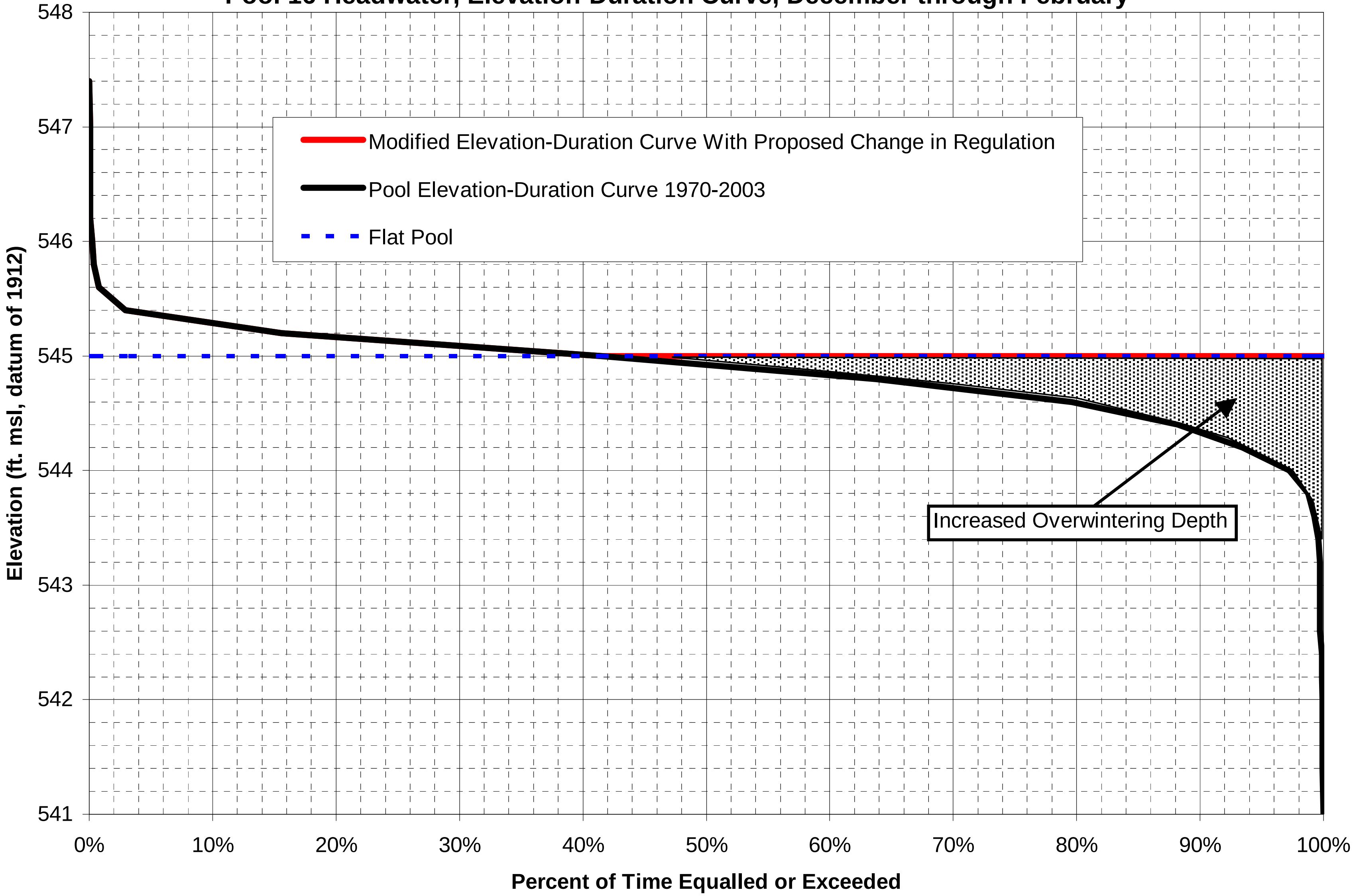
(a). Real Estate Impacts

A change in the control point location, from the current hinge point to the dam, has the potential to induce flooding, upstream of the dam, of lands for which the government has acquired no property interest (either in fee title or through a flowage easement). In order to estimate the lands potentially affected, a review of the lands acquired as part of the original construction of the nine-foot channel project was conducted. The best records of what was actually acquired are the original acquisition maps maintained by the Rock Island District's Real Estate Division, which have been digitized into a GIS database.

In order to estimate the additional lands that would need to be acquired as a result of this action, a new theoretical taking line was computed. The new theoretical taking line was computed using an existing HEC-RAS model of Pool 16, assuming dam-point control operation and an ordinary high water flow equal to the 25% duration flow (the flow that is equaled or exceeded 25% of the time). If this management action is recommended for implementation, a thorough legal review would need to be conducted to determine if this definition of the taking line is consistent with governing court decisions.

To identify the specific lands that would be subject to a potential taking, the new theoretical taking areas were mapped by overlaying the new theoretical taking profile onto a USGS topographic map and digitizing the land areas located between the elevation of the new taking profile and the limits of the lands acquired as part of the original project. The identified areas, subject to a potential taking through implementation of this management action, are shown in Figure 15. As shown in the figure, the identified areas are concentrated in low-lying areas along the upper portions of Pool 16 and along the Rock River corridor. If this management action is recommended for implementation, detailed surveys would need to be conducted to verify the land surface elevations and the limits of land parcels that would need to be acquired.

Figure 14. Upper Mississippi River
Pool 16 Headwater, Elevation-Duration Curve, December through February



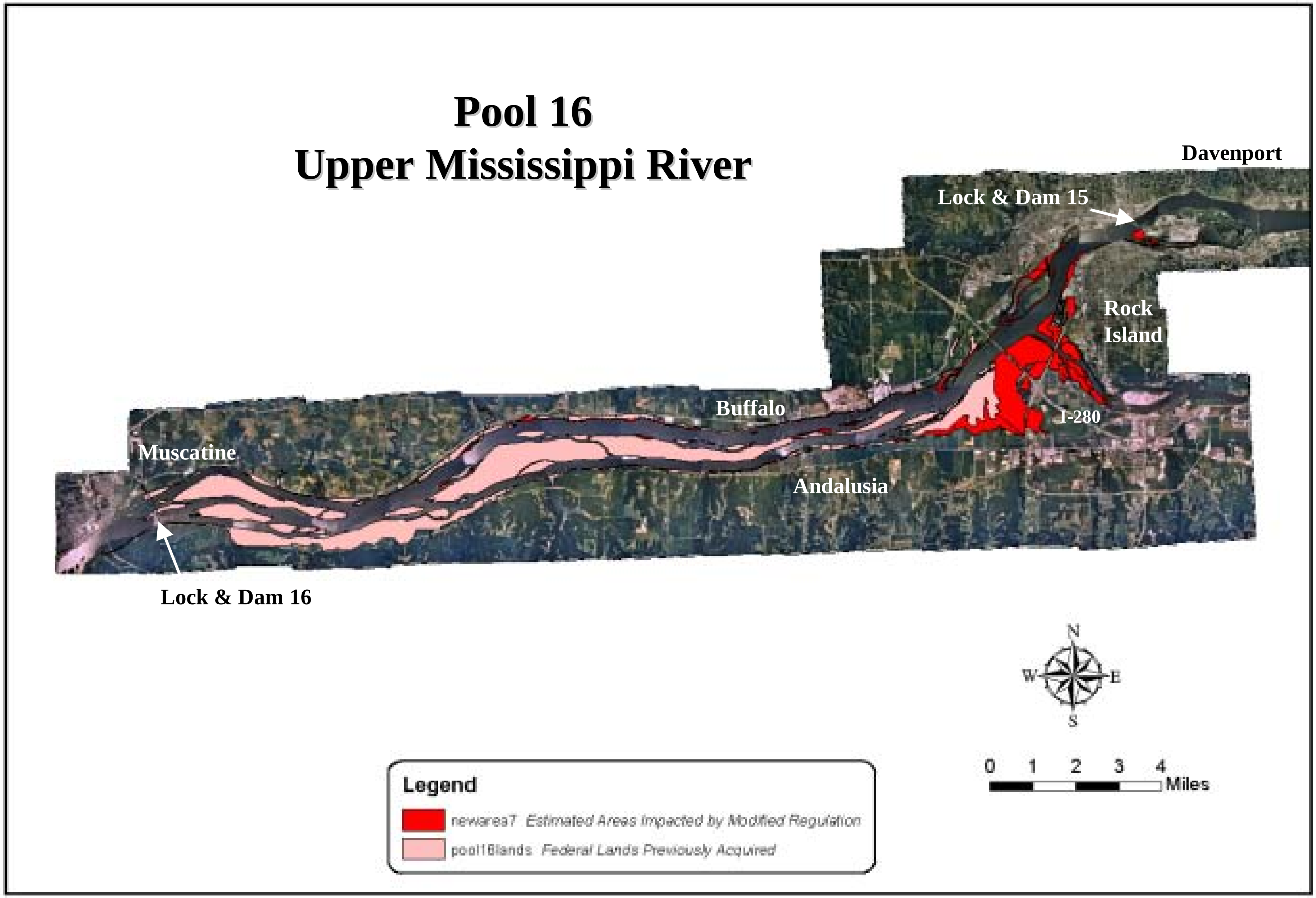


Figure 15. Estimated Areas Impacted by Change from Hinge-Point to Dam-Point Control in Navigation Pool 16.

In order to characterize the current use of the lands subject to the potential taking, the identified areas were intersected with the 1989 Land Use/Land Cover and summarized in terms of the 18 land use types used in the Habitat Needs Assessment. Table 9, below, summarizes the results of this analysis.

Table 9. Lands subject to potential taking within Pool 16, by Land Use Type

Land Use Type	Acres
No Photo Coverage	3.44
Agriculture	150.67
Developed	195.88
Floating-Leaved Aquatic Bed	8.75
Grassland	5.54
Mesic Bottomland Hardwood Forest	168.29
Open Water	444.66
Populus Community	15.38
Salix Community	48.22
Sand/Mud	10.52
Scrub/Shrub	141.62
Seasonally Flooded Emergent Perennial	82.47
Semi-permanently Flooded Emergent Perennial	58.02
Submersed Aquatic Bed	25.81
Wet Floodplain Forest	1,001.44
Wet Meadow	284.35
Total acres:	2,645.07

Representative unit costs for each of the land use cover types are being developed for use in the Restructured Navigation Study. These values will be used to compute an estimated cost for land acquisition associated with this management action.

b. Navigation Pools 24, 25, 26

A preliminary investigation of this management action is described in a Planning Assistance to States report entitled *Mississippi River Pool 25 Year-Round Environmental Pool Management* (USACE, 2004b). The report discusses application of this alternative management action for Pool 25 only, however, the results of this evaluation can be extrapolated to Pool 24 and to Mel Price Pool.

i. Estimation of Benefits

Implementation of this management action would eliminate the winter and spring time reduction in water levels that occurs on the lower part of the pools, due to hinged operation, which has negative effects on the life-cycles of numerous species. Dam point control would provide for a more natural flood pulse response. During winter, water quality conditions would be expected to improve in backwater areas due to the increased volume of water and mass of dissolved oxygen at ice-over. Oxygen depletion, which occurs in many backwaters during winter, would be less extensive due to the greater mass of dissolved oxygen in the slightly higher water column. A reduction in the magnitude, spatial extent, and frequency of winter oxygen depletion in river backwaters would increase the availability of suitable overwintering habitat for lentic fishes. Increased habitat could improve overwintering benefits to the survival and condition of fish, possibly having some positive population-level effects.

The slightly higher and slightly more stable winter water levels could also benefit furbearers such as beaver and muskrat, whose dens and foraging areas are subject to changes in winter water levels.

This management action would have a side benefit to navigation. This navigation benefit will accrue in two areas. First a slack water pool will exist for a higher percentage of time, which will make navigation in the pools safer and more efficient. The second benefit will actually be accrued south of the project within the St. Louis harbor. Without the need to draw the pools down during certain times of the year the fluctuation within the harbor will be reduced

ii. Estimation of Costs

The majority of the implementation costs of this management action are associated with real estate acquisition. Costs for Pool 25 were developed as part of the Planning Assistance to States study (USACE, 2004b), and are estimated as $10 million. These costs for Pool 25 were extrapolated, by the St. Louis District, to Pools 24 and 26. The estimated costs for Pools 24 and 26 are $9.0 million and $11.3 million, respectively. If this management action is recommended for implementation, detailed surveys would need to be conducted to verify these costs and to make final determination of the limits of land parcels that would need to be acquired.

D. Modification to the Distribution of Flow Across the Dam

If fish passage structures are authorized by Congress following completion of the Restructured Navigation Study, an analysis should be conducted at those sites to determine the proper modifications to the regulation procedures to provide for attracting flows and to adjust for the amount of flow passing through the fish passage structure.

E. Reduction in Pool Level Fluctuations on the Illinois Waterway

Four potential management actions were evaluated for reducing pool level fluctuations through modifications to the operation of the dams: more frequent dam gate adjustments; remote operation of dam gates; centralization of water control operations; and structural modifications to the wicket dam structures at Peoria and LaGrange. The following sections provide a description of each management action, discuss the potential of each to reduce short-term water level fluctuations, and provide estimated costs for implementation.

The Illinois River Ecosystem Restoration Water Level Management Analysis (USACE, 2004a) is concurrently working to evaluate a number of management actions with the potential for reducing pool level fluctuations, on the Illinois Waterway, due to both dam operations and watershed influences. The information contained in this section is drawn from information developed specifically for this effort, as well as information developed as part of the Illinois River Ecosystem Restoration Water Level Management Analysis.

1. More Frequent Adjustment of Dam Gates

a. Description

Gate operations at the dams on the Illinois Waterway are determined locally, by the project personnel, and have historically been designed to minimize the number of gate adjustments to reduce staffing requirements. Although this method of operation can be successful in maintaining the pool levels within the authorized operating limits, it is not necessarily successful at minimizing pool and tailwater fluctuations.

A strategy often utilized by the projects is to keep pool water levels within the operating limits by reducing outflows (closing dam gates) when pool levels approach the lower limit and similarly increasing outflows (opening dam gates) when pool levels approach the upper limit. Using this method of operation, there is less risk of exceeding the operational limits and the frequency of gate adjustments are reduced as the pool drifts between the upper and lower operating limits. However, this strategy results in exaggerated responses to changes in river discharges (Figure 16), and subsequently larger tailwater fluctuations, than would have occurred if the pool were managed to maintain a constant level (i.e., operated such that inflows to the pool from the upstream dam and local tributaries equal the outflow from the dam).

Fluctuations produced through this method of operation, at the upper projects on the Illinois Waterway (above Starved Rock), propagate downstream until they reach Peoria Lake, which has sufficient volume to attenuate the effects of the changing flows.

A potential management action to address the short-term fluctuations, described above, is to more intensely manage water levels at the dam projects to adjust to changes in river discharge and to maintain a more constant pool level. This management action would require the project personal to more closely monitor mainstem and tributary conditions and to make frequent, and generally smaller, changes in gate settings.

b. Potential Reduction in Fluctuations

To assess the potential for more frequent gate operations to successfully reduce water level fluctuations, the Illinois River Ecosystem Restoration Water Level Management Analysis utilized a modified UNET model (USACE, 2004a) to evaluate the benefits of performing gate adjustments every two hours. The model assumed perfect knowledge of future flow conditions and therefore represents the maximum benefit that could be achieved through this action.

The model results suggested the following:

- Optimizing management at the Dresden Island Project has the potential to reduce fluctuations in its tailwater zone and at downstream locations of the Illinois Waterway.

