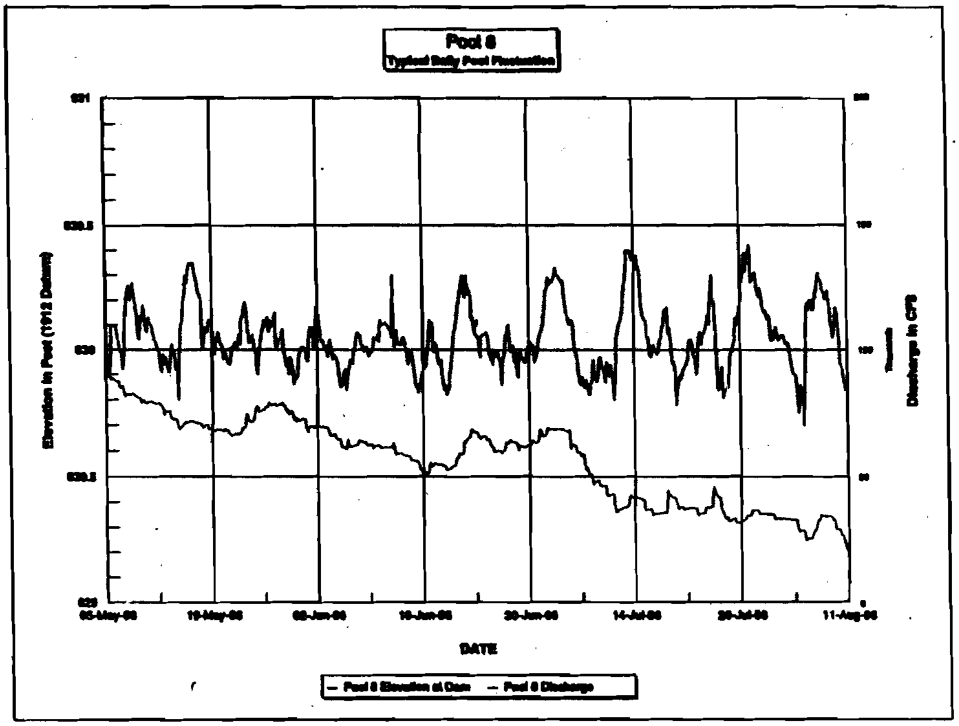
PROBLEM APPRAISAL REPORT
FOR
WATER LEVEL MANAGEMENT

UPPER MISSISSIPPI RIVER



WATER LEVEL MANAGEMENT TASK FORCE

RIVER RESOURCES FORUM

NOVEMBER 1996

PROBLEM APPRAISAL REPORT

WATER LEVEL MANAGEMENT - UPPER MISSISSIPPI RIVER

EXECUTIVE SUMMARY

This study was conducted under the auspices of the Water Level Management Task Force of the River Resources Forum. The River Resources Forum is 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. The study was funded and managed by the St. Paul District, Corps of Engineers. The WLMTF provided direction during study scoping and served in a review capacity during various stages of report preparation.

The purposes of the study were to increase the understanding of the existing system of river regulation on the Upper Mississippi River, quantify the effects of water level management alternatives, and identify water level management alternatives that may be feasible to implement. Pool 8 was selected as the study pool primarily because of the availability of existing physical and biological data for this pool.

Ten alternative water level management measures were identified for study. Because of time and funding constraints the WLMTF prioritized the alternatives for study as high, medium, and low priority. The analyses of the high priority alternatives were to quantify effects as much as practicable. Low priority alternatives were to be evaluated in a qualitative manner. The effects of medium priority alternatives were to be quantified where possible. Five alternatives were assigned a medium priority, while four alternatives were assigned low priority. The only alternative assigned a high priority was summer growing season pool drawdown.

The major portion of the study effort involved evaluating **summer growing season drawdown** as a management measure to improve conditions for the growth of aquatic vegetation. One-foot, 3-foot, and open river drawdowns were evaluated for flows ranging from 9,900 cfs to 75,500 cfs. These drawdowns would expose 2,400 to 4,600 acres, 5,600 to 9,400 acres, and 9,500 to 15,100 acres of pool 8, respectively. The amount of area exposed would depend upon river flows at the time of the drawdown. Depending upon annual conditions, a substantial portion of the area exposed could contain aquatic vegetation, primarily submersed vegetation.

To provide for the desired vegetation response, a minimum of a full growing season drawdown should be employed, with a two growing season drawdown providing additional benefits. Drawdown would have to reoccur on a periodic basis to be effective (once every 5 to 10 years).

In pool 8, the navigation channel could be maintained with a 1-foot drawdown with minimal additional dredging. With a 3-foot drawdown, substantial additional dredging (approximately 300,000 cubic yards based on 1996 channel conditions) could be required to maintain the channel. The navigation channel could not be maintained with an open river drawdown. Closure of the navigation channel could result in $32 million to $115 million in direct economic losses, depending on the duration of the shutdown.

Recreation in pool 8 would be temporarily affected with a summer drawdown, primarily by reducing boat access and by reducing the area available for water based recreation. The larger scale drawdowns would have the largest potential for effect. The direct adverse effects would be limited to the duration of the drawdown, and improved habitat conditions resulting from the drawdown would be expected to provide long-term recreational benefits.

The conclusion of the study is that limited summer growing season drawdowns of 3 feet or less appear implementable in pool 8 without requiring closure of the navigation channel. The effects of limited drawdown on the resources of pool 8 and the ability of the public to use those resources appear manageable. Because of the potential for large-scale ecological benefits, the implementation of limited drawdowns in pool 8 and/or other navigation pools warrants high priority consideration by the Corps of Engineers, river resource management agencies, and the public.

Two of the medium priority alternatives were the **isolation and water level management of small and large backwater areas**. Thirty small sites were identified in pool 8 for isolation and management, ranging in size from 2 to 61 acres. Estimated average annual costs for isolating and managing these water bodies on a periodic basis range from $140 to $3,800/acre affected. Only one large backwater area in pool 8 was evaluated for this type of management, Lawrence Lake. The average annual cost for managing Lawrence Lake was estimated at $93/acre. The conclusion of the study is that isolation and water level management of backwaters would provide site specific habitat benefits that may be cost effective to obtain on a site specific basis. However, this management measure would not have any substantial effects from a pool-wide or systemic perspective because the area affected would be too small.

During the winter of 1995-96 the St. Paul District, at the request of the Upper Mississippi River Conservation Commission and the Water Level Management Task Force, **discontinued the practice of implementing a 0.25-foot winter drawdown** in all of the District pools. The conclusion of the study is that discontinuing this minor winter drawdown may provide minor benefits to backwater habitats at no appreciable cost, and that this management approach should continue concurrent with further evaluation of the potential effects.

The St. Paul District navigation pools have a ± 0.2 foot and ± 0.3 foot operating band in the summer and winter, respectively. The conclusion of the study is that **operating on the high side of the band during the winter and on the low side of the band in the summer** could provide minor benefits to backwater habitats. Therefore, this method of operation warrants further consideration for implementation.

Increasing the frequency of dam gate adjustments on more than a daily basis would smooth out changes in pool stages. A review of pool 8 stage changes for the summer of 1996 indicates that the daily change is generally less than 0.5 foot. Going to more frequent (twice daily or more) gate changes could require remote operation of the dam gates due to personnel constraints. An ongoing study at Lock and Dam 7 will provide further information concerning the cost of installing remote gate operation capabilities. Because the daily changes in pool stages do not appear to be significant, the conclusion of the study is that further evaluation of this alternative should be held in abeyance until the results of the Lock and Dam 7 study are available.

Modifying the distribution of flows across the dam gates has the potential for improving tailwater habitat. There are constraints associated with the allowable flow through any particular dam gate to control scour and maintain the structural intergrity of the dam. Though this alternative was a low priority alternative and not evaluated in detail, it appears that implementation of this measure would not have a significant cost. The conclusion of the study is that the potential habitat benefits of this measure warrant more detailed evaluation at one or two lock and dam sites.

Large scale winter drawdowns could be used to consolidate sediments and facilitate the construction of habitat improvement projects. This measure has the potential for having substantial adverse effects on fish and furbearers. Implementation of this measure would require Congressional action because it would be in conflict with the Anti-Drawdown Law. The conclusion of the study is that this measure does not warrant further consideration as a "stand alone" management measure. However, winter drawdowns should be considered in conjunction with open water season drawdowns as a measure for improving conditions for emergent aquatic plant growth.

Spring pool raises could be used to improve conditions for species that make use of flooded habitats such as spawning northern pike. The opportunity at Lock and Dam 8 appears to be limited to a 2- to 3-foot raise without requiring costly modifications to the dam and spillways. Because the opportunities for employing this management measure appear somewhat limited, the conclusion of the study is that this alternative should be given low priority in future water level management planning efforts.

Changing the primary control point in pool 8 from mid-pool to the lock and dam would provide minor habitat benefits by eliminating unnatural water level changes in the lower portion of the pool. This alternative would likely require the acquisition of additional flowage easements or property in pool 8 by the Federal Government. This alternative could also require Congressional approval. Because the benefits of this management measure do not appear significant, the conclusion of the study is that this alternative should be given low priority in future water level management planning efforts.

The study identified potential avenues for further evaluation of water level management alternatives. Regardless of the approach taken, an extensive public involvement and coordination program will need to be an intergral part of the process.

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WATER LEVEL MANAGEMENT - UPPER MISSISSIPPI RIVER

SECTION ONE - INTRODUCTION

BACKGROUND

The Upper Mississippi River has been modified for navigation and other purposes for over 100 years. Construction of the 9-Foot Navigation Channel Project resulted in a series of locks and dams on the Upper Mississippi River, most of which in the St. Paul District were completed and operational by 1940. The primary purpose of the locks and dams is to provide adequate water depths to provide for a 9-foot navigation channel. Dredging is a necessary supplement to the locks and dams to provide the required water depths.

In addition to serving the needs of commercial navigation, much of the Mississippi River and its floodplain within the St. Paul District is managed as part of the Upper Mississippi River National Wildlife and Fish Refuge. Congress has recognized the Upper Mississippi River as a nationally significant ecosystem and a nationally significant commercial navigation system (Section 1103 of the Water Resources Development Act of 1986).

The construction of the locks and dams resulted in a series of shallow impoundments (navigation pools) on the river. The operation of the locks and dams results in relatively stable water levels during non-flood periods. There has been growing interest in water level management on the Upper Mississippi River as a means of restoring and enhancing ecological conditions. A Water Level Management Task Force (WLMTF) has been established by the River Resources Forum. The Upper Mississippi River Summit (now referred to as "The Big River Partnership") has formed a task group for water level management. Appendix A of this report contains a paper developed by the WLMTF which summarizes the potential biological benefits associated with water level management on the Upper Mississippi River.

Funds became available within the St. Paul District in Fiscal Year 1996 to undertake limited investigations of water level management on the Upper Mississippi River. St. Paul District resources were combined with those of other Federal and State agencies to undertake a study to identify opportunities to improve ecological conditions through water level management and to do limited analysis of water level management alternatives. The study was conducted under the auspices of the Water Level Management Task Force in a spirit of interagency participation and cooperation.

Pool 8 was selected as the study pool primarily because of the availability of existing data for this pool. Pool 8 is being monitored intensively under the Long Term Resource Monitoring (LTRM) portion of the Upper Mississippi River System Environmental Management Program (UMRS-EMP). Data available for pool 8 considered instrumental to the conduct of this study includes bathymetry, sediment type distribution, and aquatic vegetation. Another contributing factor in the selection process is that a 2-dimensional hydraulic model has been developed for portions of pool 8. In addition, the presence of the City of La Crosse, Wisconsin, and the high level of recreational activity that occurs in pool 8 provide the opportunity to evaluate the effects of water level management alternatives on a number of river uses.

The public and the river resource management agencies are keenly aware that water levels affect river resources and public use of the river. The focus of this study is on restoration and management of river resources, especially aquatic vegetation, through water level management. Aquatic vegetation is a very important component of aquatic habitat in the Mississippi River, providing food and cover for many species of fish and wildlife. Aquatic vegetation, especially emergent vegetation, in the river has generally declined in extent and abundance in the six decades since construction of the navigation dams. Water level management measures have proved to be effective in reestablishing aquatic vegetation in shallow freshwater systems.

PURPOSE

The purpose was to conduct an initial planning study for water level management on the Upper Mississippi River using pool 8 as the study pool. The scope of study included the identification of problems, opportunities, objectives, constraints, and alternative management measures and an evaluation of the ecological benefits, economic benefits and costs, and other potential effects of water level management alternatives.

Specific study purposes included the following:

1. Increase stakeholders' understanding of the existing system of river regulation, its constraints, and its ecological effects.

2. Quantify the ecological benefits and costs, the economic benefits and costs, and other effects of a range of water level management alternatives for pool 8.

3. Identify water level management alternatives for pool 8 that may be feasible to implement, including the measures and processes that would be necessary for implementation.

4. Develop analytical methods to evaluate water level management alternatives for future studies and for other navigation pools in the UMRS.

SECTION 2 - EXISTING CONDITIONS

PHYSICAL SETTING

Lock and Dam 8 is part of the 9-Foot Navigation Channel Project on the Upper Mississippi River. Lock and Dam 8 is located at the village of Genoa, Wisconsin, approximately 20 miles south of La Crosse, Wisconsin (figures 2-1 and 2-2). The lock and dam is located at river mile 679.2, 23.3 river miles below Lock and Dam 7, and 31.3 river miles above Lock and Dam 9. The pool impounded by the lock and dam (pool 8) has an area of 20,810 acres at project pool elevation 631.0 (National Geodetic Vertical Datum (NGVD) 1912 adjustment).

The cities of La Crosse, Wisconsin, and La Crescent, Minnesota, lie at the upper end of pool 8. The villages of Stoddard, Wisconsin, and Brownsville, Minnesota, are located near mid-pool at approximately river miles 686 and 689, respectively.

The two main tributaries that enter pool 8 are the La Crosse River which drains an area of 480 square miles in Wisconsin, and the Root River which drains an area of 1,660 square miles in Minnesota. Although the Black River empties into pool 7, a discharge of between 1,200 and 1,500 cubic feet per second (cfs) is maintained through the Onalaska spillway during summer and 500 cfs during winter down the last 4 miles of the old Black River channel to the point of original junction with the Mississippi River.