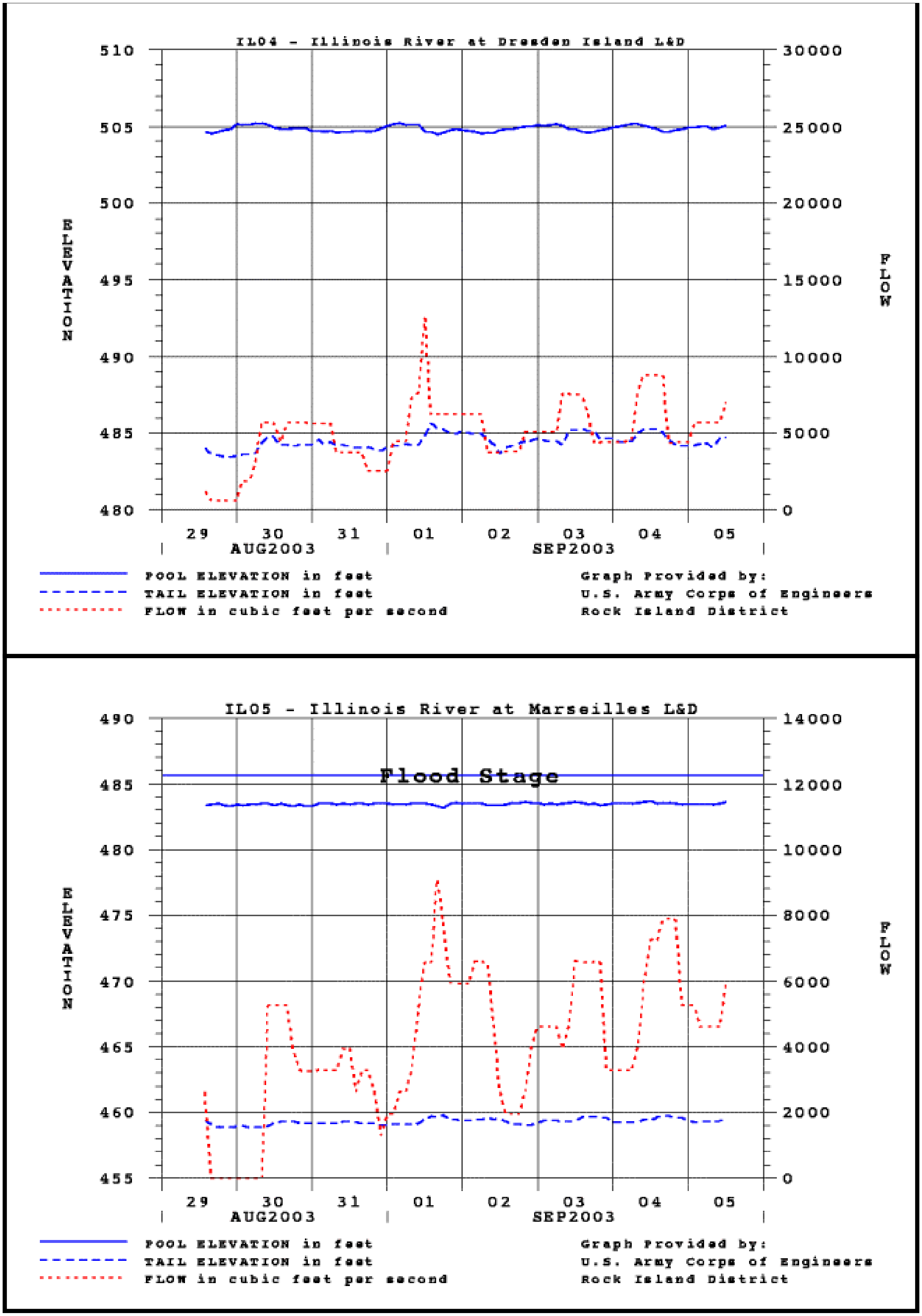


Figure 16. Short-term Water Level Fluctuations on the Illinois Waterway.

- Optimizing management at the Peoria and LaGrange Projects would significantly smooth tailwater water level regimes during the times the dams are in operation. Based on the analysis, as much as 55 to 70 percent of the fluctuations occurring over 6 to 24 hours could be eliminated. Fluctuations occurring over five days, especially those greater than one foot in magnitude, would be much less affected. This suggests that most of these long-term fluctuations arise from conditions imposed by the river flow regime and not the dam operations.

- Intensive management has the potential to bring the fluctuation regime in the river close to one driven solely by the basin flow regime.

The UNET model results suggest that there is significant potential to reduce water level fluctuations on the Illinois River by changes to water level management within existing operating limits. Maintaining water levels at a constant elevation by frequent adjustments of outflows, to match flows entering the navigation pools, would reduce the frequency of rapid water level changes downstream of the dams. Such management at Dresden Island Lock and Dam in particular would reduce water level fluctuation down to Starved Rock. Increasing the capability to smooth outflows at Peoria and LaGrange Locks and Dams would lengthen the time over which downstream water level changes occur and thereby reduce the occurrence of downstream fluctuations. In general, the reduced fluctuations would occur during low-flow periods, with fluctuations during high-flow events unaffected.

c. Cost of Implementation

The cost of implementing this management action is related to the cost of increased labor for lock and dam personnel to perform increased monitoring of river conditions and to make gate adjustments at each of the projects sites. The projects are operated using 3 shifts. To dedicate a person to this function would require staffing during all 3 shifts, at an estimated annual cost of $327,000 per dam site (assuming a WY-8, step 5 employee and a 2.5 multiplier for indirect administrative and operational costs).

2. Remote Operation of Dam Gates

a. Description

An alternative method of allowing for more frequent adjustment of the dam gates is to install remote operating systems on the dam gates to allow them to be adjusted from a computer located in the Lockhouse. This would greatly reduce the time required by lock and dam personnel to conduct gate changes, and therefore reduce staffing conflicts.

A major concern with this management action, expressed by the Rock Island District’s Operations Division, is the potential for debris and ice to affect the gate operation and the risk of damaging the gates and/or operating machinery. This concern can be partially mitigated for by installing video cameras at each gate to allow for viewing of conditions during the gate operations. However, the Operation’s Division has expressed reluctance to remotely operate the gates during periods of ice and heavy debris flows.

b. Potential Reduction in Fluctuations

This management action would have the same potential for reducing water level fluctuations as described in Section V.E.1.b, above.

c. Cost of Implementation

Costs for installation of remote operating systems were developed for all sites based upon component costs and the number of dam gates at each project on the UMR and IWW. The costs are presented in Tables 10 and 11.

3. Centralization of Water Control on the Illinois Waterway

a. Description

As discussed above, the dams on the Illinois Waterway are currently regulated independently by the individual projects. On the UMR, each of the three Districts has an office responsible for the daily regulation of all dams within their District. This centralized control offers a number of benefits. First, within each District there is a single office responsible for monitoring and forecasting river conditions, allowing for regulation of the system from a system perspective. This is important due to the inter-related nature of the projects (i.e., a change at Lock & Dam 11 affects Lock & Dam 12, which affects Lock & Dam 13, etc.).

Second, centralized control allows for more consistent regulation of the projects by a single forecaster, eliminating inconstancies in operation that can result from multiple regulators operating across daily shifts and weekdays/weekends. Lastly, centralized control reduces the need for lock and dam personnel to perform detailed monitoring of river discharges and to make determinations of gate settings, thereby reducing staffing requirements.

This potential management action is only applicable to the lower 5 projects on the Illinois Waterway (Dresden Island to LaGrange, Figure 1). As discussed in Section II.B.3, the Metropolitan Sanitary District of Greater Chicago (MSDGC) is responsible for water control from the Lockport Dam to Lake Michigan. Brandon Road pool responds very quickly to rainfall in the Chicago area is considered too flashy to be operated by a centralized office.

b. Potential Reduction in Fluctuations

The primary benefits of this management action are related to operating the dams from a systemic perspective. Routing of flows through the entire system would allow for more consistent and timely responses to changing flow conditions and a reduction in short-term fluctuations. The effect would be similar to the reductions produced by the previous two actions discussed (more frequent dam gate adjustments and remote

Table 10. CONSTRUCTION COST ESTIMATE TO REMOTE CONTROL DAM GATES FROM LOCK CCS

DRAFT ELECTRICAL CONSTRUCTION COST ESTIMATE (CEMVR-ED-DG, RADTKE)

BID ITEM: ELECTRICAL WORK Electrician Hourly Labor Rate $40.00

ITEM				MATERIAL		LABOR		EQUIPMENT		MAT.&EQUIP
NO.	DESCRIPTION	QUANTITY	UNITS	COST/UNIT	COST	HOURS/UNIT	HOURS	COST/UNIT	COST	SUBTOTALS
	Base Requirements per Dam									
1	Dedicated Pentium IV PC, Monitor, Keyboard	1	EA	$8,000.00	$8,000.00	4	4	$0.00	$0.00	$8,000.00
2	Patchcord	1	EA	$25.00	$25.00	0.25	0.25	$0.00	$0.00	$25.00
3	Intellusion or Wonderware HMI Software	1	EA	$1,500.00	$1,500.00	2	2	$0.00	$0.00	$1,500.00
4	Communications Software	1	EA	$1,500.00	$1,500.00	2	2	$0.00	$0.00	$1,500.00
5	HMI Programming ($80/Hr is 2x normal rate in	80	Units	$0.00	$0.00	1.75	140	$0.00	$0.00	$0.00
6	ControlLogix Ladder Logic Software	1	Units	$1,500.00	$1,500.00	2	2	$0.00	$0.00	$1,500.00
7	ControlLogix Ladder Logic Programming	80	Units	$0.00	$0.00	1.75	140	$0.00	$0.00	$0.00
8	ControlLogix PLC (Prime Controller) in CCS	1	EA	$5,500.00	$5,500.00	4	4	$0.00	$0.00	$5,500.00
9	ControlLogix PLC (Hot Backup) in CCS	1	EA	$5,500.00	$5,500.00	4	4	$0.00	$0.00	$5,500.00
10	Input/Output (I/O) Rack (in CCS)	1	EA	$600.00	$600.00	1	1	$0.00	$0.00	$600.00
11	I/O Modules	2	EA	$500.00	$1,000.00	1	2	$0.00	$0.00	$1,000.00
12	Fiber Optic Communciations Module (FO loop)	2	EA	$1,000.00	$2,000.00	1	2	$0.00	$0.00	$2,000.00
13	Fiber Optic Terminator (FO loop)	2	EA	$50.00	$100.00	2	4	$0.00	$0.00	$100.00
14	12 Strand Fiber Optic Cable (loop redundant c	12	CLF	$200.00	$2,400.00	3.5	42	$0.00	$0.00	$2,400.00
15	3/4" RGS conduit riser to Dam Service Bridge	200	LF	$1.41	$282.00	0.32	64	$0.00	$0.00	$282.00
16	12x12 junction box on Lock Abutment Pier (loo	2	EA	$500.00	$1,000.00	3.5	7	$0.00	$0.00	$1,000.00
17	CCTV Color Monitors	2	EA	$3,000.00	$6,000.00	12.3	24.6	$0.00	$0.00	$6,000.00
18	CCTV Fiber Cable	6	CLF	$200.00	$1,200.00	3.5	21	$0.00	$0.00	$1,200.00
19	Dewater 3 Crossover Manholes (Environmark)	3	Days	$0.00	$0.00	4	12	$20.00	$60.00	$60.00
20	Clean 3 Crossover Manholes (Environmark)	3	Days	$0.00	$0.00	5	15	$50.00	$150.00	$150.00
21	Hazardous Water Removal (Environmark) from	1	Days	$100.00	$100.00	8	8	$200.00	$200.00	$300.00
22	Troubleshooting ($80/hour)	60	Job	$0.00	$0.00	1.75	105	$0.00	$0.00	$0.00
23	PLC Controls and System Training (5 trainees)	5	EA	$1,000.00	$5,000.00	8	40	$0.00	$0.00	$5,000.00
24	Concrete Core Drill (2" diameter 24 inches long	24	inches	$27.81	$667.44	2.76	66.24	$16.05	$385.20	$1,052.64
25	Concrete Cutting (6" D x 6" W x 20' Long)	246	LF	$0.00	$0.00	0.062	15.252	$0.60	$147.60	$147.60
26	Concrete Patching	21	CF	$5.20	$109.20	0.64	13.44	$0.00	$0.00	$109.20
27	Rubbish Handling	123.7778	CY	$0.00	$0.00	0.667	82.559778	$0.00	$0.00	$0.00
28	Basis installation rqd. per facility irregardless of gate quantity				$43,983.64		823.34		$942.80	$44,926.44
29						X	$40.00			
30							$32,933.67			$32,933.67
31										$77,860.11
32										
33	Contingency 25%	$19,465.03								$19,465.03
34										
35	Mobilization and Demobilization	$10,000.00								$10,000.00
36	Overhead and Profit	33% $3,300.00								$35,417.30
37	Sub-Total **per Facility** base cost									$142,742.43
38										
39										
40	**Per Gate Requirement (assumed for Tainter & Roller alike)**									
41	Input/Output (I/O) Rack (on Pier or in Pier Hou	1	EA	$600.00	600.00	1	1	$0.00	$0.00	$600.00
42	I/O Modules	2	EA	$500.00	1,000.00	1	2	$0.00	$0.00	$1,000.00
43	Intelligent I/O Modules	1	EA	$2,100.00	2,100.00	1.5	1.5	$0.00	$0.00	$2,100.00
44	Fiber Optic Communciations Module	2	EA	$1,000.00	2,000.00	1	2	$0.00	$0.00	$2,000.00
45	Fiber Optic Terminator	4	EA	$50.00	200.00	2	8	$0.00	$0.00	$200.00
46	12 Strand Fiber Optic Cable (loop redundant c	2.5	CLF	$200.00	500.00	3.5	8.75	$0.00	$0.00	$500.00
47	CCTV	1	EA	$5,000.00	5,000.00	3	3	$0.00	$0.00	$5,000.00
48	CCTV Fiber Optic Cable	2.5	CLF	$500.00	1,250.00	3.5	8.75	$0.00	$0.00	$1,250.00
49	3/4" RGS conduit across gate span (loop)	250	LF	$1.41	352.50	0.32	80	$0.00	$0.00	$352.50
50	3/4" RGS conduit across gate span for new se	250	LF	$1.41	352.50	0.32	80	$0.00	$0.00	$352.50
51	3/4" RGS conduit expansion/contraction joint (l	2	EA	$250.00	500.00	1	2	$0.00	$0.00	$500.00
52	24x24x10 NEMA 4X SS junction box on Dam P	1	EA	$1,000.00	1,000.00	3.5	3.5	$0.00	$0.00	$1,000.00
53	Relays	8	EA	$108.00	864.00	2	16	$0.00	$0.00	$864.00
54	Sensors	5	EA	$500.00	2,500.00	16	80	$0.00	$0.00	$2,500.00
55	#12 AWG into existing controller	15	CLF	$8.90	133.50	0.727	10.905	$0.00	$0.00	$133.50
56	Anchors for Enclosures and Conduit	54	EA	$4.50	243.00	0.727	39.258	$0.00	$0.00	$243.00
57	Cost Per ONE Roller Gate -OR- Per ONE Tainter Gate				$18,595.50		346.66		$0.00	$18,595.50
58						X	$40.00			
59							$13,866.52			$13,866.52
60										$32,462.02
61										
62	Contingency 25%	$8,115.51								$8,115.51
63										
64	Mobilization and Demobilization	$250.00								$250.00
65	Overhead and Profit	33% $82.50								$13,473.08
66	Sub-Total **per dam gate** cost									$54,300.61

Prices obtained from following resources:

1. PLC Equipment from Allen-Bradley Company control and Information Products Price List USA, Eff. Nov 3, 2002
2. 2003 RSMeans Electrical Cost Data
3. 2003 MCACES Unit Price Book
4. Quality Check and Review performed by CEMVR-ED-DG and CEMVR-ED-C

Table 11. CONSTRUCTION COST ESTIMATE TO REMOTE CONTROL DAM GATES FROM LOCK CCS

DRAFT ELECTRICAL CONSTRUCTION COST ESTIMATE (CEMVR-ED-DG, RADTKE)

BID ITEM: ELECTRICAL WORK

Electrician Hourly Labor Rate $42.00

Electronic Technician Hourly Labor Rate $84.00

LD NO.	FACILITY	NO. of GATES	Base Facility Cost	Cost for All Gates		**Total Facilitiy Cost**
	ILWW Lock and Dam Name					
1	T.J. O'Brien (not applicable)	0				
2	Lockport (not applicable)	0				
3	Brandon Road	21	$142,742.43	$1,140,312.77	**NOTE 1**	**$1,283,055.21**
4	Dresdent Island	9	$142,742.43	$488,705.47		**$631,447.91**
5	Marseilles (Already Remote Controlled)	8	This MVR facilities has PLC controls.			
6	Starved Rock	10	$142,742.43	$543,006.08		**$685,748.52**
7	Peoria (wicket gates are not applicable)	1	$142,742.43	$54,300.61		**$197,043.04**
8	LaGrange (wicket gates not applicable)	1	$142,742.43	$54,300.61		**$197,043.04**
	Miss. Rvr. Lock and Dam Name					
USAF	Upper St. Anthony Falls Lock & Dam (not app	0				
LSAF	Lower St. Anthony Falls Lock & Dam	3	$142,742.43	$162,901.82		**$305,644.26**
1	Lock and Dam No. 1 (not applicable)	0				
2	Lock and Dam No. 2	20	$142,742.43	$1,086,012.17		**$1,228,754.60**
3	Lock and Dam No. 3	4	$142,742.43	$217,202.43		**$359,944.87**
4	Lock and Dam No. 4	28	$142,742.43	$1,520,417.03		**$1,663,159.47**
5	Lock and Dam No. 5	34	$142,742.43	$1,846,220.68		**$1,988,963.12**
5a	Lock and Dam No. 5A	10	$142,742.43	$543,006.08		**$685,748.52**
6	Lock and Dam No. 6	15	$142,742.43	$814,509.12		**$957,251.56**
7	Lock and Dam No. 7	16	$142,742.43	$868,809.73		**$1,011,552.17**
8	Lock and Dam No. 8	15	$142,742.43	$814,509.12		**$957,251.56**
9	Lock and Dam No. 9	13	$142,742.43	$705,907.91		**$848,650.34**
10	Lock and Dam No. 10	10	$142,742.43	$543,006.08		**$685,748.52**
11	Lock and Dam No. 11	16	$142,742.43	$868,809.73		**$1,011,552.17**
12	Lock and Dam No. 12	10	$142,742.43	$543,006.08		**$685,748.52**
13	Lock and Dam No. 13	13	$142,742.43	$705,907.91		**$848,650.34**
14	Lock and Dam No. 14	17	$142,742.43	$923,110.34		**$1,065,852.77**
15	Lock and Dam No. 15	11	$142,742.43	$597,306.69		**$740,049.13**
16	Lock and Dam No. 16	19	$142,742.43	$1,031,711.56		**$1,174,453.99**
17	Lock and Dam No. 17	11	$142,742.43	$597,306.69		**$740,049.13**
18	Lock and Dam No. 18	17	$142,742.43	$923,110.34		**$1,065,852.77**
19	Lock and Dam No. 19	0				
20	Lock and Dam No. 20	43	$142,742.43	$2,334,926.15		**$2,477,668.59**
21	Lock and Dam No. 21	13	$142,742.43	$705,907.91		**$848,650.34**
22	Lock and Dam No. 22	13	$142,742.43	$705,907.91		**$848,650.34**
24	Lock and Dam No. 24	15	These MVS facilities have PLC controls.			
25	Lock and Dam No. 25	17				
26	Mel Price Locks and Dam	33				

NOTE 1: Brandon Road Dam tainter gates are significantly shorter in height and narrower than all other tainter gates. Estimated Construction Cost was not altered. It is possible that significant controls additions may be required to allow these gates to be remotely controlled. This facility's cost should be re-evaluated in greater detail if this management action is recommended for implementation at this site. Brandon Road Dam Gates are approx. 3 ft high x 52 ft. wide

operation of dam gates), with the primary difference being where the river monitoring and regulation occurs (at the individual projects vs. from a centralized office).

c. Cost of Implementation

Implementation of this management action would involve some up-front (first) costs as well as annual operation costs. Prior to implementation, improvements would have to be made to the existing UNET model for the Illinois Waterway to improve its forecasting (routing) capabilities to a level suitable for real-time system regulation. Additionally, analyses would have to be performed to develop forecasting tools; including the development of backwater relationships between the UMR and lower IWW, rising and falling river travel times, tributary travel times, and pool stage-volume relationships. Finally, two acoustic velocity meter (AVM) gauging stations would need to be installed in LaGrange and Peoria pools to provide real-time flow measurements in the lower portion of the Illinois River, which is subject to backwater conditions.

Operation costs consist of labor costs for the river forecaster and maintenance costs for the two AVM gauging stations. Estimated costs for implementing this management action are shown in Table 12.

Table 12. Cost Estimate for Centralized Operation of Illinois Waterway Dams

First Costs:	
Improvements to UNET Forecasting Model:	$60,000
Development of Forecasting Tools:	$100,000
Installation of side-looking acoustic velocity meter gauging stations:	$40,000
Total Implementation Cost:	**$200,000**
Annual Costs:	
Forecaster (4 hrs/day, GS-12, step 5):	$121,180
Maintenance of AVM stations:	$20,000
Total Annual Cost:	**$141,180**

4. Structural Modifications to the Wicket Dams at Peoria and LaGrange

a. Description

The transition into and out of open river conditions at the two wicket dam sites, Peoria and La Grange, has the potential to induce significant water level fluctuations below the dams (Figure 17). During Water Years 1979-2001 (23 years) the wickets were raised, and therefore subsequently lowered, 97 times at Peoria and 84 times at La Grange. To better control the pool water levels at these locations, tainter gates were installed in 1990 (Peoria) and 1991 (La Grange). The gates allow for greater control of dam releases to address changes in pool conditions, however, large adjustments have the potential to cause water level fluctuations at the tails of the dams and further downstream.

Installation of the tainter gates at these dams has not significantly reduced the number of wicket operations. The wicket operations are conducted in response to rising river levels due to increases in river discharge or due to backwater effects from the Mississippi River during flood conditions.

The primary water level concern associated with wicket gate operation are the rapid fluctuations in water levels upstream and downstream of the dam immediately after the wicket gates are raised or lowered. These rapid fluctuations are due to the combined effects of the dam and the rising/falling river. The hydraulic nature of the dam is such that, immediately upon raising the wicket gates (on a falling river), a head differential (water surface differential between the pool and tailwater) must be developed in order to pass the ambient river flow through the tainter gate and through the wicket portion of the dam (through the needles and over the top of the raised wickets). This head is formed by storing water in the pool, thereby raising pool levels, and by the reduction in tailwater level due to the loss of flow being taken into storage within the pool.

b. Potential Reduction in Fluctuations

A potential management action to reduce the fluctuations produced by the wicket operation is to add a second tainter gate at each of the sites. The additional tainter gate would provide added flow capacity, when the wickets are raised, to reduce the head differential required to pass the ambient flow. The addition of one additional tainter gate would not have an effect on the availability of open pass conditions during high water, as the width of the open-pass section would still be greater than 300 feet. The addition of a second tainter gate would not reduce (or increase) the number of wicket dam operations, or the frequency of open pass conditions.

In order to assess the potential reduction in water level fluctuations associated with the addition of a second tainter gate, an analysis was performed to determine the head differential required to bass the ambient flow (at which the wickets are raised or lowered) under existing conditions and with a second tainter gate (of the same dimensions as the existing gate). Figure 18 provides the wicket and tainter gate discharge ratings for Peoria and LaGrange. For the existing condition, and the addition of a second tainter gate, the required head differential (to the nearest tenth of a foot) was computed based upon the gate discharge ratings and assuming a pool level equal to flat pool. The results of this analysis are shown in Figure 19. The exception to this is LaGrange Pool under existing conditions. The analysis indicates that there is insufficient capacity to pass the ambient flow at flat pool conditions. As a result, the pool must be raised to increase the amount of flow passing over the wickets. For this scenario, the tainter gate rating curve was proportioned up as a function of the head over the gate sill, raised to the 3/2 power (resulting in a 5.4% increase in discharge).

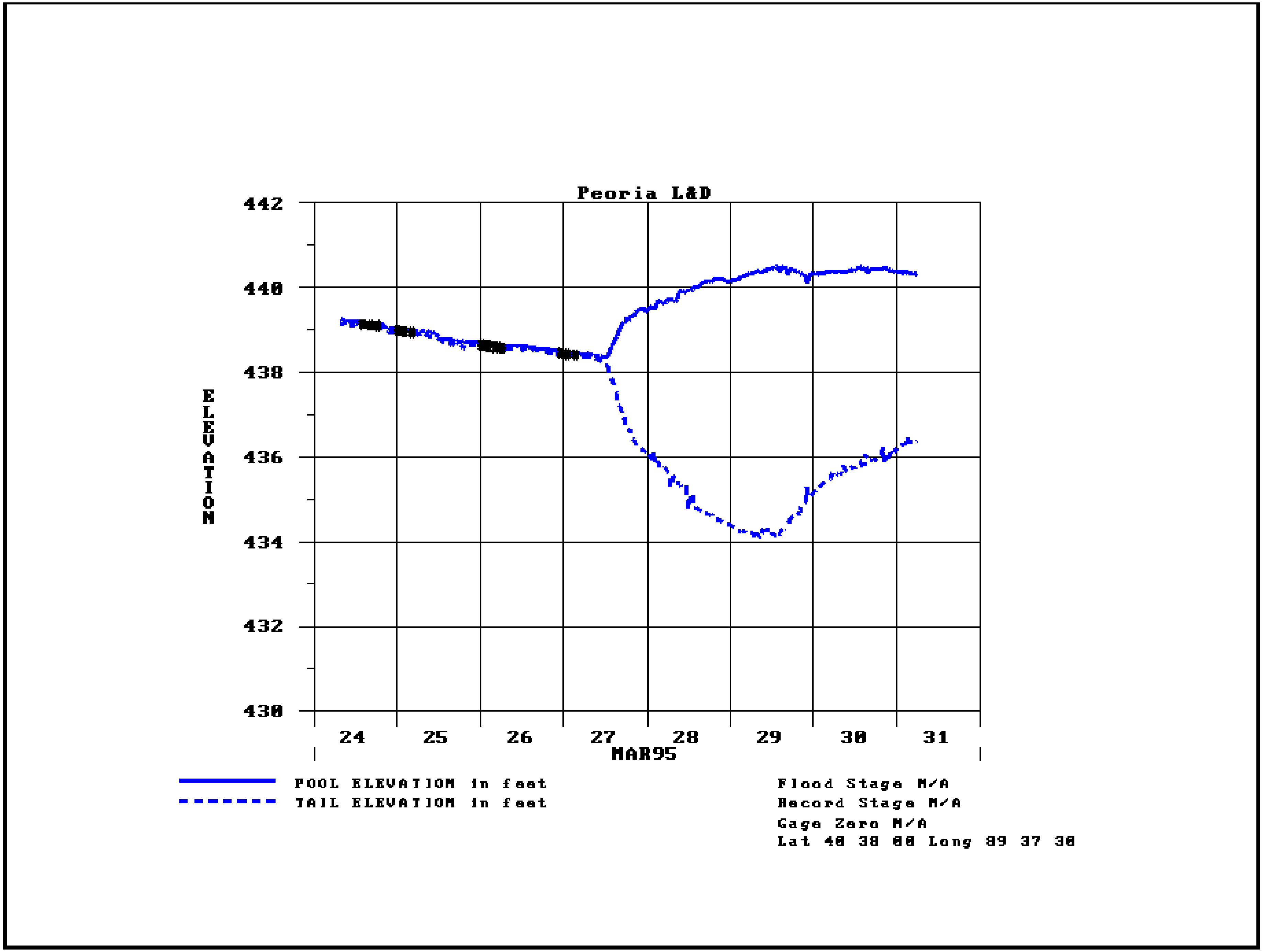


Figure 17. Pool Fluctuations During Wicket Operations At Peoria Lock & Dam.

Figure 18. Gate Discharge Ratings, Peoria and LaGrange Dams

Stage-Discharge rating of wicket gates at Peoria and LaGrange Dams, for an upstream pool elevation equal to flat pool, with no needles in place and no wickets lowered[1]

Peoria Lock & Dam (Flat Pool Elevation 440.0)

Tailwater Elevation	430.0	430.5	431.0	431.5	432.0	432.5	433.0	433.5	434.0	434.5	435.0	435.5	436.0	436.5	437.0	437.5	438.0	438.5	439.0
Discharge, in cfs	6,383	6,367	6,327	6,254	6,174	6,101	6,013	5,924	5,811	5,682	5,529	5,360	5,199	5,005	4,755	4,409	4,006	3,522	2,901

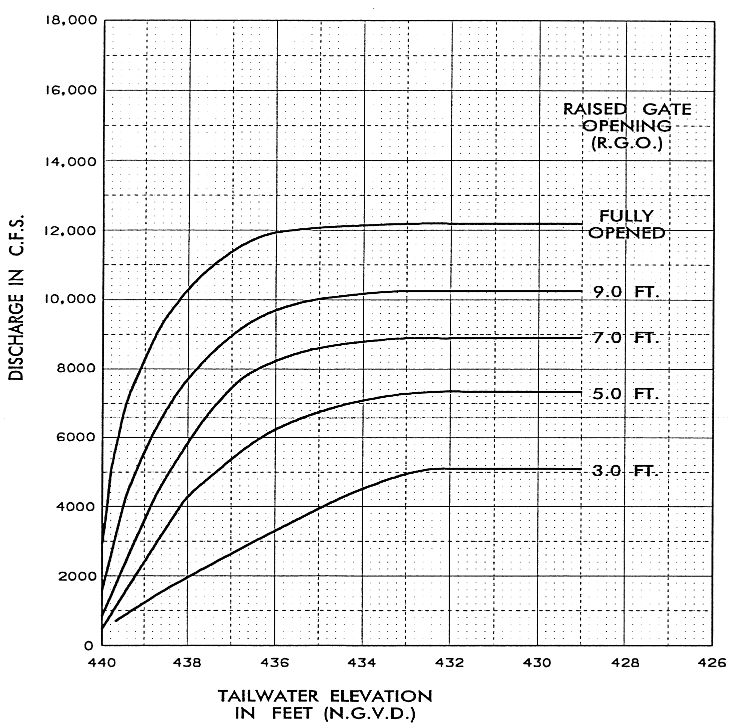
LaGrange Lock & Dam (Flat Pool Elevation 429.0)

Tailwater Elevation	418.0	418.5	419.0	419.5	420.0	420.5	421.0	421.5	422.0	422.5	423.0	423.5	424.0	424.5	425.0	425.5	426.0	426.5	427.0	427.5	428.0
Discharge, in cfs, w/ Pool Elev 429.0	5,636	5,620	5,603	5,587	5,579	5,563	5,507	5,434	5,353	5,280	5,200	5,087	4,974	4,820	4,667	4,505	4,295	4,013	3,649	3,213	2,656
Discharge, in cfs, w/ Pool Elev 429.5	6,451	6,435	6,427	6,403	6,395	6,379	6,338	6,274	6,193	6,112	6,039	5,943	5,829	5,692	5,539	5,385	5,200	4,990	4,675	4,295	3,843

[1] Adapated from Mades (1981)

Tainter Gate Discharge Ratings (USACE, 1996)

Peoria Dam



LaGrange Dam

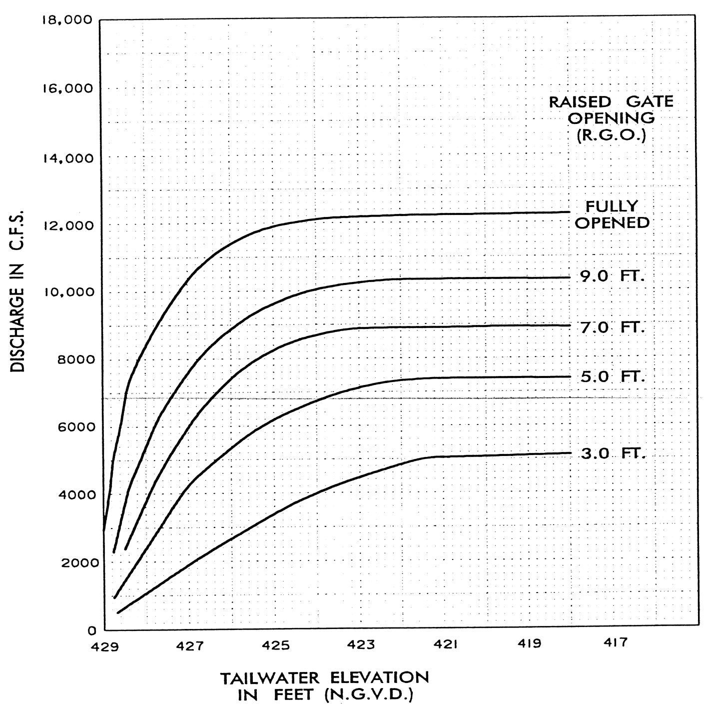


Figure 19. Computed Reductions in Stage Fluctuations with Addition of Second Gate

Existing Conditions:	Peoria		LaGrange	
Flow at Raising/Lowering of the Gates:	15,000	cfs	19,000	cfs
Regulated Pool:	440.0	ft, NGVD	429.5	ft, NGVD
Computed Regulated Tailwater:	437.7	ft, NGVD	426.5	ft, NGVD
Computed Flows through Gates				
Tainter:	10,700	cfs	12,810	cfs
Wicket:	4,248	cfs	6,180	cfs
Total:	14,948	cfs	18,990	cfs
Computed Induced Fluctuation:	2.3	ft	3.0	ft

With Second Gate:	Peoria		LaGrange	
Flow at Raising/Lowering of the Gates:	15,000	cfs	19,000	cfs
Regulated Pool:	440.0	ft, NGVD	429.0	ft, NGVD
Computed Regulated Tailwater:	439.5	ft, NGVD	427.9	ft, NGVD
Computed Flows through Gates				
Tainter:	6,600	cfs	8,500	cfs
New Tainter:	6,600	cfs	8,500	cfs
Wicket (Adjusted for lost wickets):	1,760	cfs	2,125	cfs
Total:	14,960	cfs	19,125	cfs
Computed Induced Fluctuation:	0.5	ft	1.1	ft

As shown in Figure 19, the addition of a second tainter gate has the potential to significantly reduce, but not eliminate, the fluctuations produced by placing the wicket dams into operation. The addition of a third, or more, tainter gates would serve to slightly decrease the fluctuations further, however, they would prohibit open pass conditions, requiring tows to use the lock, and greatly increasing transportation costs.

c. Cost of Implementation

The original, 1987, contract amount for construction of the 84-foot tainter gates was $9.2 million per gate. Bringing this cost forward, to 2003 dollars, yields an estimated cost of $13.9 million per gate.