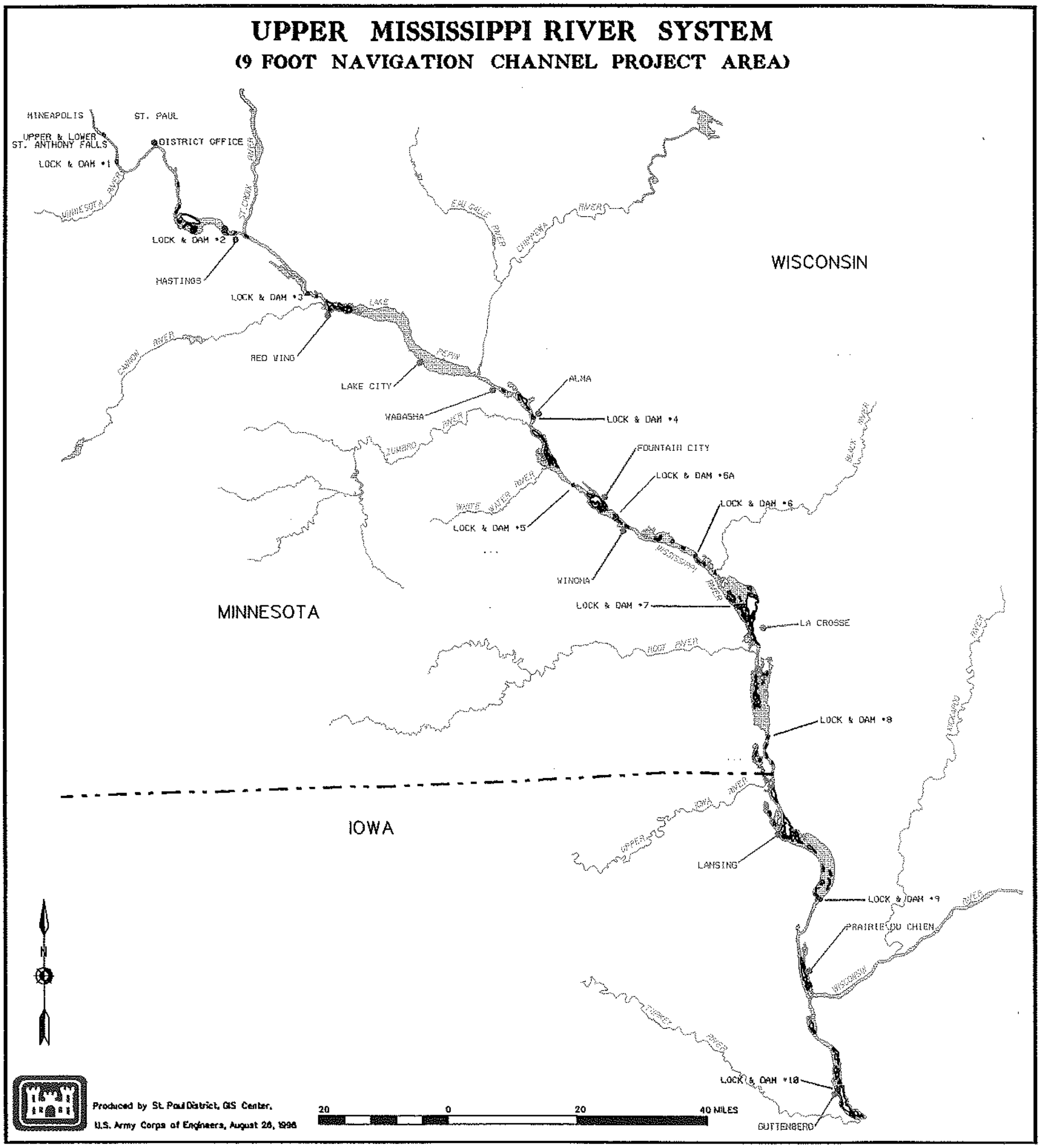


Figure 2-1. General Location Map

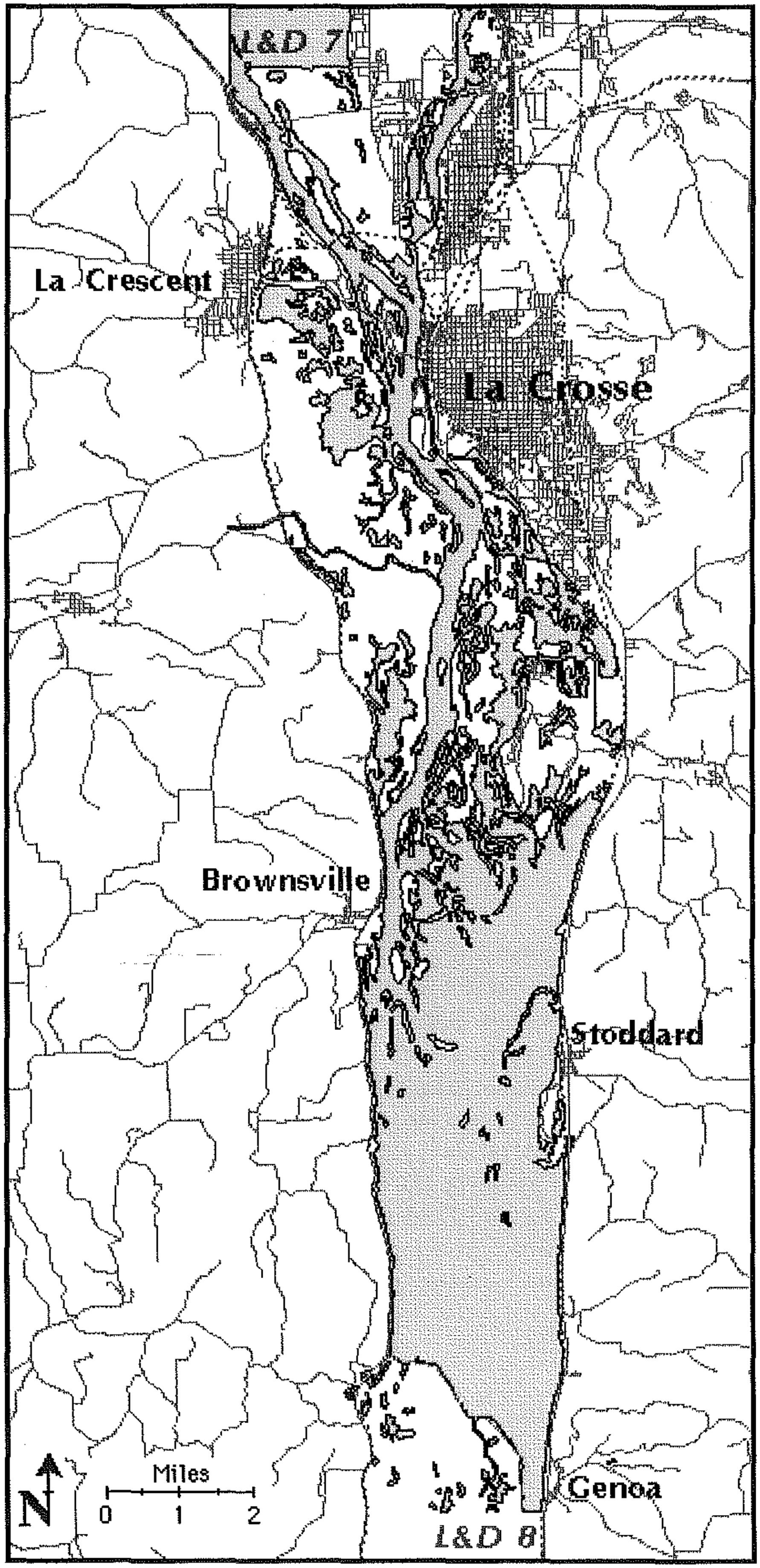


Figure 2-2. Pool 8

HYDROLOGY

The Mississippi River at Lock and Dam 8 drains an area of 64,770 square miles. The drainage basin above Lock and Dam 8 includes portions of Minnesota, Wisconsin, and South Dakota. Approximately two-thirds of the watershed is in agricultural use; the rest is primarily forested land and urban areas. Annual precipitation in the basin ranges from about 16 to 30 inches per year.

FLOW

Mean discharge at the U.S. Geological Survey gage located at Winona, Minnesota, has been 28,660 cfs over a 37-year period of record ending in September 1995. Maximum discharge recorded at the Winona gage was 268,000 cfs on April 19, 1965. Minimum flow recorded was 2,250 cfs on December 29, 1936.

Annual flow duration (percent at or above a certain discharge level) at Lock and Dam 8 is depicted on figure 2-3. Monthly flow durations are shown in table 2-1.

The annual hydrograph at Lock and Dam 8 is characterized by spring peak discharges following ice breakup, snowmelt, and spring rains. Spring runoff usually begins near the end of March and extends through April into May. The spring peak flow most typically occurs around mid-April. Summer flows generally range from 20,000 to 30,000 cfs. River discharges typically increase from fall rains in September and October. Winter discharge is steady and low, at about 20,000 cfs.

Plate 1 is a discharge hydrograph for Lock and Dam 8 for the years 1988 through 1995 (the hydrologic record for the Upper Mississippi River extends back to the turn of the century). The discharge values are for releases from the lock and dam, estimated on the basis of gate discharge ratings. The 1992 and 1994 hydrographs provide examples of the "typical" bimodal pattern of high flows from spring runoff and fall rains, with lower flows during summer and winter. The 1988 hydrograph illustrates a near-record low flow year. The 1991 hydrograph illustrates a relatively high-flow year, while the 1993 hydrograph depicts a year of summer flooding, with river discharge greater than 50,000 cfs throughout most of the growing season.

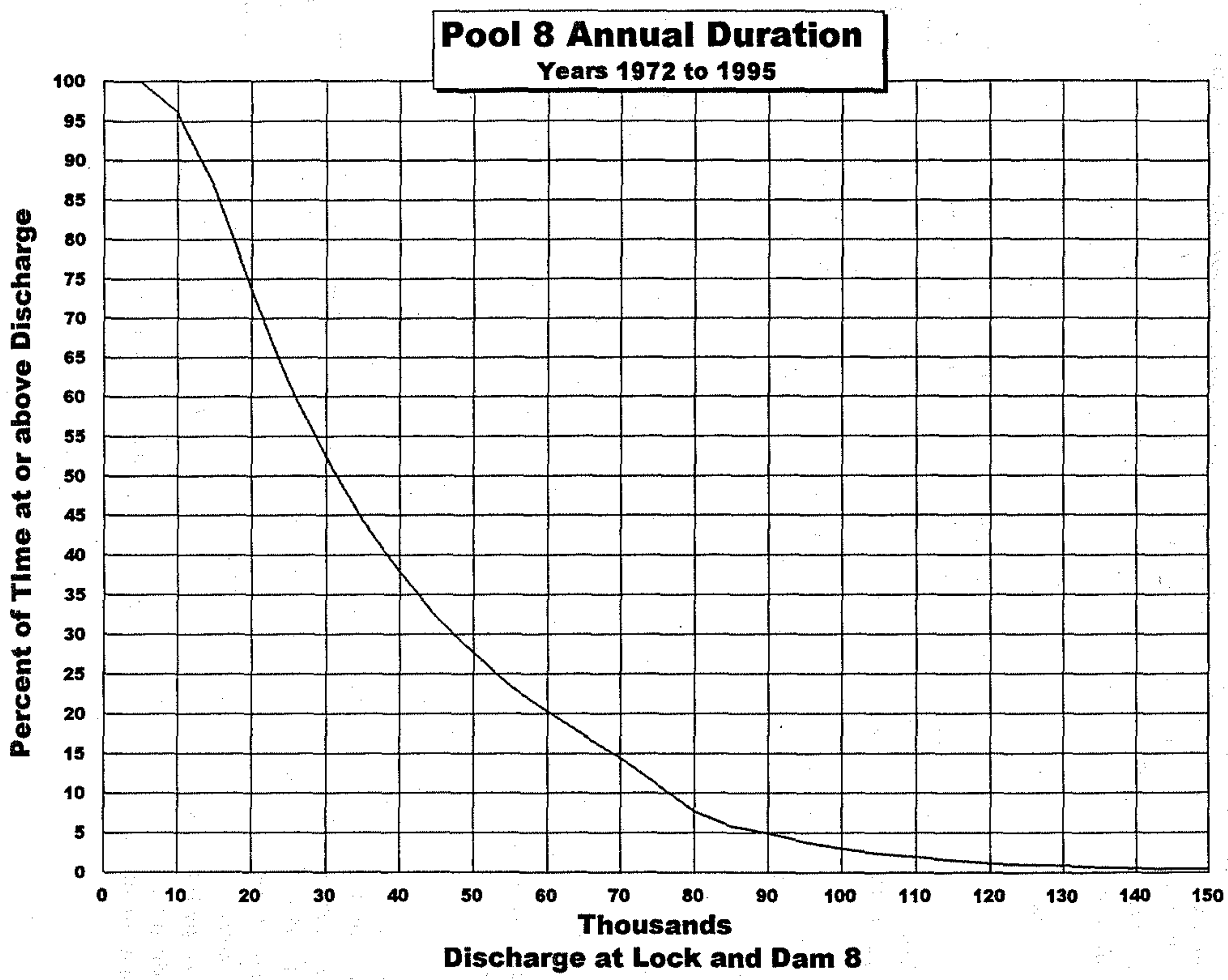


Figure 2-3. Annual Flow Duration Curve for Lock and Dam 8

Table 2–1
Monthly Flow Durations (1972–95)

Flow (cfs)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
175000					<0.5	1	<0.5						<0.5
170000					1	1	<0.5						<0.5
165000					1	1	1						<0.5
160000				<0.5	1	1	1		<0.5	<0.5			<0.5
155000				1	1	1	1		<0.5	<0.5			<0.5
150000				1	1	1	1		<0.5	1			<0.5
145000				1	1	1	1		1	1			1
140000			1	1	1	1	1		1	1			1
135000			1	2	1	1	2		1	1			1
130000			1	2	2	1	2		1	1			1
125000			2	3	2	1	3		1	1			1
120000			2	4	3	1	3		1	1			1
115000			2	6	5	1	3		1	1			2
110000			3	8	5	2	3		1	1			2
105000			3	11	7	3	3		1	2			2
100000			4	15	9	3	4		1	2			3
95000			5	19	11	3	4	1	1	3			4
90000			6	24	15	4	5	1	1	3			5
85000			8	28	18	5	6	1	1	3			6
80000			12	34	25	8	6	1	1	4	1		8
75000		<0.5	15	46	36	12	9	4	3	5	2		11
70000		1	19	58	43	16	13	6	4	8	4		14
65000		1	22	65	50	21	17	7	6	10	7	<1	17
60000		1	25	70	55	27	23	7	10	13	9	1	20
55000		1	29	75	59	32	29	11	15	16	12	1	23
50000		1	33	79	65	41	34	15	22	21	17	3	28
45000		2	39	82	69	52	40	20	27	27	22	4	32
40000	1	4	45	84	73	64	47	26	34	34	34	8	38
35000	3	5	50	88	77	72	54	35	40	43	47	17	44
30000	12	8	58	93	82	77	62	45	49	52	57	31	52
25000	28	17	66	96	87	80	70	57	60	61	68	48	62
20000	50	43	79	98	92	85	76	70	74	72	83	61	74
15000	70	75	93	99	96	93	85	81	86	84	92	81	86
10000	94	94	99	100	100	98	96	93	95	96	95	91	96
5000	100	100	100	100	100	100	100	100	100	100	100	100	100
0	100	100	100	100	100	100	100	100	100	100	100	100	100

duration excedence greater than 90 percent or less than 10 percent

duration excedence greater than 50 percent and less than 90 percent

duration excedence greater than 10 percent and less than 50 percent

FLOW/POOL RELATIONSHIPS

Pool 8 averages about 2.7 miles wide and covers approximately 20,800 acres at low control pool elevation (flat pool at 631.0 feet). Water surface elevation in pool 8 is measured daily immediately above the dam, at Brownsville, Minnesota, at the primary control point at La Crosse, and at the tailwater of Lock and Dam 7. The level of pool 8 is regulated with target rule curves (plate 2) for water surface elevations immediately above the dam and at the primary control point at La Crosse.