VI. Conclusions

In this report, six alternative water level management actions have been identified and discussed in terms of their potential to support identified ecosystem restoration goals and objectives. A prioritization of the identified water level management actions was conducted to identify those combinations of management actions and pools that produce the most benefits for the least cost (i.e., are efficient), and which are most likely to be successfully implemented (i.e., are feasible). The prioritization process was not intended to exclude any pool or management action from possible future consideration, but rather to help focus this effort on those combinations of management actions and navigation pools that appeared to be the most efficient and feasible, for development of benefit and cost information. An important component of the Restructured Navigation Study is the concept of adaptive management. Under adaptive management, continuous monitoring of the ecosystem's health, and the performance of management actions taken, is conducted to increase the river managers' knowledge of the system and to guide future decision-making.

Quantitative benefit and cost information for the prioritized water level management actions were developed, where possible. The values represent average, expected benefits and costs. Implementation of any of the management actions has the potential to produce varying ecological responses due to annual variations in hydrologic and growing conditions that effect the duration, magnitude, and timing in which the management actions could be implemented. Quantification of benefits in terms of ecological response are often not possible due to an incomplete knowledge of resource populations, other factors affecting the population dynamics, and the relationships between organism responses and physical processes. In these instances, anticipated benefits are qualitatively discussed.

The benefit and cost information will be used to aid in the development of Environmental Alternatives for consideration in the Restructured Navigation Study.

VII. Recommendations

The following recommendations are those of the authors and participating team members, and do not necessarily reflect the positions or policies of the U.S. Army Corps of Engineers, the U.S. Fish and Wildlife Service, the U.S. Geological Survey, the Departments of Natural Resources of Minnesota, Wisconsin, Iowa, Illinois, or Missouri, or The Nature Conservancy. The recommendations are referenced to their corresponding sections of the report.

- Consideration should be given to extending the application of the Indicators of Hydrologic Alteration analysis, to all portions of the UMR and IWW, to assist in guiding application of potential water level management actions. (Section II.C)

- Existing coordinating bodies should be engaged to support the prioritization, implementation, and monitoring of water level management actions resulting from implementation of the recommendations of the Restructured Navigation Study. Greater coordination between the three UMR Corps Districts and coordinating bodies should be pursued to prioritize resource allocation and monitoring. (Section II.D.3.b)

- Ongoing water level management initiatives should continue to be pursued, and not rely upon the outcomes of the Restructured Navigation Study. If the study results in authorization of a systemic ecosystem restoration program, the ongoing water level management initiatives should be integrated into the adaptive management strategy of that program. (Section II.D.3.b)

- Water level management has been test applied in all three UMR Corps Districts over the past decade, in a variety of different pools, with varying degrees of success. The study team believes that the benefits of these actions has been proven sufficient to recommend that the three UMR Corps Districts move beyond the concept of pilot projects and test applications to making water level management, for ecosystem restoration, an integrated part of the Corps' water management procedures; and that the Corps should pursue whatever authorities may be necessary to accomplish this. (Section II.D.3.b)

- Implementation planning for pool drawdowns should include an environmental monitoring plan that incorporates vegetation response as a primary measure for the benefits associated with growing season drawdowns and standardizes the measure for vegetation response system-wide.

- Implementation planning for pool drawdowns should include a monitoring and mitigation plan for cultural resource sites that may be exposed to mechanical, biochemical and/or human destruction. (Section III.A.3.f)

- For those pools in which pool-wide, growing season, drawdowns do not appear to be feasible and/or efficient, consideration should be given to identifying isolated or single outlet backwaters within those pools in which small-scale drawdowns could be implemented through the use of portable pumps and temporary closing dams. (Section IV.C)

- Collection of detailed bathymetric data should continue to be a priority of the Long Term Resource Monitoring Program, with emphasis on collecting data for those pools selected for possible implementation of pool-wide water level management actions. (Section V.A.2.c)

- Implementation of pool-wide drawdowns should be based upon the current state of vegetation within the pools and hydrologic conditions. Acquisition of channel dimensions suitable for maintaining navigation during a drawdown, through advanced dredging, should be pursued in lieu of scheduled closures of the navigation channel. Advanced maintenance dredging would allow for drawdowns in any year, at any time during the growing season, in which flow conditions are suitable, providing for a high degree of flexibility. Scheduled closures, on the other hand, risk causing large disruptions to other river uses and face unknown hydrologic conditions, which may prevent successful implementation. (Section V.A.2.d)

- The Corps should develop procedures to effectively share information concerning the goals and anticipated impacts of pool-wide drawdowns with the public in order to increase public knowledge and to allow for other users to prepare for the modified river regulation. The current procedures being used for the proposed drawdown in Pool 5 could be used as a starting point for the development of such procedures. (Section V.A.2.f)

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Appendix A

Scope of work

Appendix A
SCOPE OF WORK

Evaluation of Water Level Management Opportunities in support of the Restructured Upper Mississippi River – Illinois Waterway System Navigation Study

I. PROJECT OBJECTIVE

1.1 The purpose of this project is to conduct a systemic evaluation of Water Level Management (WLM) opportunities on the Upper Mississippi River and Illinois Waterway (UMR-IWW) for use in the Restructured Navigation Study. The results of the investigation will be used to identify potential WLM actions to support environmental objectives identified as part of the overall Navigation Study. Primary tasks to be performed include:

1.1.1 Development of a summary of past WLM initiatives and investigations.

1.1.2 Development of a summary of major constraints to implementation of potential WLM actions.

1.1.3 Identification of information needed to define the benefits and costs associated with a range of potential WLM actions.

1.1.4 Development of benefit and cost information required to support plan formulation in the Restructured Navigation Study.

1.1.5 Preparation of a technical report summarizing the procedures, assumptions, and sources of data used to develop the benefit and cost information.

II. BACKGROUND

2.1 The Restructured Upper Mississippi River-Illinois Waterway (UMR-IWW) System Navigation Study is developing a framework for the comprehensive management of the Upper Mississippi River System. This will include navigation planning, ecosystem planning, ongoing operation and maintenance activities, and floodplain management.

2.2 The recently released Interim Report outlines the navigation improvement and ecosystem restoration measures that will be carried forward for evaluation. Ecosystem restoration measures include beneficial adjustments to system operation and maintenance, ecosystem restoration opportunities, and environmental enhancement opportunities related to the navigation system. Examples of these measures include traffic impact prevention and reduction, channel modifications, systemic fish passage and water level management, and backwater, secondary channel, and island rehabilitation.

2.3 A series of four regional stakeholder workshops were conducted during November 2002. The goal of the workshops was to review and confirm environmental objectives, and to formulate management actions to address the identified objectives, for the UMR-IWW. For all reaches of the UMR-IWW, modifications to the current dam regulation were identified as a potential management action that could be used to obtain desired environmental benefits.

2.4 Water Level Management initiatives are not new to the UMR-IWW. There are currently ongoing initiatives in all three UMR Corps Districts. This effort will maximize use of existing data developed for these initiatives, and seek to leverage the knowledge and expertise of the personnel and agencies currently involved in these ongoing efforts.

III. PROJECT DESCRIPTION.

3.1 Develop Summary of past WLM initiatives and investigations – Team members will identify and compile reports and information from past and ongoing WLM initiatives and investigations. Emphasis will be given to compiling information that describes the costs, benefits, and feasibility of various WLM actions. A team member from each district will compile the information for dissemination to the larger team for use in 3.3.

3.2 Develop Summary of major constraints to implementation of potential WLM actions – Major constraints affecting the implementation of potential WLM actions will be identified and summarized for use in 3.3. Both physical and legal constraints will be identified. Physical constraints include: water supply intakes, commercial loading facilities, recreational facilities, miter gate sill depths, and locations of rock substrate in the main navigation channel. Legal constraints include: real estate issues, project authorization, and existing statutes (e.g., the "Anti-Drawdown Law").

3.3 Identify information needed to define benefits and costs associated with range of WLM actions – A workshop will be held to: define the range of WLM actions which should be included in the analysis described in 3.4, including the timing, magnitude, and duration of the actions; conduct a screening exercise to eliminate pools from further consideration which have no identified environmental objectives consistent with WLM actions or which have irreconcilable constraints; develop measures for quantification of benefits from WLM actions; and to identify major implementation costs and impacts that need to be quantified for use in the Restructured Navigation Study. It is anticipated that state representatives will participate in this workshop.

3.4 Develop benefit and cost information required to support plan formulation in the Restructured Navigation Study – Each of the 3 UMR Districts will develop identified information needs from item 3.3 for their individual District. This will likely include: development of water surface profiles for a variety of drawdown scenarios; estimation of dredging quantities required to maintain the navigation channel for a range of drawdowns; estimation of the acres of land effected by various WLM actions; costs associated with mitigating impacts of WLM actions on recreational facilities and water supply; estimation of the probability of (hydrologic) success for implementing various WLM actions; and identification of additional land acquisition, authorities, or water control plan modifications needed to implement the various WLM actions.

3.5 Preparation of technical report – A report will be prepared summarizing benefit and cost information for the identified WLM actions; as well as, the procedures, assumptions, and sources of data used to develop the benefit and cost information.

IV. PRODUCTS TO BE FURNISHED

4.1 The following products shall be furnished by the study team:

4.1.1 District summaries of previous WLM initiatives and investigations

4.1.2 Summary of major constraints to implementation of WLM Actions

4.1.3 Results summary of Information Needs Workshop

4.1.4 Draft and Final Technical Report

V. SCHEDULE AND ESTIMATED COST

5.1 **Project Schedule** – Work will begin in early January 2003, with an estimated completion date of August 29, 2003. The following Project Schedule is proposed:

Task	**Approx. Date**
Kick-off Conference Call	6 Jan 2003
Compile and Summarize Existing Literature on WLM	6 Jan – 7 Feb 2003
Compile information on major constraints to Potential WLM Actions	6 Jan – 7 Feb 2003
Distribute Summary of Past WLM Efforts and major constraints to Study Team	14 Feb 2003
Conduct Workshop to Identify Additional Data Needs	27 Feb 2003
Distribute Summaries and Workshop Results to NECC	10 Mar 2003
Development of Identified Data Needs	1 Mar – 20 Jun 2003
Complete Draft Report	20 Jun 2003
Internal Review of Draft Report	23 Jun – 3 Jul 2003
Distribute Draft Report to NECC	7 Jul 2003
Final Report	29 Aug 2003

5.2 **Personnel** - The study team will consist of the following members:

CEMVP – Jon Hendrickson, Dan Wilcox, Scott Jutila
CEMVR - Kevin Landwehr, Chuck Theiling, Tom Gambucci
CEMVS – Dave Busse, Eric Laux
USFWS – Bob Clevenstine, Gary Wege
NGO – Catherine McCalvin (The Nature Conservancy)

Appendix B.

Prioritization of WLM Actions in the St. Paul District

PILOT POOL DRAWDOWN
SCREENING OF NAVIGATION POOLS

BACKGROUND

Management of water levels on the Upper Mississippi River is drawing increasing interest as a tool for restoration and enhancement of fish and wildlife habitat. A problem appraisal study completed in 1996 under the auspices of the Water Level Management Task Force (WLMTF) of the River Resources Forum (RRF) indicates that partial drawdown of navigation pools during the growing season holds great promise for benefiting large areas of habitat, while at the same time minimizing adverse effects on other river uses.

The WLMTF recommended that the Corps of Engineers pursue efforts to implement a pilot partial pool drawdown to further evaluate the benefits of this management measure and the potential adverse effects on other river uses.

PURPOSE

The purpose of the screening process was to identify those navigation pools that would be the best candidates for a pilot partial pool drawdown. **This screening process does not exclude/prejudice any pool from possible future consideration after the pilot drawdown is completed.**

SCREENING

Initial pool screening was accomplished by the Technical Subgroup of the WLMTF. Participation on the WLMTF is open to representatives of Federal and State agencies, river user groups, interest groups and private citizens. Participation on the Technical Subgroup is open to any WLMTF participant. Participation in the Technical Subgroup during the pool screening process included representatives from the Wisconsin, Minnesota, and Iowa Departments of Natural Resources, the Corps of Engineers, the U.S. Fish and Wildlife Service, the Environmental Management Technical Center, and the Upper Mississippi Science Center.

First Level Screening

First level screening was designed to identify and eliminate from further consideration those navigation pools that obviously would be poor choices for a pilot drawdown. Based on previous study efforts, it was assumed for the screening process that a pilot drawdown would fall within the range of 1 to 3 feet at the dam. The following criteria were used in the first level screening:

- Area of backwaters: since the primary objective of a growing season drawdown would be to promote the growth of aquatic vegetation, the pool should have large areas of backwater or non-channel aquatic habitat.

- Dredging requirements: since a potential negative effect of a drawdown would be to increase dredging requirements, a pool with a history of frequent and/or high volume dredging requirements would be a poor candidate.

- Unusual hydrology: this normally should not effect the success of a drawdown effort. However, a pool with unusual hydrology would be a poor candidate for a pilot drawdown because of the potential complicating factors associated with the unusual hydrology.

- Unique socio-economic or other factors: there may be other factors that may mitigate against the selection of a pool for the pilot drawdown.

Using the above criteria, first level screening resulted in the following pools being eliminated from further consideration.

Upper St. Anthony Falls

The Upper St. Anthony Falls pool is located in Minneapolis, Minnesota, above the confluence of the Mississippi and Minnesota Rivers. This pool has little or no backwater habitat. The pool is essentially all main channel and main channel border. The dredge cuts in this pool have a relatively high average dredging frequency (48 percent), second highest of the 13 pools in the St. Paul District. It is likely that even limited drawdown in this pool would quickly increase dredging requirements.

Lower St. Anthony Falls

The Lower St. Anthony Falls is a very small pool, less than a mile in length, with no backwater habitat. There would be no reason to draw this pool down for habitat purposes.

Pool 1

Like the Upper St. Anthony Falls pool, pool 1 is primarily main channel/main channel border with very limited backwater habitat present. While average dredging frequencies in pool 1 are about average (29 percent), most of the pool requires dredging at one time or another. Again, it is likely that even limited drawdown in this pool would quickly increase dredging requirements.

Pool 2

The Minnesota River enters the Mississippi River in pool 2. At times, the Minnesota River can discharge more water into pool 2 than the main stem of the Mississippi River. This unusual hydrologic situation would make pool 2 a less than desirable candidate for a pilot drawdown effort.

Much of the monitoring effort for the pilot pool drawdown will likely originate from the La Crosse, Wisconsin, area, location of the Environmental Management Technical Center and the Mississippi River Science Center. Logistically, monitoring a pilot drawdown in pool 2 would be much more costly and difficult in pool 2 than the pools below Lake Pepin. In addition, pool 2 is located entirely within Minnesota, which could place much of the monitoring burden on one State. Selection of a pool bordered by two or three states would distribute the burden.

Pool 3

Three factors mitigate against the selection of pool 3 as a pilot drawdown pool. First, the Prairie Island Indian Reservation is located in pool 3. Obtaining concurrence from the Native American tribe would be necessary to implement a drawdown.

Secondly, the St. Croix River enters pool 3. While the St. Croix River contributes less flow than the Minnesota River does to pool 2, it still is a large enough tributary that unusually high flows on the St. Croix River could disrupt the drawdown effort.

Finally, much of the monitoring effort for the pilot pool drawdown will likely originate from the La Crosse, Wisconsin, area, location of the Environmental Management Technical Center and the Mississippi River Science Center. Logistically, monitoring a pilot drawdown in pool 3 would likely be more costly and difficult in pool 3 than the pools below Lake Pepin.

None of these three factors by themselves would be reason to exclude pool 3 from further consideration for a pilot drawdown. However, when considered collectively, they are.

Pool 4

Pool 4 is an unusual pool because of the presence of Lake Pepin and the Chippewa River. The Chippewa River provides a large amount of flow to pool 4 that also is pulsating in nature because of hydropower dams on the Chippewa River. This alone would make pool 4 a poor candidate for a pilot drawdown. In addition, pool 4 between Lock and Dam 4 and Lake Pepin is the largest channel maintenance problem area in the St. Paul District, both in terms of dredging frequency and volumes. It is likely that even a minor drawdown in lower pool 4 would substantially aggravate this problem.

Summary

In summary, the first level screening resulted in the elimination of 6 of the 13 pools from further consideration. The pools remaining at this point in the screening process were 5, 5A, 6, 7, 8, 9, and 10.

Second Level Screening

The purpose of second level screening was to evaluate the remaining 7 pools to further narrow the number of candidate pools for final selection. The first step in this process was to identify second level screening criteria. These criteria were limited to those factors considered critical to the selection of the pilot pool. The addition of minor or superfluous criteria would have only served to complicate the process while adding no value.

The following were the criteria used for second level screening.

Dredging Requirements/Commercial Navigation - The 9-foot navigation channel will need to be maintained during the drawdown. It is expected that regardless of the pool selected, the drawdown will likely require some additional maintenance dredging. The objective will be to minimize additional dredging requirements while maximizing the drawdown. While this criteria was used in the first level screening, its significance warranted its retention as criteria for the second level screening.

Habitat Benefits - Potential habitat benefits was a part of the first level screening. However, like dredging requirements noted above, the significance of this criteria warranted continued consideration as part of the second level screening. The objective of the partial pool drawdown is to improve conditions for the growth of aquatic vegetation, especially emergents. Maximization of habitat benefits is an important consideration in pool selection.

Recreation Effects - Recreational boating is likely to be negatively affected by a drawdown. Important considerations in pool selection will be potential adverse effects on recreational boating, the number of boat ramps affected, number of marina slips affected, and the presence of traditionally high recreation use areas.

Monitoring Requirements - An important part of a pilot pool drawdown will be associated ecological monitoring. The monitoring results from a pilot drawdown will play a significant role in the consideration of this management measure in the future. The ability to undertake a comprehensive and quality monitoring program in any particular pool needed to be considered.

Hydrology/Engineering - The operating conditions associated with each navigation pool will affect the potential for achieving a successful drawdown. The percent of time a pool is unregulated (gates out of the water) was used as the indicator of the potential for achieving a successful drawdown.

The procedure used was to rank the 7 pools against the criteria from 1 (best suited) to 7 (least suited). Thus, the lowest scoring pool would be considered the best suited. In instances where the pools were considered equally suited, the point values were split. The rankings for dredging requirements were based on historic dredging records and Corps of Engineers experiences concerning problem locations.

The rankings for potential habitat benefits were based on the collective judgement of river biologists and scientists, taking into account the amount of aquatic habitat in each pool and the locations of this habitat in the pools. The rankings for potential recreation effects were based on existing recreational facilities and their locations in the pools, and knowledge of recreational use patterns in the pools.

The rankings for monitoring were based on available data for the pools and the distance of the pools from existing centers of data collecting resources such as the LTRM field stations in pools 4 and 8. The rankings for hydrology/engineering criteria were based on the percent of time a pool is in an unregulated condition (gates out of the water).

Table 1 shows the raw scores and rankings. Based on the raw scores and rankings, pool 8 would be best suited pool for a pilot drawdown, followed closely by pool 9. Pools 5A and 6 would be those least suited for a pilot pool drawdown.

Table 1
Raw Scores/Ranking

	P5	P5A	P6	P7	P8	P9	P10
Dredging	7	4	2	6	5	3	1
Habitat	5.5	5.5	7	3	2	1	4
Recreation	2	6	7	4	4	1	4
Monitoring	2.5	5.5	5.5	2.5	1	4	7
Hyd./Eng.	1	5	4	2.5	2.5	6.5	6.5
Total	18.0	26.0	25.5	18.0	14.5	15.5	22.5
Pool Rank	3-4	7	6	3-4	1	2	5

It was recognized that some of these criteria may be more significant than others in the selection process. Monitoring, for instance, would be the least important of the criteria, while potential habitat benefits may be the most important. Table 2 shows the weighted scores if monitoring is given a weight of 1 and the other criteria were given a weight of 2. Table 3 shows weighted scores if potential habitat benefits are given a weight of 3.

Table 2
Weighted Scores/Ranking

	P5	P5A	P6	P7	P8	P9	P10
Dredging (2)	14	8	4	12	10	6	2
Habitat (2)	11	11	14	6	4	2	8
Recreation (2)	4	12	14	8	8	2	8
Monitoring (1)	2.5	5.5	5.5	2.5	1	4	7
Hyd./Eng. (2)	2	10	8	5	5	13	13
Total	33.5	46.5	45.5	33.5	28.0	27.0	38.0
Pool Rank	3-4	7	6	3-4	2	1	5

Table 3
Weighted Scores/Ranking

	P5	P5A	P6	P7	P8	P9	P10
Dredging (2)	14	8	4	12	10	6	2
Habitat (2)	16.5	16.5	21	9	6	3	12
Recreation (2)	4	12	14	8	8	2	8
Monitoring (1)	2.5	5.5	5.5	2.5	1	4	7
Hyd./Eng. (2)	2	10	8	5	5	13	13
Total	39.0	52.0	52.5	36.5	30.0	28.0	42.0
Pool Rank	4	6	7	3	2	1	5

Using weighted scores still results in pool 8 and 9 being the two pools that appear best suited for a pilot drawdown, while pools 5A and 6 remain the least suited. Weighting for habitat benefits does result in some separation of pools 5 and 7.

As a result of the secondary screen process it was decided to eliminate pools 5A, 6, and 10 from further consideration. The pools that will be evaluated for final selection are pools 5, 7, 8, and 9. Final selection will occur following public coordination.

Appendix C.

Prioritization of WLM Actions in the Rock Island District

CEMVR-ED-HH 16 April 2003
CEMVR-PM-A

Prioritization of Water Level Management Actions in the Rock Island District

At the March 4-5, 2003, Water Level Management (WLM) workgroup meeting, important criteria were identified for each of the WLM actions being considered with which to prioritize the pools for potential implementation of the WLM actions. This document summarizes this prioritization/screening process for the Rock Island District portion of the Upper Mississippi River (Pools 11 through 22) and the Illinois Waterway (LaGrange Pool to Dresden Pool).

In the prioritization/screening process, described below, a color scheme was utilized to help visualize the differences between pools with regard to the suitability for implementation ("Suitability Rating") of the WLM actions based on each criterion. Five ratings were used:

= Very High Suitability for Implementation

= High Suitability for Implementation

= Moderate Suitability for Implementation

= Low Suitability for Implementation

= Very Low Suitability for Implementation

It should be noted that the color refers to the suitability for implementation of the WLM action, not the criteria being considered itself. For example, if considering dredging requirements to maintain the navigation channel during a drawdown, a pool with relatively low dredging requirements would rate as "High Suitability for Implementation" (green), whereas a pool with much higher dredging requirements would rate as "Low Suitability for Implementation" (orange).

1. Lower the Pool Level Below the Existing Operating Band (i.e., drawdowns):

The following prioritization criteria for pool drawdowns were identified at the workshop: identified ecological objective or need, hydrologic chance of success, acreage exposed, advanced dredging required to maintain navigation, impacts to water supply, impacts to hydropower facilities, benefit to cost efficiency, recreation conflicts, impacts to barge terminals and fleeting areas, competing environmental interests, and impacts to commercial fisheries. These criteria can be broken down into four main categories:

- <u>Need for Action</u>: Identified objectives.
- <u>Feasibility of Action</u>: Hydrologic chance of success.

- Efficiency of Action: Acreage exposed, advanced dredging required to maintain navigation, impacts to water supply, impacts to hydropower facilities, and benefit to cost efficiency.
- Acceptability of Action: Recreation conflicts, impacts to barge terminals and fleeting areas, competing environmental interests, and impacts to commercial fisheries.

For each prioritization criteria, a rating was developed for each pool. A composite rating was then developed for each of the four main categories.

The following is a description of the source(s) of data used to rate the pools in each of the criteria.

A. Identified Ecological Objective – The UMR & IWW Environmental Objectives Database (developed as part of the Restructured Navigation Study) and the Fish & Wildlife Interagency Committee Pool Plans were reviewed for identified objectives directly related to pool-wide drawdowns.

B. Hydrologic Chance of Success – The probability of maintaining a 2-foot drawdown of 60 days between May and August was used to represent the hydrologic success rate for each pool. The table below shows the computed success rates (based on daily flow records 1980-2001) and selected Suitability Rating.

River	Pool	60-Day, 2-foot Success Rate	Suitability Rating
UMR	11	86%	High
	12	41%	Low
	13	86%	High
	14	95%	High
	15	95%	High
	16	55%	Moderate
	17	18%	Very Low
	18	50%	Moderate
	19	100%	Very High
	20	32%	Low
	21	27%	Low
	22	32%	Low
IWW	Dresden	100%	Very High
	Marseilles	100%	Very High
	Starved Rock	~ 100%	High
	Peoria	41%	Low
	LaGrange	32%	Low

C. Acreage Exposed – The total contiguous aquatic area (excluding main channel and side channel areas) identified in the Aquatic Areas Classification Database was used to represent the relative area potentially benefited by a drawdown. This database is incomplete for the Illinois Waterway. For those pools with no coverage, plan form maps were used to estimate the Suitability Rating. The table below shows the acreage, by pool, and the selected Suitability Rating.

River	Pool	AAC Contiguous Off-Channel Aquatic Area (acres)	Suitability Rating
UMR	11	15,738	High
	12	8,255	Moderate
	13	19,389	High
	14	6,955	Moderate
	15	2,525	Very Low
	16	5,602	Moderate
	17	2,568	Very Low
	18	5,496	Moderate
	19	21,051	High
	20	4,408	Low
	21	3,549	Low
	22	4,354	Low
IWW	Dresden	See Description Above	Very Low
	Marseilles	See Description Above	Very Low
	Starved Rock	See Description Above	Very Low
	Peoria	See Description Above	High
	LaGrange	14,029	High

D. Advanced Dredging Required to Maintain Navigation – Forecasted future annual dredging needs, defined in the recently published *Programmatic Environmental Assessment for Future Dredged Material Placement* for the Rock Island District, was used to estimate the relative dredging requirements that would be needed to maintain navigation during a drawdown. The table below shows the predicted future annual dredging needs, by pool, and the selected Suitability Rating.

River	Pool	Predicted future annual dredging needs	Suitability Rating
UMR	11	26,335	High
	12	14,750	High
	13	40,823	Moderate
	14	28,000	High
	15	1,800	Very High
	16	42,750	Moderate
	17	23,528	High

	18	50,290	Moderate
	19	27,257	High
	20	64,500	Low
	21	69,166	Low
	22	69,500	Low
IWW	Dresden	4,508	High
	Marseilles	19,057	High
	Starved Rock	9,762	High
	Peoria	46,940	Moderate
	LaGrange	204,140	Very Low

E. Impacts to Water Supply – Municipal and electrical powerplant water supply intake locations were compiled. Water intakes were identified in Pools 14, 15, 19, 20, and 21 on the UMR; and in Dresden and Peoria Pools on the IWW.

F. Impacts to Hydropower Facilities – Hydropower facilities are located at Dam 15, Dam 19, and Starved Rock Dam. Of these locations, the facility at Dam 19 has, by far, the greatest generating capacity.

G. Benefit to Cost Efficiency – The "Benefits" and "Composite Cost" columns below were used to derive the overall Efficiency Suitability Rating. The "Composite Cost" column reflects the 3 previous columns, weighted most heavily toward the "Dredging" Suitability Rating. For example, in Pool 11, there are high expected benefits (and therefore a "High" Suitability Rating) and relatively low dredging requirements (again leading to a "High" Suitability Rating), which leads to a "Very High" Efficiency Suitability Rating.

	Benefits	Costs				Efficiency
Pool	Acres Exposed	Dredging	Water Supply	Hydropower	Composite Cost	B/C Efficiency
11	High	High	High	High	High	Very High
12	Moderate	High	High	High	High	High
13	High	Moderate	High	High	Moderate	High
14	Moderate	High	Low	High	Moderate	Moderate
15	Very Low	Very High	Low	Low	Moderate	Low
16	Moderate	Moderate	High	High	Moderate	Moderate
17	Very Low	High	High	High	High	Low
18	Moderate	Moderate	High	High	Moderate	Moderate
19	High	High	Low	Very Low	Moderate	High
20	Low	Low	Low	High	Low	Very Low
21	Low	Low	Low	High	Low	Very Low
22	Low	Low	High	High	Moderate	Low
Dresden	Very Low	High	Low	High	High	Low

Marseilles	Very Low	High	High	High	High	Low
Starved Rock	Very Low	High	High	Low	High	Low
Peoria	High	Moderate	Low	High	Moderate	High
LaGrange	High	Very Low	High	High	Low	Moderate

H. Recreation Conflicts – Three measures of recreational usage were used to rate the pools based on potential for recreational conflicts. The number of boat trips per year was taken from Environmental Report 18 (*Effects of Recreational Boating: Recreational Traffic Forecasting and Allocation Models*, by Carlson et. al., July 2000). The number of marinas and boat ramps in each pool were taken from the Upper Mississippi River Navigation Charts (2001 edition).

River	Pool	Boat Trips per Year (2000)	No. of Marinas	No. of Boat Ramps	Suitability Rating
UMR	11	54,307	6	8	Moderate
	12	70,853	9	6	Moderate
	13	70,922	5	18	Moderate
	14	75,041	7	15	Moderate
	15	60,555	4	7	Moderate
	16	68,519	4	12	Moderate
	17	34,671	1	7	High
	18	52,728	1	16	Moderate
	19	85,614	4	16	Moderate
	20	11,878	0	6	Very High
	21	67,214	4	7	Moderate
	22	34,259	1	5	High
IWW	Dresden	16,920	5	0	High
	Marseilles	20,825	9	2	High
	Starved Rock	35,142	4	4	High
	Peoria	178,314	20	14	Low
	LaGrange	28,309	1	15	High

I. Impacts to Barge Terminals and Fleeting Areas – The number of barge terminal facilities and the number of identified fleeting areas were used to represent the potential for drawdown impacts on commercial navigation infrastructure. Values were extracted from GIS databases maintained by the Rock Island District, Corps of Engineers.

River	Pool	No. Barge Terminals	No. Fleeting Areas	Suitability Rating
UMR	11	3	2	High
	12	19	7	Moderate
	13	1	1	High
	14	18	5	Moderate
	15	15	0	Moderate

	16	14	1	Moderate
	17	11	1	Moderate
	18	4	2	High
	19	22	7	Moderate
	20	9	3	Moderate
	21	13	1	Moderate
	22	10	1	Moderate
IWW	Dresden	21	3	Moderate
	Marseilles	24	3	Moderate
	Starved Rock	11	3	Moderate
	Peoria	58	14	Very Low
	LaGrange	38	6	Low

J. Competing Environmental Interests – Pool drawdowns have the potential to produce negative impacts to fish (interruption of spawning activities), backwaters (potential isolation, reduced dissolved oxygen levels, increased water temperatures), and mussels (potential stranding). To date, no unique competing environmental interests have been identified that would eliminate a pool for consideration of this action.

K. Impacts to Commercial Fisheries – The average commercial harvest (1985-1996), in terms of individual fish, is shown below for a variety of UMR species.

River	Pool	Catfish	Buffalo	Carp	Sturgeon	Bowfin	Paddlefish	Drum	Suitability Rating
UMR	11	41,433	33,855	30,189	580	200	0	42,823	Low
	12	27,016	20,972	21,304	407	7	11	29,158	Moderate
	13	84,624	53,156	77,293	1,438	148	131	94,816	Very Low
	14	38,478	14,347	19,741	599	45	62	46,005	Moderate
	15	13,586	9,490	7,584	358	4	64	32,940	High
	16	20,257	14,716	10,408	928	3	88	20,567	High
	17	31,843	19,017	15,640	704	48	274	38,291	Moderate
	18	66,862	29,142	48,523	1,044	113	522	60,643	Low
	19	118,960	48,282	64,665	681	101	1,320	110,801	Very Low
	20	26,090	14,137	26,384	1,545	35	985	26,443	Moderate
	21	8,612	7,392	8,391	330	5	347	3,235	Very High
	22	9,403	5,951	7,729	899	13	253	5,041	Very High
IWW	Dresden								Very High
	Marseilles								Very High
	Starved Rock		17,654						Very High
	Peoria	14,863	47,722	10,754	1	1	38	5,909	Moderate
	LaGrange	41,098	14,004	18,485	55	222	320	12,452	Moderate

L. Acceptability – An overall Suitability Rating for the Acceptability Category was developed as a composite of the Suitability Ratings for potential impacts on other users of the river as well as other miscellaneous concerns listed in the table below.

River	Pool	Recreation Conflict	Barge Fleeting and Terminal Impacts	Competing Environmental Interests	Commercial Fisheries Impacts	Other Concerns	Suitability Rating
UMR	11	Moderate	High	None Identified	Low		Moderate
	12	Moderate	Moderate	None Identified	Moderate		Moderate
	13	Moderate	High	None Identified	Very Low		Moderate
	14	Moderate	Moderate	None Identified	Moderate	Rock Cut, LeClaire Canal	Low
	15	Moderate	Moderate	None Identified	High	Major Rock Cut	Low
	16	Moderate	Moderate	None Identified	High	Rock Cut; lock approach currents	Moderate
	17	High	Moderate	None Identified	Moderate		High
	18	Moderate	High	None Identified	Low	Rock Cut	Moderate
	19	Moderate	Moderate	None Identified	Very Low	Dam 19 Owned by Ameren UE	Low
	20	Very High	Moderate	None Identified	Moderate	Effects of operations on 19; Rock Cut	High
	21	Moderate	Moderate	None Identified	Very High		Moderate
	22	High	Moderate	None Identified	Very High		High
IWW	Dresden	High	Moderate	None Identified	Very High	Rock Cut	High
	Marseilles	High	Moderate	None Identified	Very High	Major Rock Cut	Moderate
	Starved Rock	High	Moderate	None Identified	Very High	Rock Cut	High
	Peoria	Low	Very Low	None Identified	Moderate	Minor Rock Cut	Low
	LaGrange	High	Low	None Identified	Moderate	Major Rock Cut	Moderate

CONCLUSIONS

Selection of the pools to be carried forward for more detailed analysis is based on those pools that have an identified ecosystem objective and rate well across the various criteria considered. Based on this analysis, Pools 11 and 13 appear to be the most suitable for pool-wide drawdowns, followed by Pools 16 and 18. Pool 19 has the potential to provide large benefits but faces several major obstacles; most notably, the private ownership of this facility.