The curves shown on plate 3 indicate pool elevation by river mile at various levels of river discharge (solid lines). During low to moderate levels of river discharge the water surface profile of the pool is not a simple plane, but has a steeper gradient in the upper part of the pool, upstream of the primary control point. This change in water surface gradient is due to the impounding effect of Lock and Dam 8, and due to intentional regulation. The water surface profile of the pool at higher levels of river discharge is very close to the pre-project water surface profile of the river.

The elevations shown on plate 3 are water surface elevations for the main channel. Water surface elevations in off-channel areas can be different from those in the adjacent main channel, especially at times of higher and changing flow, as the off-channel areas of the pool fill and drain.

The elevation differences that occur between off-channel areas and the adjacent main channel in pool 8 have not been measured. Head differential across the floodplain is greatest in the upper portion of pool 8, where the river gradient is steeper, and the off-channel areas are more hydraulically separated from the main channel. The riverbed geometry of each off-channel area and the geometry of inlets and outlets, along with level and rate of change of river discharge, determine the head differential between off-channel areas and the main channel.

Wind set-up and minor seiches occur in the large open-water area at the downstream end of pool 8. Northerly and southerly winds produce the greatest effect on lower pool 8 because of the north-south orientation of the valley. Wind set-up corresponds approximately to 0.1 foot of elevation at the dam per 10 miles per hour of sustained wind velocity from the north.

Appendix B contains more detailed information concerning Lock and Dam 8 and water level regulation for pool 8.

TRIBUTARIES

The La Crosse and Root Rivers are the major tributaries to the Mississippi River in pool 8. The La Crosse River has a drainage area of 480 square miles. The maximum flow measured on the La Crosse River was 8,200 cfs in 1935 at the U.S. Geological Survey gage near West Salem, Wisconsin, where the drainage area is 398 square miles. The La Crosse River drainage is steep, driftless terrain. These characteristics result in rapid increases in flow during rainfall events.

The Root River has a drainage area of 1,660 square miles. The maximum flow measured on the Root River was 38,700 cfs in 1952 at the U.S. Geological Survey gage at Houston, Minnesota, where the drainage area is 1,560 square miles.

Small Wisconsin tributaries include Pammel and Coon Creeks. Wildcat Creek is a small Minnesota tributary. None of these streams are gaged. All of these smaller tributaries drain relatively steep, driftless watersheds, and are flashy during rainfall events. Flow is sustained during dry periods by groundwater and spring flow. None of the tributaries to pool 8 are regulated.

WATER QUALITY

Richardson and Clemment (1993) monitored basic water quality parameters in pool 8 from 1988 to 1990. Samples were collected from 21 sites representing a variety of habitat types.

Average weekly dissolved oxygen (DO) values during the study period ranged from 6 to 17 milligrams per liter (mg/l). Cold season DO concentrations generally exceeded 10 mg/l, while late summer values ranged from 6 to 10 mg/l. Water temperatures peaked in late summer at about 29 degrees Celsius (C).

Winter turbidity levels were low (2 to 4 Nephelometric turbidity units (NTU)), while summer values generally fell between 20 and 50 NTU. Some open river sites peaked near 200 NTU during the spring thaw of 1990. Secchi disk transparency during the winter months generally ranged between 1.25 and 1.75 meters. During the summer months, transparency was usually in the range of 0.25 to 0.50 meter.

The study found similar trends for all parameters in both vegetated and unvegetated habitats, with the backwater contiguous habitat exhibiting the greatest diversity in water quality.

WATER USES

EFFLUENT DISCHARGES

The Mississippi River and tributaries in pool 8 are used for the discharge of wastewaters. Regulated effluent discharges to pool 8 are listed in table 2-2. It is likely that there are other unregulated discharges to the pool in the form of storm sewers and ditches.

WATER APPROPRIATIONS

The only known major water user in pool 8 is the Northern States Power Company French Island generating station. This facility uses the Black River as a source of once-through cooling water. Daily water use is approximately 32 million gallons. The water intakes are two 36-inch pipes with their inverts at elevation 618.0 (Anderson, 1996). The plant's two intake water pumps are rated at 1.02 million gallons per hour and normal plant operation is 16 hours per day. When the plant is operating at full capacity, water intake into the plant is about 76 cfs.

Table 2-2
Regulated Discharges in Pool 8

Name	Location	Type
Allied Signals	Isle La Plume Sl.	Non-contact Cooling Water
Altec International	Mississippi River	Non-contact Cooling Water
Amoco Oil Co.	Black River	Groundwater Remediation
Bob Johnson Oil	Black River	Groundwater Remediation
Brettinggen Auto Sale	Black River	Groundwater Remediation
Brownsville	Wildcat Creek	Wastewater Treatment Fac.
Citgo	Black River	Groundwater Remediation
Dairyland Power Co.	Mississippi River	Non-contact Cooling Water
Dairyland Power Co.	Mississippi River	Non-contact Cooling Water
1 WI. Robertson	Black River	Groundwater Remediation
Frank Len Inc.	Mississippi River	Groundwater Remediation
G. Heilemens Brewery	Mississippi River	Cooling and Rinse Water
G. Heilemens Brewery	Mississippi River	Non-contact Cooling Water
Genoa	Mississippi River	Wastewater Treatment Fac.
Huntington's Garage	Mississippi River	Groundwater Remediation
La Crescent	Blue Lake	Wastewater Treatment Fac.
La Crosse (Barron Is)	Mississippi River	Wastewater Treatment Fac.
La Crosse (Isle La Plume)	Mississippi River	Wastewater Treatment Fac.
McCloone Metal Graphics	Black River	Non-contact Cooling Water
Mobil Oil Term. 48	La Crosse River	Groundwater Remediation
National Biological Ser.	Black River	Wastewater
Northern States Power	Mississippi River	Non-contact Cooling Water
Northwest Hardwoods	Black River	Non-contact Cooling Water
Stoddard	Wetland	Wastewater Treatment Fac.
Tire Town	Black River	Groundwater Remediation
Torrance Casting, Inc.	La Crosse River	Groundwater Remediation
Trane Co.	Mississippi River	Non-contact Cooling Water
Young Broadcasting	Mississippi River	Non-contact Cooling Water
WI Technical College	Mississippi River	Non-contact Cooling Water

Source: Wisconsin Department of Natural Resources; Minnesota Department of Natural Resources

VEGETATION

General land cover types for pool 8 are shown on figure 2-4. Terrestrial vegetation present on the remaining islands and floodplain in pool 8 is typical of the northern floodplain forest. Dominant tree species include silver maple (*Acer saccharinum*), cottonwood (*Populus deltoides*), American elm (*Ulmus americana*), river birch (*Betula nigra*), and green ash (*Fraxinus pennsylvanica*). Mixed stands of black willow (*Salix nigra*) and sandbar willow (*Salix exigua*) dominate areas along the water's edge. Common shrub species include button bush (*Cephalanthus occidentalis*), red osier dogwood (*Cornus stolonifera*), panicled dogwood (*C. paniculata*), silky dogwood (*C. amomum*), false indigo (*Amorpha fruticosa*), staghorn sumac (*Rhus typhina*), smooth sumac (*R. glabra*), and honeysuckle (*Lonicera* sp.). Herbaceous layers, when present, are often dominated by poison ivy (*Rhus radicans*) and stinging nettle (*Urtica dioica*). Reed canary grass (*Phalaris arundinacea*) occurs in areas where silt, deposited during high water, remains dry during most of the summer.

Aquatic vegetation within the pool is varied. Common plant species present in the shallower areas include arrowhead (*Sagittaria latifolia*), water-lily (*Nuphar* sp. and *Nymphaea* sp.), river bulrush (*Scirpus fluviatilis*), giant bur-reed (*Sparganium eurycarpum*), lotus (*Nelumbo lutea*), coontail (*Ceratophyllum demersum*) and elodea (*Elodea canadensis*). Deeper areas are vegetated with pondweeds (*Potamogeton* sp.), coontail, and wild celery (*Vallisneria americana*). The density and extent of vegetation in the open lake-like portion of lower pool 8 are limited, presumably due to the progressive loss of islands and the resultant increased wind fetch and associated increased turbidity.

Aquatic vegetation in pool 8 and in much of the Upper Mississippi River has generally declined in abundance and extent. Initially abundant with "new reservoir" productivity in the decades following dam construction and impoundment of the navigation reservoirs, aquatic vegetation has declined in part due to the effects of continuous impoundment. The low water levels associated with summer low river discharge and periodic droughts have not occurred since construction of the dams, because minimum project pool elevations are maintained for navigation. Aquatic vegetation declined markedly during the 1988-1989 drought period, probably due to a combination of factors having to do with the underwater light climate and availability of plant nutrients in the sediments. Submersed aquatic vegetation in pool 8 has rebounded in recent years, but the extent of emergent aquatic vegetation remains limited compared to past years.

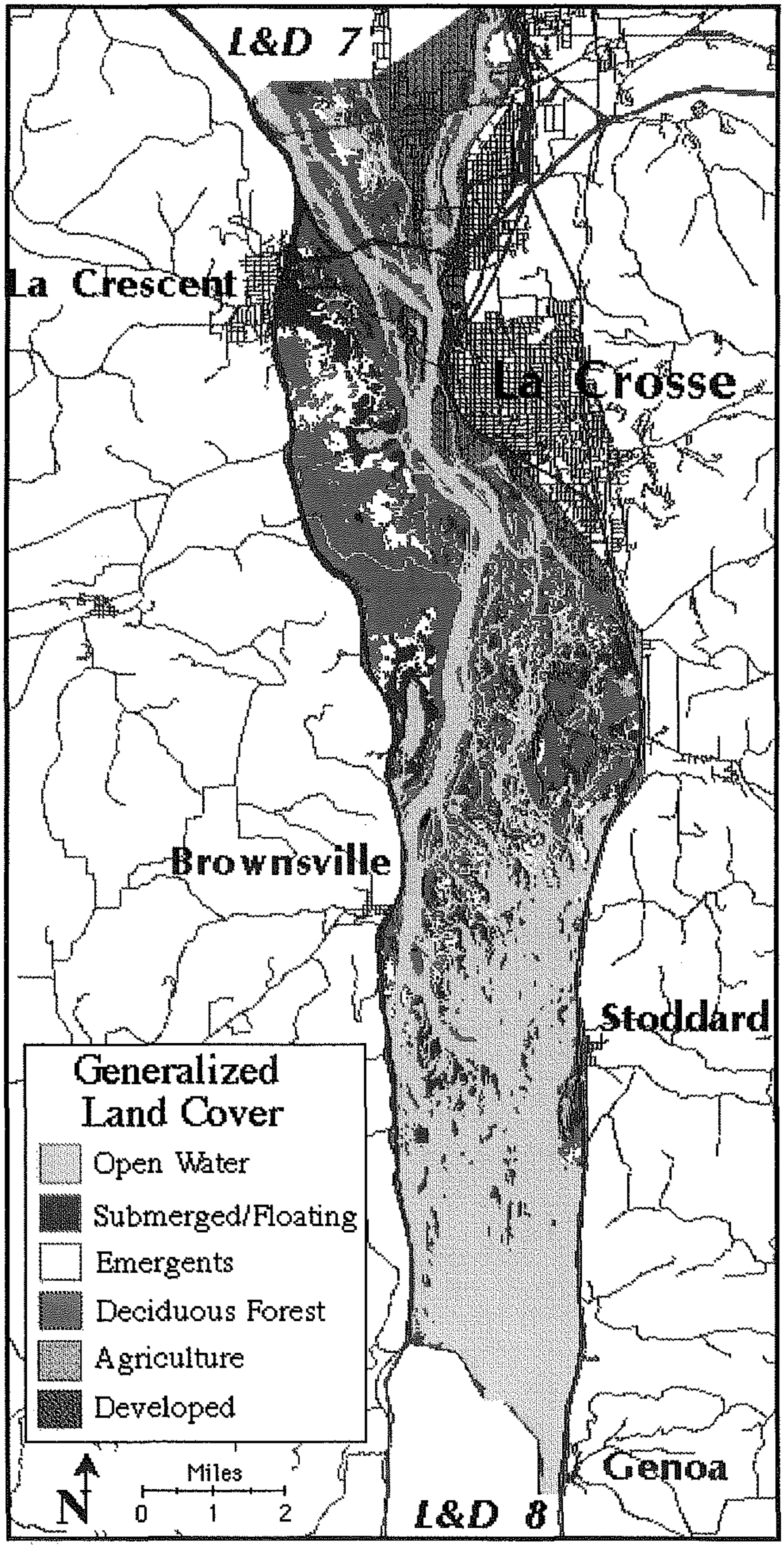


Figure 2-4. Pool 8 Generalized Land Cover

FISH AND WILDLIFE

Habitat types present in pool 8 include most of the classifications of Wilcox (1993). The most prevalent aquatic habitats include contiguous impounded, contiguous floodplain shallow aquatic, main channel border and navigation channel habitats. The important characteristics of these habitat types, relative to fish and wildlife uses, are described below.