	Criteria:	Need		Feasibility	Efficiency	Acceptability
River	Pool	Defined Nav Study WLM Objective?	Pool Plan Objective	Hydrology	B/C Efficiency	Impacts to Other Users & Other Concerns
UMR	11	Yes	Yes	High	Very High	Moderate
	12	Yes	Yes	Low	High	Moderate
	13	Yes	Yes	High	High	Moderate
	14	Yes	Yes	High	Moderate	Low
	15	Yes	Yes	High	Low	Low
	16	Yes	Yes	Moderate	Moderate	Moderate
	17	Yes	Yes	Very Low	Low	High
	18	Yes	Yes	Moderate	Moderate	Moderate
	19	Yes	Yes	Very High	High	Low
	20	Yes	No	Low	Very Low	High
	21	Yes	No	Low	Very Low	Moderate
	22	Yes	No	Low	Low	High
IWW	Dresden	No	No	Very High	Low	High
	Marseilles	No	No	Very High	Low	Moderate
	Starved Rock	No	No	High	Low	High
	Peoria	No	No	Low	High	Low
	LaGrange	No	No	Low	Moderate	Moderate

2. Raise the Pool Level Above the Present Operating Band:

The following prioritization criteria for raising the pool level above the present operating band were identified at the workshop: identified ecological objective or need, hydrologic chance of success (this criteria was later dropped, see discussion below), limits of real estate interest acquired for construction of the 9-foot channel project, benefit to cost efficiency, structural limitations imposed by the dams, and competing environmental interests.

A. Identified Ecological Objective – The UMR & IWW Environmental Objectives Database (developed as part of the Restructured Navigation Study) and the Fish & Wildlife Interagency Committee Pool Plans were reviewed for identified objectives directly related to pool-wide raises. No objectives directly stating a need/desire for pool raises were identified. Objectives that would potentially be supported by this action include those related to providing additional habitat for overwintering fish.

B. Hydrologic Chance of Success – While a limiting factor for pool-wide drawdowns, periods of high flow would not erode the benefits (additional overwintering habitat for fish) of a pool raise. Therefore this criterion is not considered useful for prioritization of the pools.

C. Limits of Real Estate Interest Acquired for Construction of the 9-foot Channel Project – At the time of construction of the UMR 9-foot Channel Project, real estate interests (either fee title or flowage easements) were acquired for those lands permanently or periodically inundated by operation of the project. Raising the pool level above the authorized operating band has the potential (depending on flow conditions) to impact lands for which no real estate interest was acquired. This is true for all pools on the UMR, with the exception of Dam 19 (which was constructed, and operated, by Ameren UE and its predecessors) for which no real estate interests were acquired (with the minor exception of immediately around the lock structure).

D. Perceived Benefit to Cost Efficiency – The potential for significant costs, associated with this WLM action, is great. For most sites, modification to the dam structure, real estate acquisition, and compensation for seepage and blocked gravity drainage effects would be required to implement this action. For many pools, creation of deepened overwintering areas through dredging of off-channel areas would appear to be a better solution.

E. Structural Limitations – Pool raises may be prohibited by the existence of fixed spillway crests at the dams. These spillway crests are often at or near flat pool elevation; therefore any attempt to raise the pool would result in more water over the spillway. Increased passage of water over the spillway has the potential to produce downstream scour. Spillway modification to accommodate a pool raise is technically feasible, but would be expensive and would have the potential to affect flood heights if permanently raised.

Long uncontrolled gravity spillway sections exist at Dams 12, 13, 16, 17, 18, 21, and 22. On the Illinois Waterway, narrow uncontrolled spillways utilized as ice chutes are present at Starved Rock Dam, Marseilles Dam, and Dresden Island Dam.

F. Competing Environmental Interests – A pool raise has the potential to cause inundation, and subsequent mortality, of floodplain terrestrial vegetation and flooding of furbearer dens. In addition, a pool raise may temporarily increase the downriver Nitrogen export. To date, no unique competing environmental interests have been identified that would eliminate a pool for consideration of this action.

CONCLUSIONS

For the reasons stated above, this action will not be carried forward for further analysis.

3. Change Pool Control Point From Mid-Pool to Dam During Winter:

The following prioritization criteria for changing the pool control point from mid-pool to the dam (during winter) were identified at the workshop: identified ecological objective or need, limits of real estate interest acquired for construction of the 9-foot channel project, benefit to cost efficiency, and competing environmental interests.

Within the Rock Island District, only two dams operate under a hinged operation: Dam 16 and Dam 20.

- Dam 16 – Dam 16 operates using a hinge point at Fairport, IA, for flows greater than approximately 75,000 cfs. During December through February, Dam 16 is in hinged operation approximately 13% of the time. The maximum drawdown at the dam is 1.4 feet.
- Dam 20 – Dam 20 operates using multiple control points at Keokuk, IA, Gregory Landing, MO, and at Dam 20. The operation of Dam 20 is designed to minimize impacts on the tailwater at Dam 19, and therefore impacts to the operating head for the hydropower facility. Dam 19 was built prior to construction of the 9-foot channel project, and is owned and operated by Ameren UE.

A. Identified Ecological Objective – The UMR & IWW Environmental Objectives Database (developed as part of the Restructured Navigation Study) and the Fish & Wildlife Interagency Committee Pool Plans were reviewed for identified objectives directly related to changing the Pool Control Point from Mid-Pool to the Dam. No objectives directly stating a need/desire for changing the control point location were identified. Objectives that would potentially be supported by this action include those for increased backwater depths in Pool 16, related to providing additional habitat for overwintering fish.

B. Limits of Real Estate Interest Acquired for Construction of the 9-foot Channel Project – At the time of construction of the UMR 9-foot Channel Project, real estate interests (either fee title or flowage easements) were acquired for those lands permanently or periodically inundated by operation of the project. Changing the control point location has the potential (depending on flow conditions) to impact lands for which no real estate interest was acquired.

C. Perceived Benefit to Cost Efficiency – The potential for significant costs, associated with this WLM action, is great. At both of the sites, real estate acquisition and compensation for any property impacts would be required to implement this action.

D. Competing Environmental Interests – A change in the control point location has the potential to cause inundation, and subsequent mortality, of floodplain terrestrial vegetation and flooding of furbearer dens in the lower portion of the navigation pool. To date, no unique competing environmental interests have been identified that would eliminate either pool for consideration of this action.

CONCLUSIONS

Due to the lack of supported objectives, this action will not be further investigated for Pool 20. Pool 16 will be carried forward for further analysis.

4. Modify Distribution of Flow Through Dam Gates:

Review of the UMR & IWW Environmental Objectives Database (developed as part of the Restructured Navigation Study) and the Fish & Wildlife Interagency Committee Pool Plans identified no objectives related to tailwater habitat conditions, which could benefit from this action. However, modifying the distribution of flow also has the potential to provide attracting flows for a new fishway.

The potential for fishways at the UMR and IWW dams is being investigated by the Fish Passage Workgroup of the Restructured Navigation Study. As part of future, follow-up studies, conducted subsequent to completion of the Restructured Navigation Study, this WLM action should be considering for providing attracting flows at those sites where fishways are recommended.

5. Moderate Short-Term Water Level Fluctuations:

While this WLM action would generally be beneficial at all dam sites on the UMR and IWW, there are a number of sites where short-term fluctuations are more common and/or severe in magnitude.

Peoria and LaGrange Dams (IWW) – Operation of the wicket dams at these sites produces rapid changes in the tailwater elevation when the wickets are placed into operation during falling river conditions. Changes of 2 feet in a six-hour period are not uncommon.

Upper IWW – Short-term water level fluctuations on the upper IWW are the result of tributary inflows, dam operations, and stormwater discharges from the City of Chicago.

Dams 19 and 20 – During low flow periods (flows less than 55,000 cfs), the Ameren UE hydropower plant at Dam 19 uses a "cycling" mode of operations during which water is alternately stored and released to maximize power generation. This operation produces daily tailwater fluctuations of approximately 2 feet and 20,000 cfs. These fluctuations propogate downstream, through Dam 20. The short-term fluctuations are largely attenuated by the time the water reaches Dam 21.

Alternatives for moderating the magnitude and/or frequency of short-term water level fluctuations at these sites will be identified. In addition, it may be desirable to provide for greater control of water levels at those sites for which pool drawdowns are recommended.

6. Intentional Winter Water Level Fluctuations (limited range):

Review of the UMR & IWW Environmental Objectives Database (developed as part of the Restructured Navigation Study) and the Fish & Wildlife Interagency Committee Pool Plans identified no objectives related to this WLM action.

Appendix D.

Prioritization of WLM Actions in the St. Louis District

Prioritization of Water Level Management Actions in the St. Louis District

At the March 4-5, 2003, Water Level Management (WLM) workgroup meeting, important criteria were identified for each of the WLM actions being considered with which to prioritize the pools for potential implementation of the WLM actions. This document summarizes this prioritization/screening process for the St. Louis District's portion of the Upper Mississippi River (Pools 24 through 26).

In the prioritization/screening process, described below, a scheme was utilized to help visualize the differences between pools with regard to the suitability for implementation ("Suitability Rating") of the WLM actions based on each criterion. Three ratings were used:

HIGH = High Suitability for Implementation

MODERATE = Moderate Suitability for Implementation

LOW = Low Suitability for Implementation

It should be noted that the rating refers to the suitability for implementation of the WLM action, not the criteria being considered itself. For example, if considering dredging requirements to maintain the navigation channel during a drawdown, a pool with relatively low dredging requirements would rate as "High Suitability for Implementation", whereas a pool with much higher dredging requirements would rate as "Low Suitability for Implementation".

1. Drawdown Below Maximum Regulated Pool:

The following prioritization criteria for pool drawdowns were identified at the workshop: identified ecological objective or need, hydrologic chance of success, acreage exposed, advanced dredging required to maintain navigation, impacts to water supply, impacts to hydropower facilities, benefit to cost efficiency, recreation conflicts, impacts to barge terminals and fleeting areas, competing environmental interests, and impacts to commercial fisheries. These criteria can be broken down into four main categories:

- Need for Action: Identified objectives.
- Feasibility of Action: Hydrologic chance of success.
- Efficiency of Action: Acreage exposed
- Acceptability of Action: Recreation conflicts, impacts to barge terminals and fleeting areas, competing environmental interests, and impacts to commercial fisheries.

For each prioritization criteria, a rating was developed for each pool. A composite rating was then developed for each of the four main categories.

The following is a description of the source(s) of data used to rate the pools in each of the criteria.

A. Identified Ecological Objective - The UMR & IWW Environmental Objectives Database (developed as part of the Restructured Navigation Study).

B. Hydrologic Chance of Success - The probability of maintaining a 1-foot to 2-foot drawdown of 30 days between May and August was used to represent the hydrologic success rate for each pool. The table below Acceptability of Action Acceptability of Action shows the computed success rates (based on daily flow records 1940-2002) and selected Suitability Rating. This represents the probability without additional dredging.

River	Pool	30-Day, 1-Foot Success Rate	Suitability Rating	30-Day, 2-Foot Success Rate	Suitability Rating
UMR	24	75	High	22	Low
UMR	25	86	High	75	High
UMR	26	86	High	42	Moderate

C. Acreage Exposed - The total acreage exposed that is likely to be vegetated is based on a previous USGS Report and conversation with Joe Wlosinski and David Busse. Based on this and the hydrologic chance of success an average annual acres exposed was developed.

Pool	***Average annual acres of vegetation***	***Suitability Rating***
L&D#24	1,368	HIGH
L&D#25	1,542	HIGH
L&D#26	1,634	HIGH

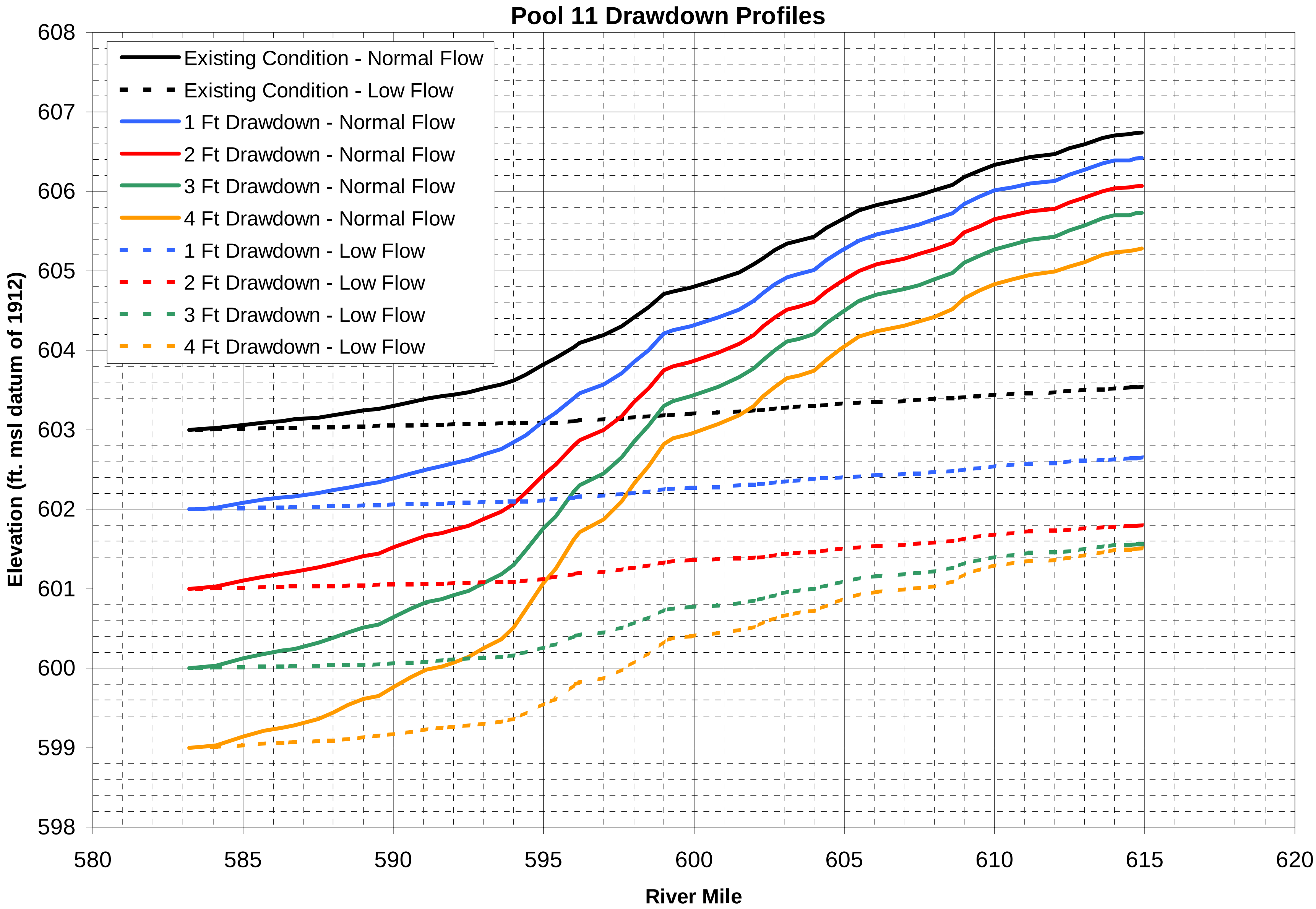
D. Acceptability of Action: At all three Mississippi Lock and Dams in MVS operate with hinge-points that require drawdowns in excess of those anticipated with Environmental Pool Management. Therefore, impacts to recreation, navigation and other competing interests are minimal. The suitability index for all three pools is HIGH.

2. Year Round EPM: This option involves changing the Water Control plan and buying the necessary Real Estate interests to not drawdown, because of hinge-point operation during critical environmental period (winter, fish spawn, water fowl migrations). All three pools could provide significant benefits and therefore are rated HIGH on the suitability index.

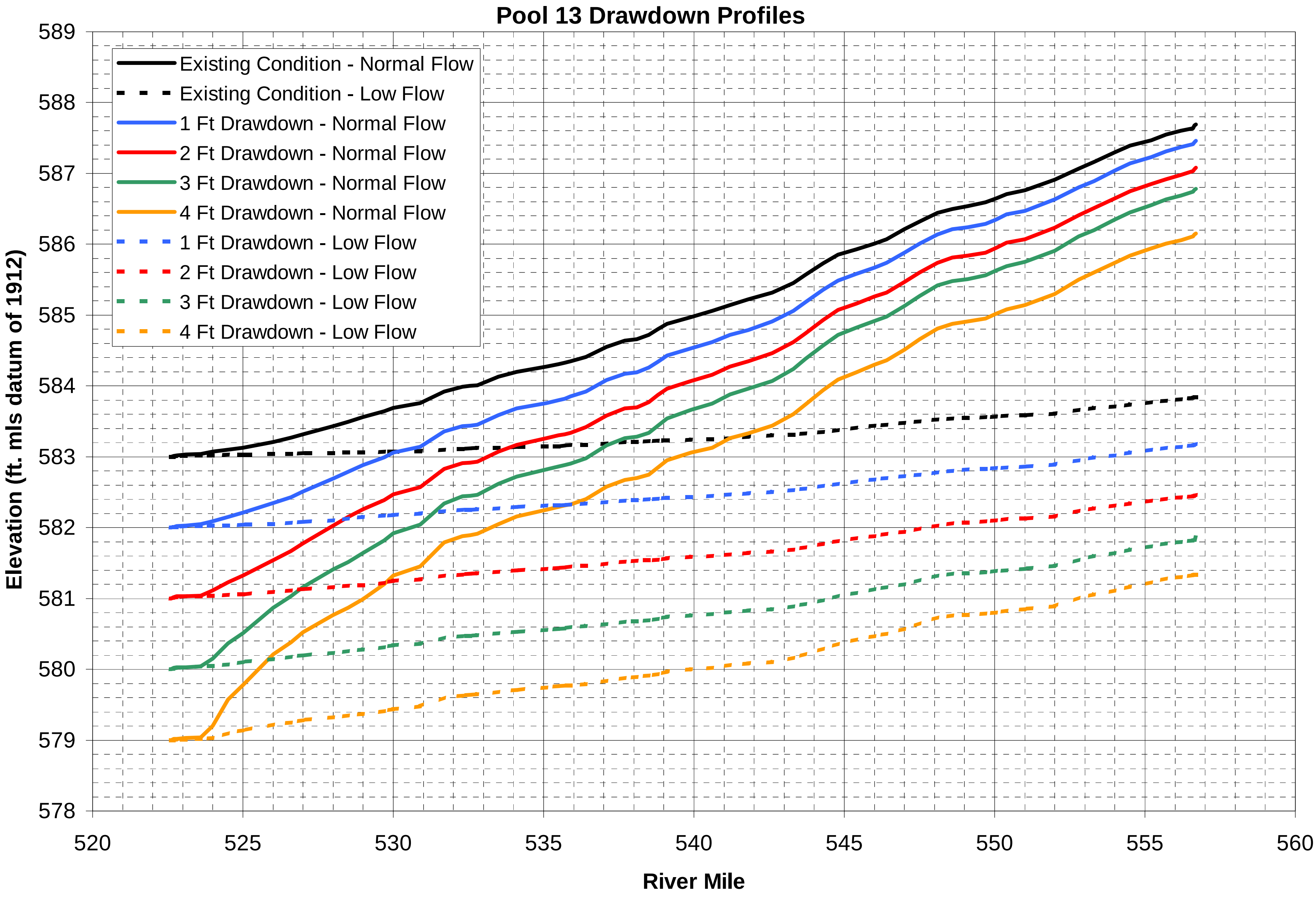
3. Preemptive Dredging: EPM in the three pools in MVS is sometimes limited due to less than project dimensions during the EPM period. Based on experience of the Water Control Staff in MVS the suitability index for the three pools should be rated as MODERATE. Further research should be undertaken to determine if increased dredging for EPM is desirable.
4. Raising Maximum Pool 1 foot: Dams 24 & 25 have relatively low overflow structures that would require an addition to the overflow section. This fact rates this option for Pool 24/25 as LOW. Dam #26 has an overflow section that would allow for an increase in maximum pool. Various other factors would also have to be studied including, but limited to, Real Estate considerations and structural integrity of the structure, but those not withstanding the suitability index for Mel Price L&D is HIGH.
5. All other Options described in the MVR report are rated Low for similar reasons as stated in the MVR report.

Appendix E.

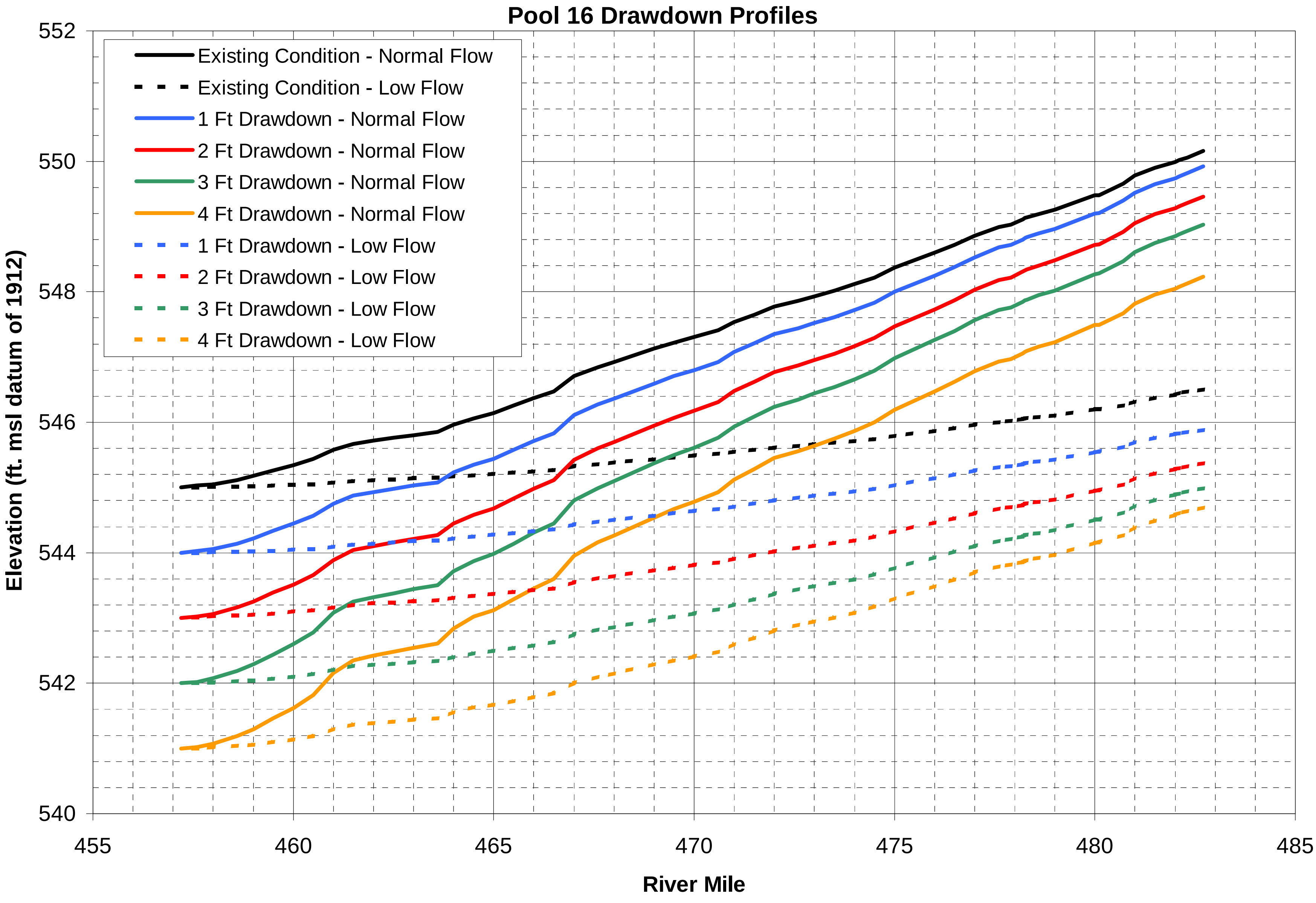
Computed Drawdown Water Surface Profiles
Rock Island District



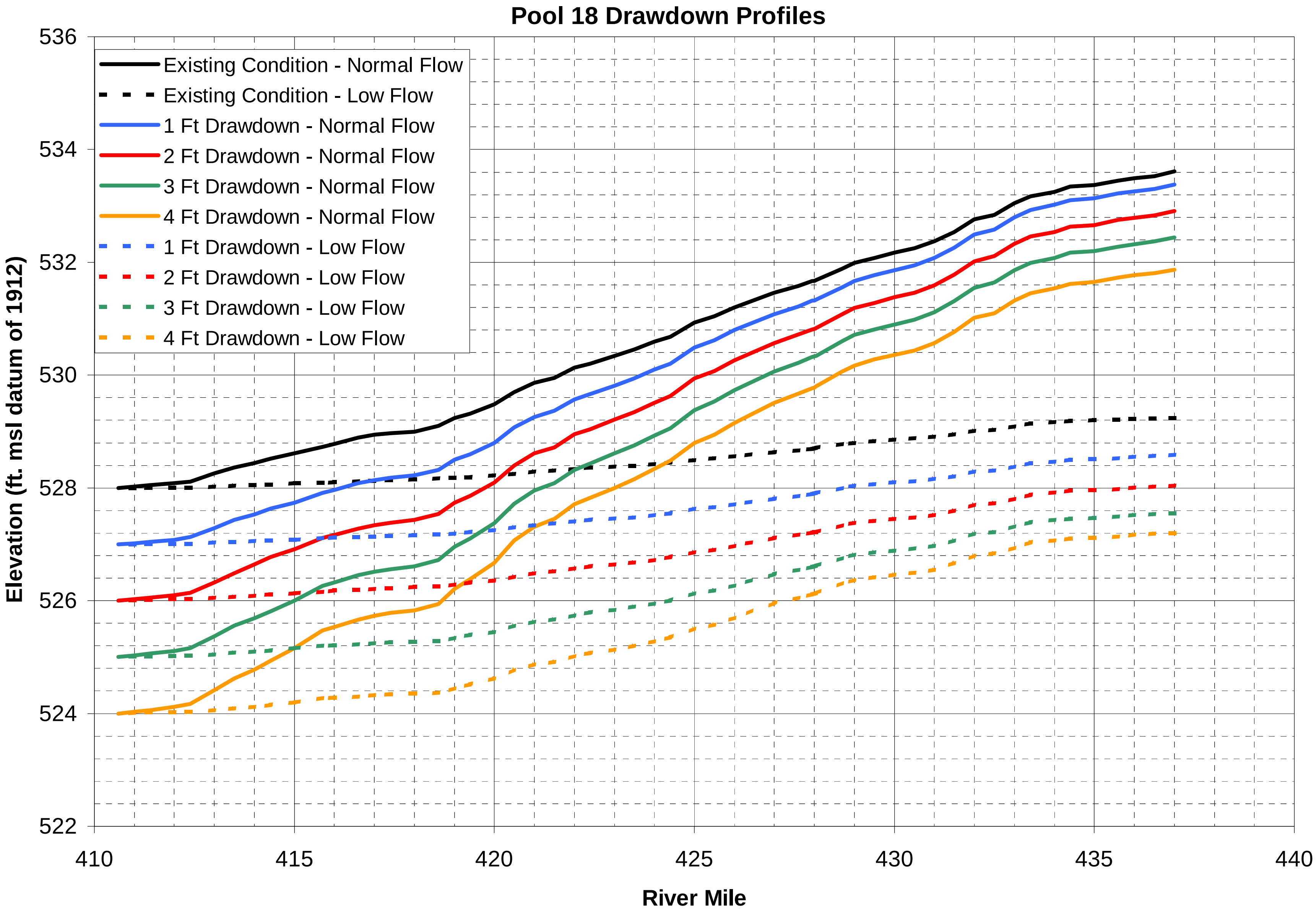
Pool 11 Drawdown Profiles
Existing Condition - Normal Flow
Existing Condition - Low Flow
1 Ft Drawdown - Normal Flow
2 Ft Drawdown - Normal Flow
3 Ft Drawdown - Normal Flow
4 Ft Drawdown - Normal Flow
1 Ft Drawdown - Low Flow
2 Ft Drawdown - Low Flow
3 Ft Drawdown - Low Flow
4 Ft Drawdown - Low Flow
Elevation (ft. msl datum of 1912)
608
607
606
605
604
603
602
601
600
599
598
580
585
590
595
600
605
610
615
620
River Mile

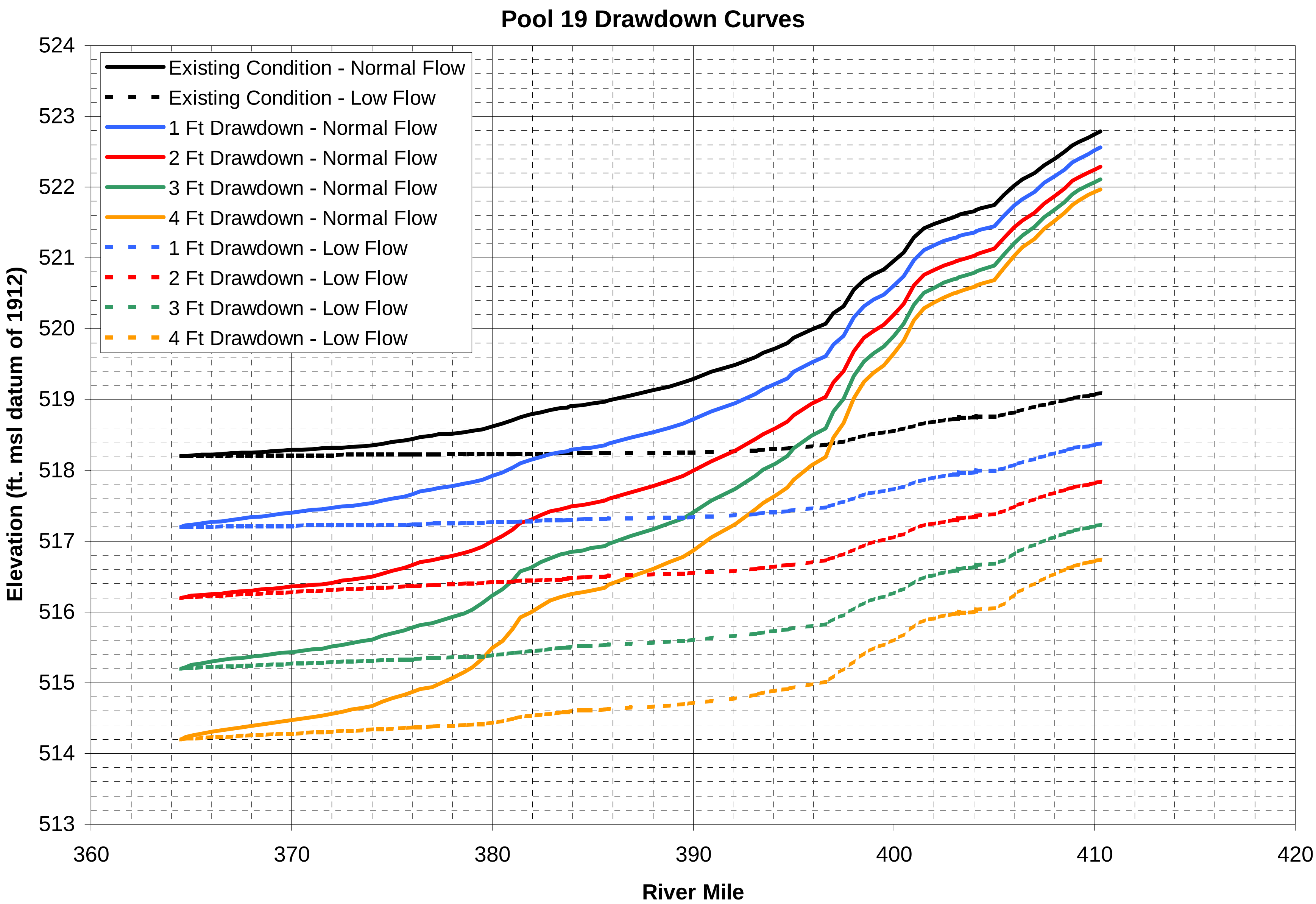


Pool 13 Drawdown Profiles
Existing Condition - Normal Flow
Existing Condition - Low Flow
1 Ft Drawdown - Normal Flow
2 Ft Drawdown - Normal Flow
3 Ft Drawdown - Normal Flow
4 Ft Drawdown - Normal Flow
1 Ft Drawdown - Low Flow
2 Ft Drawdown - Low Flow
3 Ft Drawdown - Low Flow
4 Ft Drawdown - Low Flow
Elevation (ft. mls datum of 1912)
589
588
587
586
585
584
583
582
581
580
579
578
520
525
530
535
540
545
550
555
560
River Mile



Pool 16 Drawdown Profiles
Existing Condition - Normal Flow
Existing Condition - Low Flow
1 Ft Drawdown - Normal Flow
2 Ft Drawdown - Normal Flow
3 Ft Drawdown - Normal Flow
4 Ft Drawdown - Normal Flow
1 Ft Drawdown - Low Flow
2 Ft Drawdown - Low Flow
3 Ft Drawdown - Low Flow
4 Ft Drawdown - Low Flow
Elevation (ft. msl datum of 1912)
552
550
548
546
544
542
540
455
460
465
470
475
480
485
River Mile


Pool 18 Drawdown Profiles
Existing Condition - Normal Flow
Existing Condition - Low Flow
1 Ft Drawdown - Normal Flow
2 Ft Drawdown - Normal Flow
3 Ft Drawdown - Normal Flow
4 Ft Drawdown - Normal Flow
1 Ft Drawdown - Low Flow
2 Ft Drawdown - Low Flow
3 Ft Drawdown - Low Flow
4 Ft Drawdown - Low Flow
Elevation (ft. msl datum of 1912)
536
534
532
530
528
526
524
522
410
415
420
425
430
435
440
River Mile



Pool 19 Drawdown Curves
Existing Condition - Normal Flow
Existing Condition - Low Flow
1 Ft Drawdown - Normal Flow
2 Ft Drawdown - Normal Flow
3 Ft Drawdown - Normal Flow
4 Ft Drawdown - Normal Flow
1 Ft Drawdown - Low Flow
2 Ft Drawdown - Low Flow
3 Ft Drawdown - Low Flow
4 Ft Drawdown - Low Flow
Elevation (ft. msl datum of 1912)
524
523
522
521
520
519
518
517
516
515
514
513
360
370
380
390
400
410
420
River Mile

Appendix F.