Contiguous Impounded - Contiguous impounded habitat in pool 8 lacks bathymetric diversity (figure 2-5). Low elevation islands, once fairly prevalent throughout the contiguous impounded habitat in pool 8, have been reduced to a few scattered remnants in the lower 7 miles of pool 8. Water depths vary from 3 to 7 feet; however, abrupt topographic variation is generally lacking. Vegetation is absent or sparse.

Contiguous Floodplain Shallow Aquatic - The primary delineator that separates contiguous impounded habitat from contiguous floodplain shallow aquatic habitat is an interspersion of emergent islands. Shallow aquatic habitat is characterized by water depths typically less than 3 feet and a mix of emergent, rooted floating aquatic and submergent aquatic vegetation. Sheltered areas generally have lower water velocities than unsheltered areas and exhibit more vigorous and diverse stands of aquatic vegetation.

Main Channel Border - Main channel borders are the areas between the navigation channel and the riverbank. Channel borders contain the channel training structures (wing dams, closing dams, revetted banks), and thus a diversity of depths, substrates and velocities can be found in this habitat type. Normally, channel borders lack rooted aquatic vegetation, although vegetation may be present in isolated patches.

Navigation Channel - Navigation channel habitat is a minimum of 9 feet deep and 300 feet wide. No aquatic vegetation is present. Current velocities are much higher in the navigation channel than in most other habitat types.

Secondary Channel - Another important, but not as prevalent, aquatic habitat found in the lower portion of the pool is secondary channel habitat. Secondary channel habitat in pool 8 is characterized by deep water (typically 6 to 18 feet), a lack of rooted vegetation except along margins, and flow under normal pool conditions. Crosby Slough is representative of this habitat. Secondary channels are important for maintaining an interspersion and diversity of habitat types and contributing to the redistribution of organic matter and dissolved oxygen. Deeper holes in these channel areas provide important winter habitat for fish.

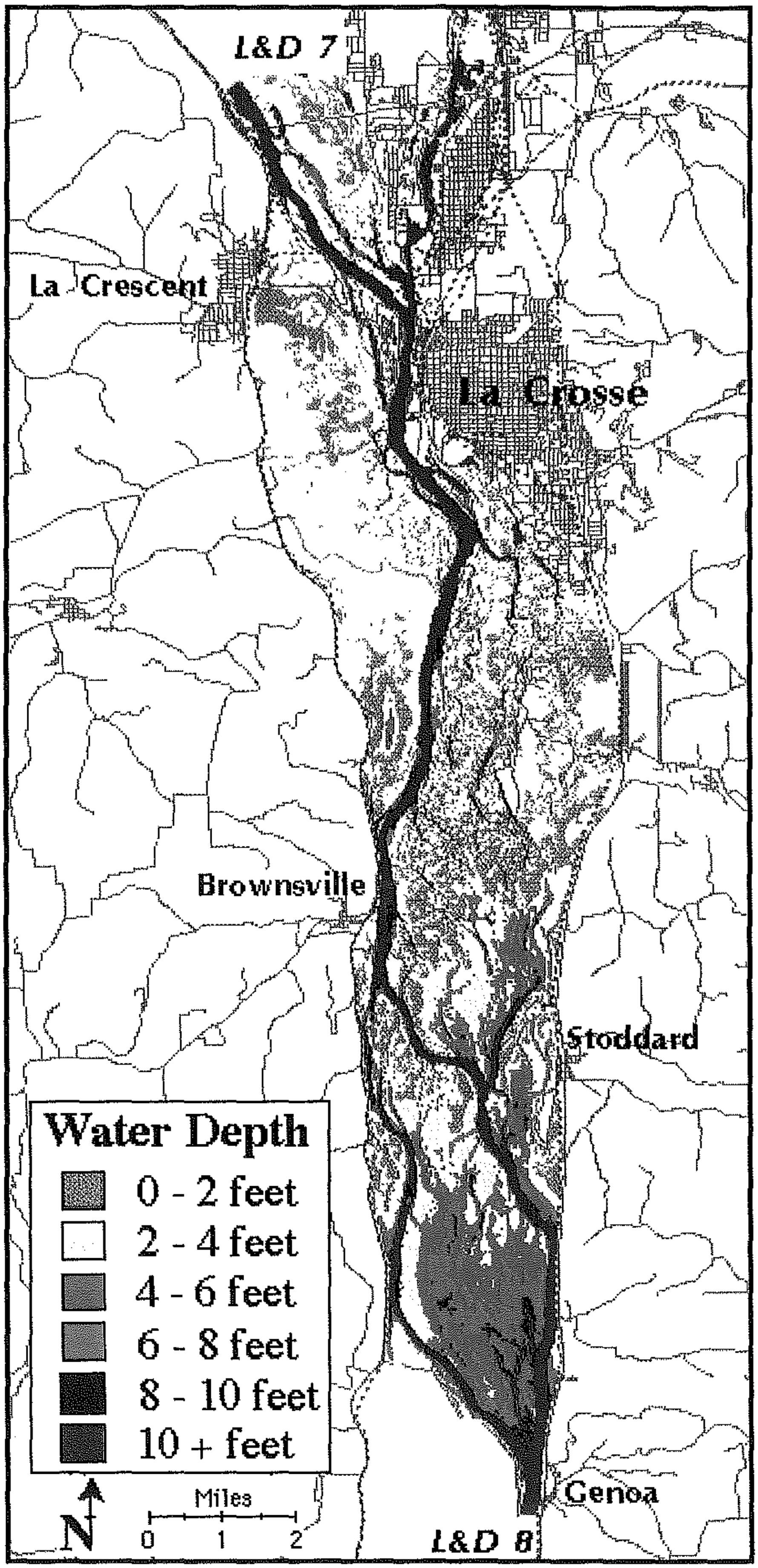


Figure 2-5. Pool 8 Water Depth

WILDLIFE

Located in proximity to northern boreal, prairie, and eastern hardwood biomes, and on a major migratory bird flyway, pool 8 supports a diversity of wildlife including many species of waterfowl, wading birds, raptors, furbearers, rodents, large mammals, reptiles and amphibians. The interspersion of aquatic, wetland and terrestrial areas in the pool 8 area provides valuable habitat for an abundance of wildlife. Bald eagles (Haliaeetus leucocephalus) are common during migration and some nest along the river in pool 8. The area is especially important for diving ducks, tundra swans (Cygnus columbianus), Canada geese (Branta canadensis) and other waterfowl that use the aquatic and wetland habitats for resting and the wetland and adjacent terrestrial habitats for feeding during migration. Because of its importance to waterfowl, a large portion of lower pool 8 has been designated by the U.S. Fish and Wildlife Service as a closed area during the hunting season. The importance of the area is emphasized by the designation of the Upper Mississippi River as a waterfowl area of major concern in the North American Waterfowl Management Plan.

AQUATIC LIFE

The Upper Mississippi River is an ancient river system that has had a number of connections to other drainages during glacial times. This long geomorphic history and the mix of channel and shallow aquatic habitats in pool 8 has resulted in a high diversity of aquatic life. Species adapted to both lentic and lotic conditions are prevalent. Common species typically found in association with backwater areas include black crappie (Pomoxis nigromaculatus), bluegill (Lepomis macrochirus), shortnose gar (Lepisosteus platostomus) and largemouth bass (Micropterus salmoides). Species typically found in association with main channel/side channel habitats include sauger (Stizostedion canadense), walleye (S. vitreum vitreum), channel catfish (Ictalurus punctatus), flathead catfish (Pylodictis olivaris), freshwater drum (Aplodinotus grunniens), redhorse sucker (Moxostoma sp.) and white bass (Morone chrysops). Carp (Cyprinus carpio) and a variety of minnows are also commonly found in association with a wide variety of habitats. Fish sampling, conducted from 1989 to 1993 by the LTRM program in lower pool 8, indicated catch rates and species richness were low in open impounded areas compared to other habitats on the river. Shoreline areas appeared to have greater species richness than did offshore areas.

Woody debris and rock placed for bank revetments and channel training structures provides an abundance of hard substrate for filter-feeding invertebrates such as caddisflies (Hydropsyche spp.) and midges

(Glyptotendipes spp.) which in turn provide food for many species of lotic fishes. Silt and clay substrates in pool 8 support burrowing and filter-feeding macroinvertebrate species, including mayflies (Hexagenia spp.), and fingernail clams (Musculium sp. and Physa sp.). Macroinvertebrates are most abundant in silt and clay substrates within aquatic plant beds. An abundance of macroinvertebrates occur on aquatic plants, and provide a primary food base for lentic fishes in pool 8.

A number of surveys for Unionid mussels have been conducted in pool 8 in association with other studies and projects. The results of those surveys give an indication of the mussel resources present in pool 8. The mussel resources of upper Crosby Slough are relatively unimpressive. Fifteen live individuals representing five taxa were collected during a September 1994 sampling effort. Threehorn (Obliquaria reflexa), threeridge (Amblema plicata), pink papershell (Proptera laevissima), hickorynut (Obovaria olivaria), and white heelsplitter (Lasmigona complanata) were collected.

A similarly unimpressive mussel resource was sampled from the mouth of the Lawrence Lake area in August 1995. One mapleleaf (Quadrula quadrula), one pimpleback (Quadrula pustulosa), eleven threehorn and three threeridge were collected.

In contrast are the mussel beds sampled in lower Crosby Slough, Raft Channel, Stoddard Bay and the Heron/Trapping Island area of pool 8. Extensive mussel surveys have been conducted in these areas. The mussel beds are fairly diverse, but dominated by a few species. Threeridge, mapleleaf and threehorn were the most commonly collected and most abundant species in Stoddard Bay. Other species present, but less abundant, included the giant floater (Anodonta grandis), pink heelsplitter (Proptera alata), pimpleback, pocketbook (Lampsilis ovata ventricosa), white heelsplitter and deertoe (Truncilla truncata).

A higher diversity of mussel species was sampled in lower Crosby Slough. In addition to those listed above for Stoddard Bay, the following species were also collected from lower Crosby Slough: rockshell (Arcidens confragosus), fat mucket (Lampsilis radiata siliquoidea), hickorynut, pink papershell, fragile papershell (Leptodea fragillis), washboard (Megalonaias gigantea), paper floater (Anodonta imbecellis) and wartyback (Quadrula nodulata). The mussel beds in portions of Crosby Slough are fairly extensive and are indicative of a transition area between channel species and backwater species. Mussel beds appear to be concentrated on the eastern shelf and side slopes of Crosby Slough. Surveys indicate mussel beds in the upper portion of the lower slough are more diverse in species composition and higher in population densities.

The mussel resources of Raft Channel are diverse and moderately dense. As with lower Crosby Slough, the beds appear to be concentrated on the rather abrupt side slopes of the channel. Most of the species listed previously were sampled in Raft Channel. One additional species not previously mentioned was collected--the butterfly (Ellipsaria lineolata).

Mussel surveys conducted in the Heron/Trapping Island vicinity revealed an impressive bed of mussels dominated by threeridge. Of particular note, however, is the collection of a federally endangered Higgins' eye pearly mussel (Lampsilis higginsi) from the Heron/Trapping Island vicinity. The presence of this species is noteworthy because L. higginsi are typically associated with both dense and diverse beds of mussels, although single collections of this species are not uncommon.

In almost all recent mussel surveys conducted in pool 8, the non-indigenous species, the zebra mussel (Dreissena polymorpha), has been collected.

THREATENED AND ENDANGERED SPECIES

Two federally listed endangered species, the peregrine falcon (Falco peregrinus) and Higgins' eye pearly mussel may or do, respectively, occur in pool 8. One federally listed threatened species, the bald eagle, does occur in pool 8. The peregrine falcon and the bald eagle may be sighted during migration. Bald eagles occasionally use trees on islands and in the adjacent wooded floodplain areas for roosting.

One historical record and one recent record of the Higgins' eye pearly mussel are known from pool 8. Mussel surveys conducted in the early 1980's adjacent to the navigation channel, in 1989 in the Pool 8 Islands Phase I habitat project area, and in 1991 in Crosby Slough did not indicate the presence of Higgins' eye in these areas. Mussel surveys conducted in August-September 1994 near the Stoddard boat ramp did not reveal the presence of Higgins' eye pearly mussels at this site. A mussel survey was conducted in Stoddard Bay and in the area below Heron and Trapping Islands in 1995. This survey did not reveal the presence of any Higgins' eye pearly mussels in Stoddard Bay. However, one Higgins' eye pearly mussel was located below Heron and Trapping Islands in 1995.

A State threatened (Iowa) and endangered (Wisconsin) butterfly was collected from Raft Channel, while a State threatened (Wisconsin) wartyback was collected from lower Crosby Slough.

Fish sampling by the LTRM program has identified three Wisconsin-listed endangered fish species in pool 8--pallid shiner (Notropis amnis), crystal darter (Ammocrypta asprella), and skipjack herring (Alosa chrysochloris). In addition, the program has identified four Wisconsin-listed threatened fish species present in pool 8--speckled chub (Hybopsis aestivalis), blue sucker (Cycleptus elongatus), river redhorse (Moxostoma carinatum) and black buffalo (Ictiobus niger). In 1994, one young-of-the-year blue sucker was collected near the Benover Slough opening in the Pool 8 Islands Phase I project area.

CULTURAL RESOURCES

Robert F. Boszhardt, of the Mississippi Valley Archeology Center (MVAC), has conducted the most recent detailed study of pool 8, which he completed in 1989. The study focused on the lower part of pool 8 for the barrier islands project. In this study, Boszhardt reviewed the literature on pool 8 to date and reported on his phase I archeological survey of the project area. Much of this overview is drawn directly from Boszhardt's report, with some cuts and editing (Boszhardt, 1989a).

No overview cultural resources study involving field work has been undertaken in pool 8, according to Boszhardt. One literature/archival records review found a number of prehistoric and historic sites along the margins of pool 8 that include mounds, camps, villages, and structures representing some 10,000 years of human presence (Overstreet, 1982). Within the pool itself, archaeological sites have been recorded for two higher sandy landforms that likely represent cutoff or outlier terraces: these places are Goose Island and the White Camp area on a point just southwest of Stoddard. Both of these landforms have extensive remains of prehistoric occupation, ranging in time from Late Archaic to Oneota. The 1983 literature and records review by Overstreet also documented a few historic sites in pool 8, consisting of a bridge and the sunken steamboat wreck, the War Eagle, both near La Crosse.

A few surveys of selected or specified portions of pool 8 were undertaken in the 1980's. These included a survey in 1983 by an undergraduate student at the University of Wisconsin-La Crosse as an independent study project, a compliance survey of Hintgen Island by the Mississippi Valley Archaeology Center in 1988 and a survey of a small area at the upper end of the pool by MVAC (Boszhardt, 1988). These surveys found little evidence of cultural remains other than a few flakes on the upper end of Hintgen Island and remains of the former steamboat ferry landing ("Grand Crossing") that connected La Crosse and La Crescent prior to bridges. In addition, informants have reported a prehistoric archaeological site at Pettibone Island, and MVAC undertook an archival study of the island that focused on reports of 1830s to 1840s fur trading posts and Winnebago camps (Boszhardt, 1989b).

Boszhardt's literature review included an examination of county histories for Houston (Minnesota) and Vernon (Wisconsin) Counties, which border the pool, accounts of early explorers and travelers through this portion of the Upper Mississippi River, historic maps of the relevant portion of the Mississippi floodplain beginning with the Government Land Office Surveys (1846 for Wisconsin and 1851-53 for Minnesota) and continuing until the lock and dam construction, and miscellaneous documents such as steamboat records housed at the Area Research Center at the University of Wisconsin-La Crosse and fur trade accounts from the Green Bay and Prairie du Chien records in the archives of the State Historical Society of Wisconsin (copies of which are on file at MVAC). In addition, Boszhardt interviewed local collectors or other persons familiar with the floodplain. The field work consisted of travel to the various islands. At the time of the survey, the water level was at a relatively low stage, allowing pedestrian survey of the shorelines and beaches. Conditions for this type of coverage were excellent. The shorelines were walked by two persons. In addition, exposed back cuts were troweled clean and corings using a 1-inch-diameter oakfield soil probe allowed evaluation of stratigraphic sequences.

The results of Boszhardt's study leave unanswered many questions about the existence of cultural resources in pool 8. Informant interviews, he relates, did not reveal knowledge of archaeological or historic sites in the project area specifically, but did lead to the reporting of two prehistoric sites farther upstream in pool 8. Historic accounts found reference to an 1842 fur trade post at the foot of Coon Slough and several steamboat wrecks in Coon Slough itself. One of the wrecks may have occurred along the shore of one of the proposed barrier islands.

Boszhardt notes that the 1842 fur trade post was recounted by Nathan Myrick some 40 and 50 years later. In these accounts, he referred to a post operated by Henry B. "Scoots" Miller at the foot of Coon Slough. Miller became Myrick's partner later that year at La Crosse. Two trading posts are also documented on the Government Land Office survey plats for the area at the foot of Coon Slough, though these were probably not the same as Miller's. One post is shown on the Wisconsin mainland just above Genoa (Brown, 1846). The second post is shown nearly opposite the main channel on the Minnesota shore on what is floodplain. These posts were strategically situated at the point where Raft Channel and Coon Slough merge, thus providing control over fur trade traffic along the river and as convenient points to provide wood fuel for steamboats in the summer months. Farther upstream in pool 8, accounts refer to a post opposite the mouth of the Root River operated by Francois La Bathe in the late 1830's-early 1840's. La Bathe is known to have operated both trading posts and woodyards ("Chantiers") along this portion of the Upper Mississippi River during that period (Boszhardt, 1989b).

As noted earlier, although the main ("Raft") channel flowed west of Island 120, the deeper, swifter current of Coon Slough to the east was preferred by steamboats, Boszhardt says. However, as Coon Slough was more crooked than the Raft Channel, this led to several recorded steamboat wrecks. These include the wreck of the Lady Franklin at the foot of Coon Slough in

1856 and of the Northern Light at the first bend below the bend of Coon Slough in 1866. The location of the wreck of the Northern Light described as the first bend below the bend of Coon Slough could correspond with the lower (southeasternmost) proposed barrier islands; however, George Merrick (1987:103) described the wreck as having occurred at the sharp bend in Coon Slough, which probably referred to a bend lower down in Coon Slough than the project area.

No wrecks were found to be recorded for the Raft Channel along the west side of Island 120, and other than maps, no reference to the Raft Channel was located in the documents reviewed. It seems logical that this channel, being straighter than Coon Slough, was preferred by the large lumber rafts after about 1850. In fact, several sawmills are recorded in 1878 at Brownsville just upstream from Island 120, including one at the head of the island immediately below the town. The first wreck of the steamboat lumber raft Bella Mac occurred in April 1882 2 miles above Brownsville as the raft was returning to La Crosse for a load of lumber. This wreck, with a loss of nine lives, was caused by a boiler explosion. The stricken vessel drifted 2 miles downriver where it became stranded on the Wisconsin shore (probably just above Island 120). The Bella Mac was salvaged and rebuilt later that summer. No other record of historic sites on Island 120 or adjacent floodplain landforms was located.

Surface collection of exposed shorelines found a short concrete and rock wall at the very northern tip of Island 120. The wall is now separated from the island by a few meters and lies slumped due to erosion. From this foundation to the southeast for about 40 meters were scattered late historic artifacts including round nails and round spikes. These suggest the possibility that a small building was located at this site; however, no structures were found depicted on any historic maps of the area including the detailed 1929-31 Brown surveys. The index to 1933-34 pre-lock and dam flowage charts shows a trail, leading from this area of Island 120 down along the west shore, that may be related to these materials.

Other artifacts recovered along the northeast tip of Island 120 include a chain and padlock, a boat plug, a 1937-38 copper Wisconsin trappers tag, and a railroad spike. Other than the railroad spike, these materials probably reflect sporadic visits to this site by boaters, trappers, hunters, etc. The presence of a railroad spike is anomalous. It may have been associated with installment of rock revetment along this shore in the late 1800s. This revetment is shown as having been in place on the 1894 Mississippi River Commission Chart (No. 171), and penciled-in notations on 1877 Navigation Improvement maps indicate the revetment was placed here in the 1880s. Small sections of old revetment were observed in places along this shore, generally several meters out from the present shore.

In addition, the pedestrian survey along these shores observed numerous large stumps several meters out into the water, suggesting extensive erosion since the construction of the lock and dam as well as evidence of historic sediment alluviation. The stumps observed were of large trees, all sheared off at the same level, presumably reflecting clearing practices in advance of inundation of pool 8.

Evidence for historic alluviation was observed in exposed bank profiles along the extreme northeast end of Island 120 and in several soil probes. The highest exposed banks at the time of the survey stood 1.4 meters above the water level. Sediments exposed in these banks consisted of banded light and dark, medium-fine sand suggesting recent flood aggregation. In a few places, solid silt benches were exposed at the water level. These likely represent the original (pre-1850) island matrix. Coring farther down the shore of Island 120 found only medium-fine sand to the water table, suggesting the original island surface is entirely submerged at these places.

In addition, on the southeasternmost islands being considered for the barrier island, the survey found rock scattered over their grassy surfaces. This undoubtedly represents ice movement of the old rock revetment across the island surface, says Boszhardt. Ice-formed ramparts were observed at several places along these shorelines. In front of these small island remnants, numerous large, old stumps also mark the original island shore several meters into the water.

In conclusion, Boszhardt states, it is clear that much of the original island formation at the proposed barrier island has been either lost to erosion or inundated from the pooling above Lock and Dam 8. While these islands continue to erode, the survey also found that they had been subjected to historic accretion since Euro-American clearing of the land was initiated upstream about A.D. 1850. In light of the strategic location of the proposed pool 8 barrier islands at a point where the Mississippi River main channel divides, and given documented prehistoric and early historic use of the Upper Mississippi River floodplain by numerous successive cultures, it seems likely that archaeological deposits exist on the proposed islands, buried by post-settlement alluvium and/or now beneath the artificially raised water levels of pool 8. However, no evidence for potentially significant cultural resources was located during the Phase I survey.

Boszhardt has reported that a mussel hunter found several sites in the Goose Island area. The sites contained ceramic materials and burned rock (Anfinson, Personal Communication, 17 February 1996).

Data drawn from a recent database completed for pool 8 shows that 138 sites exist within the floodplain and its surrounding lands, as of the spring of 1995. Of these, 63 occur within the navigation zone. The navigation zone is defined as the areas within the Mississippi River main channel, island and backwater corridor and extending landward one-quarter mile past the railroad grade or principal meander belt levee shown on the 7.5-minute U.S. Geological Survey quadrangle, regardless of ownership. The navigation zone also includes publicly owned backwater sloughs in leveed districts where water levels are controlled. The navigation zone does not include the crest of the bluff even if it lies within the one-quarter mile corridor. Sixteen sites have been located on islands. Thirty-one of the total number of sites lie on channel shorelines: 21 on side channel shorelines and five each on tributary and main channel shorelines.

The nature of the sites listed is as follows:

Mounds: 20	Petroglyphs: 2	Cemetery: 21
Habitation: 76	Lithic Scatter: 2	Shipwreck: 1
Unknown: 7	Isolated Find: 1	Industrial: 1
Farmstead: 1	Rock Shelter: 1	

The great majority of these sites (96) have not been evaluated for their National Register significance; 15 have been found not eligible and six have been found eligible. Four of the six eligible sites fall in the navigation zone.

The Mississippi River Commission maps for pool 8 show numerous roads in the floodplain leading to agricultural lands and, in some cases, structures. The presence of these roads and structures demonstrates the potential for late 19th century use of the floodplain.

Based upon MVAC's findings and on past studies of pool 8, the probability for finding sites along the shorelines of the pool is good. However, older sites may be buried under significant levels of alluvium. The geomorphological study being conducted in 1996 should be able to provide detailed information to verify or alter this conclusion. The best strategy to take in evaluating the impact of the various water level management alternatives may be archeological monitoring.

SOCIOECONOMIC SETTING

The setting of the upland areas bordering lower pool 8 can be characterized as rural-small town. The developed communities bordering the study area include Brownsville on the Minnesota side of the river, and Stoddard and Genoa on the Wisconsin side. Brownsville has an approximate population of 500, while the approximate populations of Stoddard and Genoa are 800 and 300, respectively. The rural areas bordering lower pool 8 contain a mixture of agriculture and wooded areas. Flat areas on the bluff tops and in the stream valleys are farmed. Those areas too steep for farming are wooded.

La Crosse, Wisconsin, with an urban population of over 75,000 and La Crescent, Minnesota, (population 4,000) are located in the upper portion of pool 8. Lower pool 8 is bounded by transportation corridors on both sides of the floodplain. Railroad tracks border both sides of the river in lower pool 8. On the Wisconsin side, State Highway 35 parallels the river, while on the Minnesota side, State Highway 26 follows the river.

TRANSPORTATION INFRASTRUCTURE

Interstate 90 crosses the Mississippi (river mile 701.8) and Black (river mile 3.5) Rivers, County B crosses the Black River at river mile 1.7, and State Highway 14/16/61 crosses the Mississippi River at river mile 697.5. These are the only highway crossings in pool 8, and all are located in the La Crosse area. There is one railroad crossing in pool 8 at Mississippi River mile 699.8 and Black River mile 1.0.

Submerged cables and/or pipelines cross the Mississippi River at river miles 697.6, 697.8, and 699.8. Three submerged cable and/or pipeline crossings of the Black River occur between river miles 0.0 and 1.0.

RECREATION

Public recreation areas in lower pool 8 are Goose Island Park and Wildcat Park. Goose Island Park is 645 acres in size and is located on the Wisconsin side of the river at river miles 691 to 693. The park is not located on the main channel; however, boat access to the main channel is available via Mormon Slough and other backwater routes. The main focus of the park is for picnicking, camping, and as an access point to the river and adjacent backwaters.

Wildcat Park covers 105 acres and is located on the Minnesota side of the main channel at river mile 688. The primary focus of this park is also for picnicking, camping, and as an access point to the river. Recreational facilities and public access are also available in Brownsville, Stoddard, and Genoa.

There are no accurate counts of the total number of boaters who use pool 8. Information compiled from a variety of sources suggests that pool 8 comprises 10 to 12 percent of the total boating use in the St. Paul District (through pool 10). A rough estimate of the distribution of use among pools, applied to the total number of annual boaters measured in the Economic Impacts of Recreation study (Carlson et al., 1995), suggests there are approximately 450,000 boater visits in pool 8 annually (nearly 175,000 boats).

Boaters can access pool 8 from 36 sites, including 15 marinas (plate 4). Launching ramp sites are distributed fairly evenly up and down the pool, while the marinas are located primarily in the upper pool. There are approximately 1,140 marina slips in pool 8, with 90 percent located in the upper stretches.

Information about boaters making recreational lockages is quite limited in comparison to information about commercial lockages. The total number of recreational craft locking through Locks and Dams 7 and 8 has varied from 7,000 to over 9,000 annually in the 1990's; each lockage averages about 3.8 craft.

Research based on a limited sample of recreational lock users in pools 7 and 8, conducted in 1994, provides additional insight into recreational boaters using lock 8 (Vogel, Titre, and Chilman, 1995). While the sample surveyed was too small to provide high confidence in the specific percentages identified, the results provide useful indicators with regard to potential effects of proposed water level management alternatives.

The study found that 70 percent of boaters locking through Lock 8 lived outside the pool 7 and 8 study area. This is in stark contrast to the boaters who do not lock through, with 80 percent residing in the local area.

Nearly 75 percent of the boaters using lock 8 can be considered frequent users of the river (boating weekly or several times monthly), with the remaining 25 percent participating only a few times each year.

Locking through is a relatively infrequent activity for most. The majority of boaters (70 percent) reported locking through "occasionally" or "rarely" in comparison to the total number of trips they take on the river.

REAL ESTATE

The primary purpose of the navigation dams in the St. Paul District is to maintain a minimum channel depth of 9 feet for navigation. To allow navigation, project pool elevations must be maintained at or above project pool elevation at the primary control points. Operation of the dams is required at low and moderate flows, but the dams are not needed during high flows, and dam gates must be raised from the water well before flood stages are reached. Except for water that goes into valley storage as the inflows increase, all inflow must be discharged.

Prior to construction of the dams, field surveys established the ordinary high water profile. The location of the primary control point for pool 8 was determined to be at La Crosse, Wisconsin, at river mile 696.85. Project pool elevation of 631.0 is maintained at the primary control point, and the pool elevation at the dam is allowed to fall as the discharge increases. Drawdown at the dam is limited to 1 foot so that conditions for navigation and fish and wildlife are not damaged by extremely low water.