Drawdown Impacts of Commercial Navigation Infrastructure

TABLE F1. Potential Impacts to Barge Facilities

Pool	Operator	River Mile	Bank	Existing Depth (ft) at Flat Pool	Likely to Be Impacted by Drawdown?			
					1-Foot	2-Foot	3-Foot	4-Foot
5	Dairyland Power Cooperative.	751.4	L	12	No	No	No	Yes
8	Cargill Inc.	697.5	L	18	No	No	No	
	Dundee Cement Co.	697.4	L	12	No	No	No	
	Mississippi Docks Inc.	697.3	L	9	Yes	Yes	Yes	
	River Boats America Inc.	697.2	L	8	Yes	Yes	Yes	
	Brennan Marine Inc.	696.4	L	12	No	No	No	
9	Dairyland Power Cooperative	678.5	L	10	No	Yes	Yes	
	Interstate Power Co.	660.3	R	13	No	No	No	
	Weymiller Marine Inc.	659.4	R	13	No	No	No	
11	Wisconsin Power & Light Co.	608.0	L	16	No	No	No	No
	Dairyland Power Cooperative.	606.2	L	9	Yes	Yes	Yes	Yes
	Winterset Grain Co.	592.2	R	27	No	No	No	No
16	Rock Island River Terminal Corp.	480.8	L	12	No	No	No	No
	W. G. Block Co.	479.6	R	9	No	Yes	Yes	Yes
	Mississippi River Grain Corp.	475.9	R	10	No	No	Yes	Yes
	Blackhawk Fleet Inc.	475.8	R	10	No	No	Yes	Yes
	Peavey Co.	475.7	R	12	No	No	No	No
	Koch Materials Co.	475.4	R	15	No	No	No	No
	Linwood Mining and Mineral Corp.	475.2	R	9	No	Yes	Yes	Yes
	LaFarge Cement	474.5	R	9	Yes	Yes	Yes	Yes
	Cargill Inc.	469.8	R	10	No	Yes	Yes	Yes
	Cargill Inc.	469.7	R	9	Yes	Yes	Yes	Yes
	Rock Island River Terminal Corp.	469.6	R	9	Yes	Yes	Yes	Yes
	Central Iowa Power Cooperative.	468.0	R	9	Yes	Yes	Yes	Yes
18	Continental Grain Co.	433.0	L	12	No	No	No	No
	Garnac Grain Co. Inc.	427.6	L	15	No	No	No	No
	AGRI Industries.	418.2	R	12	No	No	No	Yes
	Altair Trading Corp.	415.5	L	9	Yes	Yes	Yes	Yes
19	Twomey Co.	409.5	L	15	No	No	No	No
	Burlington River Terminal Inc.	405.2	R	9	Yes	Yes	Yes	Yes
	Garnac Grain Co. Inc.	405.1	R	10	No	No	Yes	Yes
	Carpenter Stations Inc.	404.5	R	30	No	No	No	No
	Mississippi River Grain Elevator Inc.	404.2	L	9	Yes	Yes	Yes	Yes
	P-D Harbor Service Co.	404.0	R	12	No	No	No	No
	Burlington River Terminal Inc.	403.6	R	11	No	No	No	Yes
	The Cropmate Co.	399.5	R	14	No	No	No	No
	Iowa Southern Utilities Co.	399.4	R	14	No	No	No	No
	Continental Grain Co.	390.4	L	10	No	Yes	Yes	Yes
	Green Bay Elevator Co.	390.0	R	12	No	No	No	Yes
	Agrico Chemical Co.	389.0	R	14	No	No	No	No
	Hall Towing Co. Inc.	382.0	R	11	No	No	Yes	Yes
	Hall Towing Co. Inc.	382.0	R	11	No	No	Yes	Yes
	Hall Towing Co. Inc.	382.0	R	11	No	No	Yes	Yes
	Colusa Elevator Co.	376.4	L	12	No	No	No	Yes
	Hunold Storage Inc.	374.8	R	10	No	Yes	Yes	Yes

Appendix G.

Drawdown Impacts to Recreational Facilities

TABLE G1. Potential Impacts to Recreational Facilities (Marinas and Boat Ramps)

Pool	Name	River Mile	Marina Depth (ft)	Likely to Be Impacted by Drawdown?			
				1-Foot	2-Foot	3-Foot	4-Foot
5	Clear Lake	752.5		No	Yes	Yes	Yes
	Alma Municipal Courtesy Dock	751.7		No	Yes	Yes	Yes
	Great River Harbor	747.9	5	No	Yes	Yes	Yes
	West Newton Colony Ramp	747.7		No	Yes	Yes	Yes
	Halfmoon Landing	747.6		No	Yes	Yes	Yes
	Belvidere Slough Landing	746.9		No	Yes	Yes	Yes
	Weaver Landing	744.8		Yes	Yes	Yes	Yes
	Buffalo City Landing	744.1		Yes	Yes	Yes	Yes
	Upper Spring Lake Landing	742.5		Yes	Yes	Yes	Yes
	Minnieska Landing	741.9		Yes	Yes	Yes	Yes
	Lower Spring Lake Landing	741.1		Yes	Yes	Yes	Yes
7	Trempealeau Landing	714.0		No	No	Yes	
	Larry's Landing	713.8	5-6	No	No	Yes	
	Long Lake Access	712.9		No	No	Yes	
	Round Lake Landing	712.9		No	No	Yes	
	Dakota Ramp	707.1		No	Yes	Yes	
	Brice Prairie Landing	706.4		Yes	Yes	Yes	
	Desbach Park	705.0		Yes	Yes	Yes	
	Mosey's Landing	703.5		Yes	Yes	Yes	
	La Crosse Sailing Club	703.0		Yes	Yes	Yes	
	Nelson Park Landing	702.9		Yes	Yes	Yes	
	Fisherman's Road Landing	702.7		Yes	Yes	Yes	
	Upper Dike Landing	702.6		Yes	Yes	Yes	
8	Sias Isles Boat Livery	702.4		Yes	Yes	Yes	
	Upper I-90 Ramp	702.1		Yes	Yes	Yes	
	Lower I-90 Ramp	701.8		Yes	Yes	Yes	
	Lower Spillway Landing	701.7		Yes	Yes	Yes	
	B. River French Is. Landing	701.5		Yes	Yes	Yes	
	Black's Cove Marina	700.2		Yes	Yes	Yes	
	R & R Marine	700.1		Yes	Yes	Yes	
	Richmond Bay Landing	700.1		Yes	Yes	Yes	
	Al's Marina	699.8		Yes	Yes	Yes	
	Logan St. Landing	699.5		Yes	Yes	Yes	
	Clinton St. Landing	699.4		Yes	Yes	Yes	
	Clinton St. Landing West	699.4		Yes	Yes	Yes	
	Bob's Bait Shop Marina	699.4		Yes	Yes	Yes	
	French Is. Yacht Club	699.4		Yes	Yes	Yes	
	Beacon Bay Marina	699.4		Yes	Yes	Yes	
	Panke's Boat Livery	699.3		Yes	Yes	Yes	
	Hill's Boat Livery	699.2		Yes	Yes	Yes	
	Sportsman's Landing	698.5		Yes	Yes	Yes	
	Bikini Yacht Club	698.1	12	Yes	Yes	Yes	
	Pettibone Yacht Club	697.3	8	Yes	Yes	Yes	
	La Crosse Municipal Harbor	696.7	18	Yes	Yes	Yes	
	Green Island Ramp	695.8		Yes	Yes	Yes	
	Chut's Landing	695.3		No	Yes	Yes	
	Upper Goose Is.	692.8		No	Yes	Yes	
	Upper Goose Is. East	692.8		No	Yes	Yes	
	Goose Island Landing	692.0		No	Yes	Yes	
	Hunter's Point Landing	690.6		No	Yes	Yes	
	Lawrence Lake Marina	690.5		No	Yes	Yes	
	Shady Maple Walkdown	690.2		No	Yes	Yes	
	Wildcat Park	688.5		No	Yes	Yes	
	Wildcat Park South	688.5		No	Yes	Yes	
	Water's Edge Motel	686.5	10	No	Yes	Yes	

	Stoddard Park Landing	685.7		No	Yes	Yes	
	Reno Walkdown	681.5		No	Yes	Yes	
	Engh's Boat Livery	679.8		No	Yes	Yes	
	Genoa Harbor	679.3	4-5	No	Yes	Yes	
	New Albin Access	673.4		No	Yes	Yes	
	Victory Landing	672.9		No	Yes	Yes	
	Black Hawk Marina	671.3		No	Yes	Yes	
	Black Hawk Park	671.2		No	Yes	Yes	
	Green Lake Ramp	670.2		No	Yes	Yes	
	De Soto Landing	667.3		No	Yes	Yes	
	Winneshiek Landing	665.0		No	Yes	Yes	
9	Lansing Municipal Harbor	663.8	4-6	No	Yes	Yes	
	Big Slough Landing	663.3		No	Yes	Yes	
	Xavier Gas Dock	662.7	6	No	Yes	Yes	
	S&S Houseboat Rentals	662.5	8-10	No	Yes	Yes	
	Village Creek Access	662.2		No	Yes	Yes	
	Ferryville Landing	657.6		Yes	Yes	Yes	
	Heytman's Landing	654.1		Yes	Yes	Yes	
	Cold Springs	653.9		Yes	Yes	Yes	
	Lynxville Landing	651.3		Yes	Yes	Yes	
	Landing 615	614.9	12	No	Yes	Yes	Yes
	Guttenberg Courtesy Docks	614.8		No	Yes	Yes	Yes
	Schleicher's Landing	613.0		No	Yes	Yes	Yes
	Turkey River Landing	607.8		No	Yes	Yes	Yes
	Power and Light Landing	607.7		No	Yes	Yes	Yes
	Cassville Courtesy Docks	606.5		No	Yes	Yes	Yes
	Eagle's Roost Resort	605.5	2	No	Yes	Yes	Yes
	Lowell's Landing	603.6	7	No	Yes	Yes	Yes
11	Bertom Lake	601.4		No	Yes	Yes	Yes
	Anthony's Resort	600.0		No	Yes	Yes	Yes
	McCartney Landing	598.4		No	Yes	Yes	Yes
	Lynn Hollow Access	596.7		No	Yes	Yes	Yes
	Findley's Landing	596.0		No	Yes	Yes	Yes
	Potosi Public Access	592.2		Yes	Yes	Yes	Yes
	Grant River Public Use Area	591.0		Yes	Yes	Yes	Yes
	Arrowhead Marina	589.7	6-8	Yes	Yes	Yes	Yes
	Mud Lake Park	589.4		Yes	Yes	Yes	Yes
	Pool 11 Access	583.0		Yes	Yes	Yes	Yes
	Bellevue Courtesy Dock	556.4	10	No	No	Yes	Yes
	Point Pleasant Boat Landing	556.2	8	No	No	Yes	Yes
	Shady Haven Camper Park & Marina	556.0	8	No	No	Yes	Yes
	Bellevue Research Station and Public Use Area	555.5		No	No	Yes	Yes
	Pleasant Creek Public Use Area	553.0		No	No	Yes	Yes
	Lazy River Marina	540.8		No	Yes	Yes	Yes
	Mississippi Palisades State Park	539.0		No	Yes	Yes	Yes
	Paradise Harbor	538.6	4-6	No	Yes	Yes	Yes
	Marquette Park	537.6		No	Yes	Yes	Yes
13	Savanna Marina	537.0	4-6	No	Yes	Yes	Yes
	Barge Lake Landing	536.2		No	Yes	Yes	Yes
	Sabula Municipal Courtesy Dock	535.7	12	No	Yes	Yes	Yes
	Homeport	535.5	19	No	Yes	Yes	Yes
	Island City Harbor	534.5	4	No	Yes	Yes	Yes
	South Sabula Access	534.2		No	Yes	Yes	Yes
	Big Slough Public Use Area	531.1		No	Yes	Yes	Yes
	Thompson Causeway Recreational Area	526.0		Yes	Yes	Yes	Yes
	Bulger's Hollow Public Use Area	525.8		Yes	Yes	Yes	Yes
	Michelson's Landing	523.7		Yes	Yes	Yes	Yes
	LeClaire Park	482.4		No	No	No	No
	Sunset Park	480.1		No	No	No	No

16	Sunset Harbor and Marina	479.8	6	No	No	No	No
	Credit Island	479.8		No	No	No	No
	Harbor Ranch Boat Ramp	479.3		No	No	No	No
	Loomis Landing	473.0	5	No	No	Yes	Yes
	Buffalo Municipal Ramp	473.0		No	No	Yes	Yes
	Buffalo Shores Park	472.0		No	No	Yes	Yes
	Wintergreen Inn	471.5	3-4	No	Yes	Yes	Yes
	Andalusia Slough Public Use Area	470.5		No	Yes	Yes	Yes
	Clark's Ferry Recreational Area	468.3		No	Yes	Yes	Yes
	Loud Thunder Forest Preserve	467.1		No	Yes	Yes	Yes
	Shady Creek Recreational Area	464.8		No	Yes	Yes	Yes
	Fairport Landing / Chart House Lounge	463.0	4	No	Yes	Yes	Yes
	Izaak Walton League	462.8		No	Yes	Yes	Yes
	Fairport Public Use Area	461.7		Yes	Yes	Yes	Yes
18	Toolsboro Public Access	434.9		No	No	No	No
	Ferry Landing Public Use Area	433.2		No	No	No	Yes
	New Boston Municipal Ramp	433.1		No	No	No	Yes
	Keithsburg Public Ramp	427.3		No	No	Yes	Yes
	Fourth Pumping Station Recreational Area	424.9		No	Yes	Yes	Yes
	Big River State Forrest	424.1		No	Yes	Yes	Yes
	Sin City Resort	423.3	4-6	No	Yes	Yes	Yes
	Putney's Landing	422.8		No	Yes	Yes	Yes
	Hawkeye Dolbee Access	421.9		No	Yes	Yes	Yes
	Delabar State Park	417.6		No	Yes	Yes	Yes
	Casey Barrow Access	416.1		Yes	Yes	Yes	Yes
	Oquawka Municipal Ramp and Harbor	415.6		Yes	Yes	Yes	Yes
	Yellow Banks Marina	415.2	4	Yes	Yes	Yes	Yes
19	Henderson Creek Public Access	410.1		No	No	No	Yes
	Weyl's Marina	409.1		No	No	Yes	Yes
	Tama Beach Public Access	409.0		No	No	Yes	Yes
	Bluff Harbor Marina	404.5	4-6	No	No	Yes	Yes
	Gulfport Public Ramp	404.3		No	No	Yes	Yes
	Burlington Municipal Ramp	404.1		No	No	Yes	Yes
	Green Bay Access Area	390.5		No	Yes	Yes	Yes
	Dallas City Public Ramp	390.5		No	Yes	Yes	Yes
	Willow Patch Public Ramp	384.0		No	Yes	Yes	Yes
	North Shore Marina	383.8	5-7	No	Yes	Yes	Yes
	Riverview Park and Municipal Ramp	383.7		No	Yes	Yes	Yes
	Ortho Way Access	379.5		Yes	Yes	Yes	Yes
	Nauvoo Boat Ramp	375.8		Yes	Yes	Yes	Yes
	Riverview Park and Boat Ramp	374.9		Yes	Yes	Yes	Yes
	Larry Creek Access	369.1		Yes	Yes	Yes	Yes
	Keokuk Yacht Club	366.2	6	Yes	Yes	Yes	Yes
	B and H Marine and Public Ramp	366.2		Yes	Yes	Yes	Yes
	Chaney Creek Access	364.7		Yes	Yes	Yes	Yes