On navigable lakes and rivers, the Federal Government can use the riparian lands up to the ordinary high water mark for navigation, through the right of navigational servitude. By use of the mid-pool control point method of operation, the only area above the ordinary (pre-project) high water mark overflowed by operation of the dam is between the control point and the dam. This method of regulation greatly limited the area above the ordinary high water mark affected by dam operation and limited the cost to the Government of acquiring real estate flowage rights.

The Federal Government acquired virtually all the land in pool 8 for establishment of the Upper Mississippi River National Wildlife and Fish Refuge and for construction of the Mississippi River 9-Foot Channel Navigation Project. Land and water areas were acquired in fee title, and flowage easement was obtained on land around the periphery of the lower half of the pool. The Corps of Engineers and the U.S. Fish and Wildlife Service administer the federally owned land in pool 8.

Federal land in pool 8 was acquired in fee title primarily in the areas below project pool elevation and on islands within the pool. Federal Government rights of use on the Federal fee title land in pool 8 are complete. There are no legal restrictions against overflowing of water on the fee title land.

In areas that would be flooded intermittently by intentional regulation of Lock and Dam 8 and that were above the ordinary high water mark, flowage easement rights of use were acquired by the Federal Government prior to initial operation. These areas extend along the periphery of pool 8 from the primary control point at La Crosse downstream to Lock and Dam 8. Flowage easement rights of use were acquired for properties along the pool shoreline between the control point and the dam that were not acquired in fee title.

Flowage easement properties were acquired along the pool shoreline in order to encompass the land lying above the ordinary high water mark that would be overflowed by operation of the dam. The ordinary high water mark was a legally defined line along navigable rivers where recurring water levels prevented use of the land for agricultural or other purposes. In practice, the ordinary high water mark was identified by changes in vegetation cover and stranded debris. The flowage easements were acquired tract by tract, not up to any particular elevation, in order to encompass the pool downstream of the control point at La Crosse. The landward boundaries of most of the flowage easements, therefore, do not follow a particular elevation contour, but are assumed to be at least a few feet above the water surface elevation profile of the pool when the dam goes out of control at 95,000 cfs.

The flowage easement boundaries are described in the taking documents by metes and bounds. Flowage easement boundaries around pool 8 have not been monumented. Many flowage easement properties are narrow bands along the shore. Flowage easements were acquired along the railroad embankments that follow much of the pool 8 shoreline, for example, and are very narrow. The relationship between elevation and the landward boundaries of flowage easement properties cannot be defined exactly, lacking detailed elevation surveys.

Rights of use on flowage easement are defined in the eminent domain taking orders issued for the various flowage easement properties in Federal District Courts:

> **"...flowage easement being the full, complete and perpetual right, power, and privilege to overflow each and all of the tracts of land described, together with the right, power and privilege to cut, remove, and dispose of all wood, timber, and other natural and artificial structures, projections, or obstructions on said land, or in the slack-water pool created or to be created by said lock and dam, or on the margins thereof, which may in any way or at any time shall interfere with navigation or the use of the lands and pool for the maintenance and operation of said lock and dam, or to render said lock and dam, or the pool created thereby, inaccessible, unsafe, or unsanitary, together with the right to enter upon said lands from time to time, as occasion may require for any of the purposes aforesaid."**

This language is unequivocal on the right of the Federal Government to cause water to overflow the flowage easement property.

The Corps of Engineers acquired 9,496 acres of land and 635 acres of easements and obtained special rights on 14,588 acres of land and water area in pool 8 administered by the U.S. Fish and Wildlife Service prior to initial project operation (figure 2-6). All of the Corps-administered land except for recreation areas at Goose Island Park, Wildcat Park, Stoddard Park, and at the lock and dam have been placed under cooperative agreement for management by the U.S. Fish and Wildlife Service as part of the refuge system. Aside from land acquired for construction of Lock and Dam 7, the Corps of Engineers did not acquire any land or flowage easements in pool 8 above the primary control point.

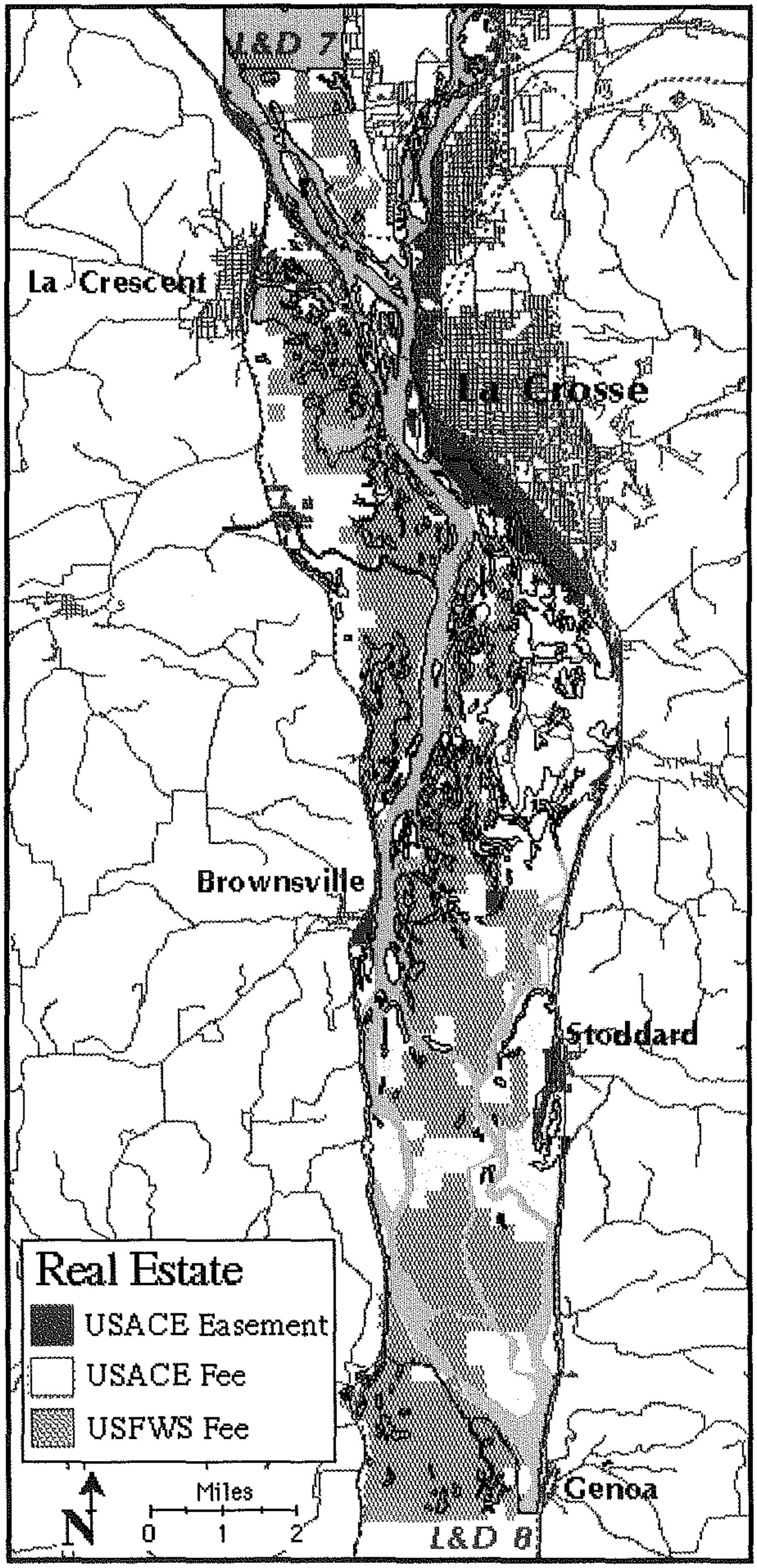


Figure 2-6. Federal Land Ownership in Pool 8

SECTION THREE - PLANNING CONSIDERATIONS

GOALS AND OBJECTIVES

Goals and objectives for a resource such as the Upper Mississippi River can vary greatly depending upon perspective. Federal and State agencies have mandates that require them to focus on particular aspects or uses of river resources. The public and users of the river all have their perspectives on desired future conditions of the river, and on what functions or uses should receive priority for management.

The overall goal for this water level management study is to improve ecological conditions in pool 8 through water level management. The Water Level Management Task Force collectively agreed that modifications to river regulation that result in a more natural (unregulated) hydrologic regime would improve ecological conditions. The Water Level Management Task Force drafted the following overall goal for this study.

'Revitalize the river's natural processes to encourage drying and scouring to increase habitat diversity and quality for the benefit of a range of fish and wildlife species indigenous to the Upper Mississippi River.'

Specific objectives that describe desired future conditions are normally defined in the course of water resource planning efforts. Specific objectives for the future condition of pool 8 and the Upper Mississippi River that are ecologically sustaining and socially desired have not been defined through a planning process for integrated management. The Water Level Management Task Force did agree upon a set of more limited objectives to be attained through water level management for purposes of this study. These objectives are:

1. Establish annual emergent aquatic vegetation.

2. Establish perennial emergent aquatic vegetation.

3. Establish submersed aquatic vegetation.

4. Consolidate high water-content sediment.

These first four are the primary objectives for water level management identified for this study. The following objectives relate to certain water level management alternatives.

5. Improve tailwater habitat conditions.

6. Provide a more natural flood hydrograph.

7. Enable the use of excavating equipment to construct habitat projects.

Each water level management alternative considered in this study has one or more associated objectives. These are discussed in Section 4 in the description of the alternatives.

OPPORTUNITIES AND CONSTRAINTS

All systems of river regulation have opportunities for improvement and constraints on change. The water regulating structure (Lock and Dam 8) provides an opportunity to manage water levels in pool 8 for purposes in addition to commercial navigation. This is a significant opportunity because much of the pool can be affected with the use of an existing water control structure. Water level management is commonly used to improve the ecological condition in regulated freshwater systems. Water level management experiences from around the world amply demonstrate that opportunity exists for improving the ecological conditions of the Upper Mississippi River.

Constraints on changing the present system of river regulation include hydrologic, engineering, legal and administrative constraints (Wilcox and Willis, 1993). Lock and Dam 8 has physical constraints that determine the range over which water levels can be managed (elevation) and how rapidly changes can be achieved (discharge capacity). Appendix B of this report addresses the constraints associated with regulation of pool 8. These constraints can be summarized as follows:

Hydrologic - Inflow to pool 8 is largely unregulated and is determined by precipitation and runoff.

Engineering - The dam design limits the range of water level regulation.

- Pool 8 is part of the Upper Mississippi River 9-Foot Navigation Channel Project and must be regulated as part of this system.

- The rate of change in the releases from the dam is determined by discharge capacity of the gate portion of the dam, the gate operating mechanisms and controls, and the availability of personnel to change gate settings.

- Distribution of flow between gates across the face of the dam is limited by the need to avoid exceeding velocities that might scour the base of the dam.

Legal - A number of laws and regulations govern the regulation of pool 8.

- Pool 8 is part of the Upper Mississippi River 9-Foot Navigation Channel Project, and adequate water depths for navigation must be provided.

- Regulation of pool 8 cannot inundate non-Federal lands for which the Federal Government has not obtained the legal rights of use such as fee title or flowage easements.

- Changing the present system of regulation could have significant effects on the ecology of the river and the human environment, requiring analysis of these potential effects and compliance with the substantive and procedural requirements of the National Environmental Policy Act and a number of other laws and regulations.

<u>Administrative</u> - Administration of Corps of Engineers water control management activities is described in internal agency Engineering Manual 1110-2-3600, dated November 30, 1987. The Corps system of water control management imposes procedural and substantive requirements on changing reservoir regulation plans.

Because regulation of the Upper Mississippi River is a complex, high-stakes enterprise, constraints on changing the present system are correspondingly complex. Other than the hydrologic constraints, however, all the constraints on changing the present system of river regulation have been imposed by construction of the navigation system and by laws and regulations. These constraints are possible to change. One area of emphasis in this study has been to identify and to quantify, where possible, the constraints associated with water level management alternatives that involve changes to the present system of river regulation.

<u>Ecological</u> - In addition to contraints on changing river regulation, changing ecological conditions in the Upper Mississippi River has many constraints. No single management measure, including water level management, can be expected to bring about a major change in ecosystem state. The decline in aquatic vegetation that has occurred throughout much of the Upper Mississippi River has its origins in hydrologic events that affect underwater light and nutrient availability as well as the effects of impoundment and river regulation. Water level management measures must be carefully planned to avoid adverse ecological effects. Opportunities do exist for improving ecological conditions on the Upper Mississippi River through water level management by simulating an unregulated hydrologic regime to the extent practicable.

SECTION FOUR - ALTERNATIVES

This section describes the water level management alternatives identified by the Water Level Management Task Force for study and their assignment of priority within the study process.

ALTERNATIVES IDENTIFIED

The following water level management alternatives were identified for study. They range from the physical modification and independent management of small waterbodies to changes to the present system of river regulation.

SMALL-SCALE MEASURES

Temporary Isolation and Drawdown of Small Waterbodies

Small waterbodies could be temporarily isolated and drawn down (and reflooded) on a one-time or infrequent basis. The objective of this management measure would be to establish or increase the extent of vegetation and to consolidate sediments, thereby improving habitat conditions for fish and wildlife. This management technique would best be suited to small waterbodies that are already isolated from the river, or could be isolated with a minimal amount of effort. Drawdown would typically be accomplished with portable pumps.

Regular Water Level Management of Small Waterbodies

Berms constructed to temporarily isolate small waterbodies could be left in place to minimize the cost of conducting subsequent drawdowns. The closure berms could be breached to reconnect the small waterbodies with the river following the initial drawdown, and could readily be closed with fill or sandbags prior to subsequent drawdowns. Permanent water control structures could be installed to allow more water level management flexibility. Subsequent drawdowns could be conducted as needed to maintain desired vegetation and substrate conditions.

MID-SCALE MEASURES

Temporary Isolation and Drawdown of Larger Waterbodies

Large waterbodies could be temporarily isolated and drawn down on a one-time or infrequent basis. As with the small-scale drawdown alternatives previously discussed, the objective of this management measure would be to establish or increase the extent of vegetation and to consolidate sediments, thereby improving conditions for fish and wildlife.

This management technique would best be suited to waterbodies that already are mostly isolated from the river, or could be isolated with a minimal amount of effort. Drawdown of large waterbodies could be expensive to accomplish by pumping. An alternative measure that could be employed would be to draw the pool down by a few feet for a short period of time to dewater the sequestered area.

Regular Water Level Management of Larger Waterbodies

Larger waterbodies could be permanently isolated from the river through the use of dikes, berms, etc. Water control structures could be installed to allow more water level management flexibility. Water level management would take place on a regular basis, or at least more frequently than with the alternative discussed previously.

LARGE-SCALE MEASURES WITHIN THE PRESENT SYSTEM OF RIVER REGULATION

Discontinue 0.25-Foot Winter Drawdown

Appendix B describes winter operation for Lock and Dam 8. Under this alternative, the 0.25-foot drawdown of pool 8 over the winter would be discontinued. The objective is to provide slightly more water volume in backwater areas over the winter which, in turn, would reduce habitat reductions and fish kills associated with dissolved oxygen depletion.

The St. Paul District discontinued the practice of winter drawdown of the navigation pools in the winter of 1995-96. The 0.25-foot change in winter water levels is probably too small to monitor to determine effects on frequency and spatial extent of dissolved oxygen depletion in backwaters, but the effects are likely to be positive. Intensive monitoring of under-ice conditions in Lawrence Lake in pool 8 during the winter of 1995-96 revealed that a small increase in water level conveyed cold water and dissolved oxygen in the lake immediately under the ice, and that subsequent decreases in water level resulted in removal of the oxygenated layer of water (Soballe, Rogala, and Fischer, 1996). Water exchange may be more important than initial volume of backwaters at the onset of winter in maintaining dissolved oxygen in backwater areas.

Regulation on the "High" or "Low" Side of the Regulating Band

The regulating band for pool 8 during the open water season is ±0.2 foot. With this alternative, the District would make a conscious attempt to regulate the pool at the high or low side of this band. Potential ecological benefits would be to provide slightly deeper water which may improve habitat conditions for certain organisms and provide some degree of control of undesirable vegetation, or to provide slightly shallower water to improve conditions for the growth of vegetation.

This alternative (regulation on the low side of the regulation band as water conditions allow during the growing season) has been successfully conducted in pools 24, 25, and 26 in the St. Louis District. There, the regulating band is wider, and changes in river discharge are much larger and more frequent. This practice has resulted in lush growth of annual vegetation (Wlosinski and others, in preparation) which, when reflooded in the fall, provides habitat for small fish and migrating waterfowl. Prevailing turbidity and the wide range of water level fluctuations that occur in that reach of the river prevent establishment of much perennial aquatic vegetation through water level management.

Increase the Frequency of Gate Adjustments

Increasing the frequency of gate adjustments would smooth out some of the more abrupt changes in flow through the dam gates. Potential ecological benefits would be to reduce the frequency and amplitude of short-term (time scale of hours to days) water level fluctuations. A smoother stage hydrograph would improve habitat conditions in the extensive shallow aquatic and wetland areas. More frequent gate adjustments during a pool drawdown would reduce reflooding of portions of the drawdown zone and increase the area with good vegetation response.

Modify Distribution of Flow Through the Dam Gates

There is some flexibility in how flows are distributed between gates across the face of the dam. The potential exists to improve tailwater habitat conditions through changing the distribution of flow through the gates.

LARGE-SCALE CHANGES TO THE PRESENT SYSTEM OF RIVER REGULATION

Spring Pool Raises

Normally, the operation of Dam 8 has little effect on spring high water levels. It may be possible to raise water levels during years with low river discharge in the spring to benefit species that make use of flooded habitats.

Winter Drawdown

Under this alternative, the pool would be drawn down to dewater backwater areas. This would allow earth-moving equipment to be used to improve physical habitat conditions; e.g., create deep holes or channels, remove accumulated fine sediments, and build islands.

Change the Primary Control Point from Mid-pool to the Dam

Pool 8 has a mid-pool primary control point for flows up to 23,000 cfs. At flows above 23,000 cfs, control is shifted to the dam (secondary control). Under this alternative, the control point for pool 8 would be at the dam for all flows up to the point where the dam no longer controls the pool. Changing the primary control point to the dam would eliminate the unnatural condition under primary control where water levels between the primary control point and the dam actually decrease as the river discharge is rising.

Short-term (1 to 2 weeks) Drawdowns

As described for Mid-Scale alternatives, short-term drawdowns of the pool could be used to draw down larger waterbodies.

Mid-term (1 to 2 months) Drawdowns

Pool 8 would be drawn down for 1 to 2 months during the growing season. The primary purpose of the drawdown would be to expose substrate primarily to promote the growth of annual emergent aquatic plants. Some perennial plant growth and sediment consolidation would also occur.

Long-term (entire growing season and longer) Drawdowns

Under this alternative, pool 8 would be drawn down for an entire growing season or longer, perhaps through the following growing season. The primary objective would be to promote the growth of perennial emergent aquatic plants and for sediment consolidation. The growth of annual plants would also occur.

ALTERNATIVES SELECTED FOR EVALUATION

All the alternatives identified merit further evaluation. However, the time and funding constraints for the study required focusing on the alternatives that appeared to have the greatest potential for providing substantial benefits. Thus, the Water Level Management Task Force designated the alternatives as either high, medium, or low priority for evaluation.

High Priority - These alternatives would be the focus of the study effort. The benefits and negative effects of the alternatives would be quantified, wherever possible.

Medium Priority - These alternatives would also be studied, with benefits and negative effects quantified, where possible. The level of effort expended would be less than for the high priority alternatives.

Low Priority - These alternatives would be studied only as time allows. The benefits and negative effects would be addressed in a qualitative manner.

The alternatives were prioritized as follows. For each alternative, it is noted whether the measure would affect the entire pool or whether it would target specific sites within the pool.

High Priority

* mid-term growing season drawdowns (pool-wide)
* long-term drawdowns (pool-wide)

Medium Priority

* small-scale measures (site-specific)
* medium-scale measures (site-specific)
* discontinue winter drawdowns (pool-wide)
* regulate on the high or low side of the regulating band (pool-wide)
* change the primary control point from mid-pool to the dam (pool-wide)

Low Priority

* increase the frequency of gate adjustments (pool-wide)
* modify the distribution of flow across the dam gates (site-specific)
* spring pool raises (pool-wide)
* winter drawdowns (pool-wide)

SECTION FIVE - EVALUATION

This section discusses the evaluation of alternative water level management measures. A brief description of each alternative is followed by an evaluation of the expected effects upon river resources and river users. In many instances, study time and funding constraints only allowed for a qualitative evaluation of potential effects.

SMALL-SCALE MEASURES

Under this alternative, small waterbodies in the pool 8 floodplain would be isolated and drawn down to promote better conditions for the growth of emergent aquatic vegetation. Initially, two options were to be evaluated: (1) temporary isolation and drawdown, and (2) provision of closure berms and possibly water control structures to allow repeated drawdown in years following the initial construction and drawdown. As cost estimates were developed, it became evident that construction mobilization and berm construction were the most costly items for isolating many of these wetlands. The additional cost of adding a water control structure became a relatively small increment. Therefore, it was assumed that, if an area had to be bermed and was over 5 acres in size, a low-cost water control structure would be installed to allow management of water levels on a regular basis. For sites that would be isolated through the use of sandbags and/or were less than 5 acres, it was assumed that no water control structure would be added.

Initially, 33 waterbodies in pool 8 (plate 5) were identified as having the physical characteristics that would lend themselves to isolation and drawdown. Screening eliminated sites #30 and #31, and a third site (#24 - Lawrence Lake) was considered large enough to be treated as a mid-scale measure. Table 5-1 contains information concerning the remaining 30 sites, while table 5-2 summarizes cost and potential area benefited information.

The cost approximations shown are not detailed construction cost estimates. They are based on construction costs experienced within the UMRS-EMP habitat rehabilitation and enhancement projects (HREP) program. The construction costs include costs for mobilization/demobilization (mob/demob), construction of low berms, and installation of a low-cost water control structure. The sites with no construction costs are waterbodies that are naturally isolated by topography or man-made features such as roads and railroads.

Table 5-1
Small Scale Drawdown Sites in Pool 8

Site #*	Acres	Depth**	Ownership	Diking	Access	Structure
1	9	0-1	Federal	none required	good	no
2	13	0-1	Federal	600' of sandbags	poor	no
3	6	0-1	Federal	none required	good	no
4	7	0-1	Federal	200' of berm	poor	yes
5	14	0-1	Non-Federal	200' of berm	good	yes
6	2	0-1	Federal	300' of berm	good	no
7	2	no data	Non-Federal	100' of berm	poor	yes
8	7	0-2 (0-1)	Federal	100' of berm	adequate	yes
9	8	0-2 (1-2)	Federal	300' of berm	adequate	yes
10	2	0-1	Federal	none required	adequate	no
11	6	0-2	Non-Federal	100' of berm	adequate	yes
12	2	no data	Non-Federal	none required	adequate	no
13	4	no data	Non-Federal	100' of berm	good	no
14	7	no data	Federal	100' of berm	adequate	yes
15	6	no data	Non-Federal	100' of sandbags	adequate	no
16	10	no data	Non-Federal	none required	poor	no
17	26	0-2	Federal	200' of berm	adequate	yes
18	3	no data	Non-Federal	none required	poor	no
19	10	no data	Non-Federal	none required	poor	no
20	11	no data	Federal	none required	poor	no
21	7	0-4 (2-3)	Federal	100' of berm	poor	yes
22	9	0-2	Federal	900' of sandbags	poor	no
23	3	no data	Federal	300' of sandbags	poor	no
25	2	no data	Federal	none required	good	no
26	2	no data	Federal	100' of sandbags	adequate	no
27	61	0-2 (1-2)	Federal	400' of berm	good	yes
28	3	no data	Federal	none required	good	no
29	10	no data	Non-Federal	none required	good	no
32	4	no data	Federal	none required	good	no
33	6	0-3	Federal	100' of berm	adequate	yes

* Sites 24, 30, and 31 eliminated from consideration

** Depth data based on 1989 LTRM bathymetry; range in parenthesis indicate the most prevelant depth range.

Table 5-2
Summary of Small Scale Drawdown Costs

Site #	Acres	Ave Depth	Estimated Construction Cost**	Estimated Operational Cost/Event***	Average Annual Cost	Ave Annual Cost/Acre Benefited
1	9	1	$0	$10,000	$1,892	$210
2	13	1	$50,000	$25,000	$14,189	$1,091
3	6	1	$0	$10,000	$1,892	$315
4	7	1	$50,000	$20,000	$9,304	$1,329
5	14	1	$30,000	$15,000	$6,150	$439
6	2	1	$30,000	$15,000	$6,150	$3,075
7*	2	2	$30,000	$15,000	$6,150	$3,075
8	7	1	$30,000	$20,000	$7,096	$1,014
9	8	2	$40,000	$20,000	$8,200	$1,025
10	2	1	$0	$15,000	$2,838	$1,419
11	6	2	$30,000	$20,000	$7,096	$1,183
12*	2	2	$0	$15,000	$2,838	$1,419
13*	4	2	$20,000	$15,000	$5,046	$1,261
14*	7	2	$30,000	$20,000	$7,096	$1,014
15*	6	2	$20,000	$20,000	$7,568	$1,261
16*	10	2	$30,000	$25,000	$8,042	$804
17	26	2	$40,000	$35,000	$11,038	$425
18*	3	2	$30,000	$20,000	$7,096	$2,365
19*	10	2	$30,000	$25,000	$8,042	$804
20*	11	2	$30,000	$25,000	$8,042	$731
21	7	3	$40,000	$25,000	$9,146	$1,307
22	9	2	$50,000	$25,000	$14,189	$1,577
23*	3	2	$40,000	$20,000	$11,352	$3,784
25*	2	2	$0	$10,000	$1,892	$946
26*	2	2	$20,000	$15,000	$6,622	$3,311
27	61	2	$50,000	$15,000	$8,358	$137
28*	3	2	$0	$10,000	$1,892	$631
29*	10	2	$0	$15,000	$2,838	$284
32*	4	2	$0	$10,000	$1,892	$473
33	6	2	$30,000	$20,000	$7,096	$1,183
Total	262	n.a.	$750,000	$550,000	$172,776	N/A
Mean	8.7	n.a.	$25,000	$18,333	$5,759	$659

* no bathymetric data available, average depth of 2 feet assumed for pumping costs
** rounded to nearest $10,000
*** rounded to nearest $5,000

The operational costs are costs associated with a single drawdown event; e.g., mob/demob of pumping equipment and pumping costs. The operational cost estimates do not include estimates for maintenance pumping if seepage becomes a problem, as predicting seepage is beyond the depth of detail of this study. However, if seepage becomes a problem, the operational costs of maintenance pumping could equal or exceed the costs of the original drawdown pumping.

Average annual costs were computed at the current Federal interest rate of 7 5/8 percent for a period of 25 years. The figures include discounted future costs for future operational "events" at years 8, 15, and 22. Each "event" includes the estimated operational cost plus 20 percent of the initial estimated construction cost for project maintenance for sites that would be isolated by earth berms. For sites isolated with the use of sandbags, it was assumed that the sandbags would have to be fully replaced for each drawdown event.

Hydrologic/Hydraulic Changes

Isolation and management of small waterbodies would have site-specific hydrologic/hydraulic effects on those waterbodies. Connectivity between channel areas and the isolated water bodies would be interupted, at least on a temporary basis. Overall, there would be no appreciable impact on the hydrology or hydraulics of pool 8 because of the small size of the areas being affected.

As noted earlier, seepage could be a factor in the ability to maintain drawdowns in the isolated waterbodies. The potential for seepage would need to be evaluated on a site-specific basis prior to implementation of a drawdown project.

Water Quality

Construction of berms and excavation of interior channels and pumping basins would create minor, localized, and temporary increases in suspended solids. Drawdown of the small-scale sites by pumping would mobilize higher water content surficial sediments, creating a suspended solids plume at the discharge point during the latter phases of drawdown. Upon refilling of the sites, the oxidized sediments, coupled with leaching of standing vegetation, would mobilize plant nutrients, creating the possibility of algal blooms within the drawdown sites. Flooded terrestrial vegetation within the drawdown zones would senesce and die, depleting dissolved oxygen as the plant tissue decomposed over the winter. Single-inlet drawdown sites would probably not have much dissolved oxygen during winter; however, flow-through sites could have adequate dissolved oxygen during the winter following drawdown. If achievable, consolidation of sediment in the drawdown sites may limit sediment resuspension by wave action and resuspension by fish activity. Seepage may prevent drying of sediments.

Ecological

Construction of berms and interior excavation to allow drawdown would disturb limited areas of shallow aquatic and floodplain habitat. Berm construction would disturb strips of floodplain habitat approximately 50 feet wide, or about 6 acres for every mile of berm constructed. The managed waterbodies would be temporarily isolated from the river, preventing movements to and from flowing parts of the system by fish. Upon drawdown of the sites, fish and other forms of aquatic life would be stranded and desiccated unless "rescued." The stranded fish and macroinvertebrates in the drawdown sites would become easy prey for eagles, herons, egrets, wading birds, mink, and raccoons. Most species of submersed aquatic plants in the dewatered zones would be killed, but their seeds are resistant to dessication. Submersed aquatic plants would rapidly recolonize the drawdown zones upon reflooding. Most species of emergent aquatic plants present in the drawdown zones would survive the drawdown period. The undesired exotic purple loosestrife (Lythrum salicaria) would survive and probably colonize further during a drawdown.

During drawdown and dewatering of the sediments, annual plants and seedlings of emergent aquatic plants and willows and cottonwoods would develop in about a month and a half. The species composition and density of vegetation that would develop would depend on a variety of factors, including the plant propagules (seeds, tubers, and rhizomes) present in the sediment, the seasonal timing of drawdown, the degree of sediment dewatering that occurs, weather conditions, etc. If the drawdown sites were reflooded in the fall to the pre-drawdown water level, the terrestrial woody and herbaceous plants would be killed within about 1 month, along with most of the seedlings of emergent aquatic plants. Some emergent aquatic plants could become established in the shallowest (less than about 1 foot) depth areas of the drawdown zones. The standing vegetation would provide good habitat for small fish if the closure berm or water control structures were reopened to allow fish access. The standing vegetation would also provide an abundant food source for migrating waterfowl and spawning habitat for fish the following spring. Consolidation of the sediments during drawdown should persist for some time following reflooding, limiting sediment resuspension by wave action and bioturbation, and creating good conditions for recolonization by submersed aquatic plants. Benthic macroinvertebrates probably would recolonize the reflooded sites in the year following drawdown.

If the small-scale drawdown sites were kept drawn down into winter, and were drawn down at least partially following the spring flood for the next growing season, perennial emergent aquatic plants could become established in much of the drawdown zones. This water level management regime would approximate an extended period of low river discharge in an unregulated river. Many species of emergent aquatic plants can become established only under dewatered substrate conditions followed by a long and gradual increase in water level, allowing germination of propagules and survival of seedlings without deep reflooding before they attain sufficient height.

Establishment of perennial emergent aquatic plants would be desirable in many smaller floodplain waterbodies to provide habitat for fish and wildlife. Once the plants were established, high water and grazing by muskrats would reduce the extent and density of emergent plants over a number of years to the point where another drawdown would be appropriate management.

Operations

Isolation and drawdown of the waterbodies identified in table 5-1, either on a one-time or on a recurring basis, would have no effect on the operation of pool 8.

Channel Maintenance

Isolation and drawdown of the waterbodies identified in table 5-1, either on a one-time or on a recurring basis, would have no effect on maintenance of the navigation channel in pool 8.

Commercial Navigation

Isolation and drawdown of the waterbodies identified in table 5-1, either on a one-time or on a recurring basis, would have no effect on commercial navigation in pool 8.

Transportation Infrastructure

Isolation and drawdown of the waterbodies identified in table 5-1, either on a one-time or on a recurring basis, would have no effect on the transportation infrastructure in pool 8.

Water Appropriations

Isolation and drawdown of the waterbodies identified in table 5-1, either on a one-time or on a recurring basis, would have no effect on the water intake to the French Island generating station.

Real Estate

Twenty of the sites evaluated are located on Federal property within the Upper Mississippi River National Wildlife and Fish Refuge. No additional real estate requirements should be necessary for implementation.

Ten sites are located on private property. Implementation of a project at these sites normally would require fee title acquisition, an easement, or some other agreement with the landowner, depending upon the real estate regulations of the implementing agency, in this instance most likely a state natural resource agency.

Recreation

Isolation and drawdown of select small waterbodies, either on a one-time or on a recurring basis, would have negligible effects on recreation. The majority of sites are remote, and they are small in comparison to the total size of available areas in the pool. There could be localized disruption to recreation at the site (or sites) chosen during periods of operation. In many cases these sites are naturally isolated; however, in some instances they are accessible by recreational craft. Isolation of the sites for water level management would curtail recreational boat access during the period of isolation.

Long-term benefits to recreationists would be expected, to the extent that improvements to fish and wildlife are realized. These effects are not defined well enough to be quantified.

Aesthetics

Some intrusions on the natural environment would be associated with all of these projects; i.e., construction activity and/or pumps running. For the most part, these projects would be located in isolated areas. Others are located in areas where there is more human use. Any adverse effects are expected to be localized and are not considered significant. Establishment of vegetation in sites with little existing vegetation would be an aesthetic improvement.

Cultural Resources

The general effects of drawdown on cultural resources are discussed in detail in later sections of this report under the evaluation of pool-wide drawdowns.

Thirty backwater sites have been identified as potential drawdown sites for the small-scale measures (see table 5-1). Thirteen of these sites would require the construction of a berm, five would be closed with sandbags, and 12 would require no structure. Implementation of the small-scale drawdowns could also require the excavation of interior channels and pumping basins, the acquisition of fill from somewhere, and the construction of access to the sites. Many of these actions have the potential to affect archeological sites.

In the discussion below, the drawdown sites are divided into groups. Five of the drawdown site groups lie in areas with many known archeological sites, including burials, habitation sites and historic sites. The following groups of drawdown sites fall into this category:

- drawdown sites 1 through 7, which lie just downstream of Lock and Dam No. 7 or along the Black River.

- drawdown sites 8 through 14, which cluster near the downstream end of French Island or near Minnesota, Taylor and Barron Islands.

- drawdown sites 25 through 29, which lie on or near Goose Island.

- drawdown sites 32 and 33, which lie along the Wisconsin shore just below Stoddard. (Site 31 also falls within this group, but is not being considered for small-scale drawdown.)

- drawdown sites 15, 16, 18, 19, and 20, which lie along the Minnesota shore. All are well back from the main channel and follow near Minnesota State Highway 16. Although fewer known archeological sites exist in this area, three mounds and a petroglyph are among those known.

Due to the significance and density of archeological sites in the areas described above, archeological surveys would need to be conducted prior to any ground-disturbing activities needed to isolate the drawdown sites for water level control. When a site is drawn down, an archeologist should survey the exposed shoreline for cultural resources and should report the effect the drawdown may be having on the sites found. The source of any fill would need to be evaluated for cultural resources before use.

Drawdown sites 17, 22, and 23 lie among the mid-channel islands between river miles 692 and 695. Almost no archeological sites are known to exist on these islands. The reason may be that they are deeply buried. Nevertheless, archeological surveys should be conducted prior to any ground-disturbing activities needed to isolate the drawdown sites for water level control. When a site is drawn down, an archeologist should survey the exposed shoreline for cultural resources and should report what effect the drawdown may be having on the sites found.

Implementation Procedures

Isolation and water level management of small aquatic areas could be implemented by river resource management agencies. Of the 30 sites identified in pool 8, 20 are located on the Upper Mississippi River National Wildlife and Fish Refuge. The U.S. Fish and Wildlife Service would be the lead agency in implementing any management actions at these sites.

For the 10 sites located outside the Refuge, the State natural resource management agency would be the lead agency, working in conjunction with the landowner, for implementing management actions at these sites.

The U.S. Fish and Wildlife Service has indicated that operation and maintenance requirements would be serious concern with use of this management measure on the Refuge. It is expected that this would be an important consideration for any implementing agency in their decision whether to employ this management measure.

MID-SCALE MEASURES

With this alternative, large waterbodies would be temporarily isolated and drawn down in a manner similar to that discussed for small waterbodies. An analysis of pool 8 indicates that only one large waterbody (Lawrence Lake) could be isolated without a significant investment in diking systems. Lawrence Lake is located on the Minnesota side of the floodplain between river miles 690.5 and 693.0. Table 5-3 shows the depth-area relationship for Lawrence Lake.

Table 5-3
Depth-Area Relationship for Lawrence Lake

Depth Range (ft)	Acres	Percent	Cumulative Percent
0.0 - 1.0	336	53	53
1.0 - 2.0	141	22	75
2.0 - 3.0	83	13	88
3.0 - 4.0	28	4	92
4.0 - 5.0	18	3	95
5.0 - 6.0	17	3	98
> 6.0	16	2	100
	639		

Initially, two drawdown scenarios for Lawrence Lake were to be evaluated, gravity drawdown and pumping. Bathymetric data indicates that the controlling depth for gravity drawdown of Lawrence Lake is approximately 2 feet. A 2-foot drawdown would dewater approximately 75 percent of the lake. Therefore, a 2-foot drawdown of Lawrence Lake was used as the operating scenario.

A 2-foot drawdown of Lawrence Lake by gravity would not be physically possible during medium (40,000 cfs) to high flow (75,000 cfs) conditions. In fact, the maximum drawdown that could be achieved at these higher flow levels would be about 1.8 feet under open river conditions at 40,000 cfs. At a low flow condition of 22,000 cfs, a 2-foot drawdown of Lawrence Lake by gravity would require about a 3-foot drawdown at the lock and dam.

Because of the physical constraints and the unlikelihood that a major drawdown of pool 8 would be undertaken solely for the purpose of dewatering Lawrence Lake, pumping is the only practicable option. The effects of drawing down Lawrence Lake by pool drawdown are included in the evaluation of the pool-wide growing season drawdown alternatives.

To draw down Lawrence Lake by pumping would require isolating the lake with a 2,000-foot-long low dike across its lower end above the area occupied by the Lawrence Lake marina and the boathouses. This would avoid the conflicts associated with isolating the marina and boathouses from the river. This would reduce the area of Lawrence Lake that could be isolated and managed to approximately 557 acres, 429 of which have water depths of 2 feet or less. The depth breakdown of the manageable portion of Lawrence Lake would be as shown in table 5-4.

Table 5-4
Depth-Area Relationship for Manageable Portion of Lawrence Lake

Depth Range (ft)	Acres	Percent	Cumulative Percent
0.0 - 1.0	304	55	55
1.0 - 2.0	125	23	78
2.0 - 3.0	74	13	91
3.0 - 4.0	23	4	95
4.0 - 5.0	13	2	97
5.0 - 6.0	12	2	99
> 6.0	6	1	100
	557		

Because of the level of investment required to isolate and manage an area such as Lawrence Lake, it was assumed for cost estimating purposes that the dike constructed to isolate the lake would have to be more substantial and durable than the berms used to isolate the small areas evaluated in the previous section. It is estimated that construction of a 2,000-foot dike across the lower end of Lawrence Lake, with rock protection and a water control structure, would cost an estimated $300,000. The estimated cost of a 2-foot drawdown of Lawrence Lake for an entire growing season (June 15 through September 30) using pumps is approximately $50,000 per event. As with the small-scale drawdowns, this estimate does not include costs for maintenance pumping if seepage becomes a problem.

The same 25-year project life and cost annualization procedures were applied to Lawrence Lake as were used for the small-scale measures. The average annual cost of isolating and managing Lawrence Lake water levels would be approximately $40,000, with an estimated cost per acre benefited of about $93.

Hydrologic/Hydraulic Changes

The connectivity between Lawrence Lake and the river would be eliminated, at least during non-flood periods. Drawing down Lawrence Lake by pumping would have no appreciable effect on the hydrology/hydraulics of pool 8 because of the relatively small area being affected.

As discussed previously, drawing down Lawrence Lake by gravity would require about a 3-foot drawdown at Lock and Dam 8. The hydrologic/hydraulic effects of this type of pool-wide drawdown are discussed later in this report. Maintaining a drawdown in Lawrence Lake after the pool was raised would require a closure dike and providing pumping capacity to remove seepage and local rainfall runoff.

Water Quality

Water quality effects of a drawdown of a larger floodplain waterbody such as Lawrence Lake would be essentially the same as those described above for small-scale sites, except that construction of an isolating berm and greater pumping volume would impose greater construction- and drawdown-related increases in suspended solids. If sufficient sediments were mobilized during drawdown, a dissolved oxygen sag could occur in the pump discharge plume. A berm across the lower end of Lawrence Lake enabling drawdown would reduce effective fetch and wind-induced sediment resuspension during periods of open water when aquatic vegetation is not abundant. A closure berm, even if left open at some point or with a water control structure that was operated to allow flow into and out of the lake, would greatly affect the circulation of water between the lake and the river. Areas of Lawrence Lake with sufficient winter dissolved oxygen would probably be reduced due to more restricted hydraulic exchange with the river.

Ecological

Ecological effects of isolation and drawdown of a larger floodplain waterbody such as Lawrence Lake would be similar to those described for the small-scale drawdowns. The managed waterbodies would be temporarily isolated, preventing movements of fish to and from flowing parts of the river. The Lawrence Lake site in pool 8 has abundant emergent, floating-leaved, and submersed aquatic vegetation, so a drawdown would not produce significant improvement in habitat quality.

A 2-foot growing season drawdown of Lawrence Lake followed by fall reflooding would result in about 300 to 400 acres of annual vegetation, and could result in the establishment of up to about 300 acres of emergent aquatic plants. An extended drawdown regime designed to establish emergent aquatic plants could result in much of the lake converting to stands of emergent vegetation, covering up to about 400 acres. Increased extent of emergent aquatic plants in Lawrence Lake could improve habitat conditions for nesting and migrating waterfowl. This could have positive or negative effects on other forms of fish and wildlife depending on individual species requirements. This would need to be fully evaluated during pre-implementation studies.

Operations

Isolation and drawdown of Lawrence Lake, either on a one-time or a recurring basis, would have no effect on the operation of pool 8.

Channel Maintenance

Isolation and drawdown of Lawrence Lake would not be expected to have any adverse effects on the maintenance of the navigation channel in pool 8.

Commercial Navigation

Isolation and drawdown of Lawrence Lake would not be expected to have any adverse effects on commercial navigation.

Transportation Infrastructure

Isolation and drawdown of Lawrence Lake, either on a one-time or a recurring basis, would have no effect on the transportation infrastructure in pool 8.

Water Appropriations

Isolation and drawdown of Lawrence Lake, either on a one-time or a recurring basis, would have no effect on the water intake to the French Island generating station.

Real Estate

Lawrence Lake is located entirely on Federal property within the Upper Mississippi River National Wildlife and Fish Refuge. No additional real estate requirements should be necessary for implementation.

Recreation

Isolation and drawdown of Lawrence Lake, either on a one-time or a recurring basis, would have negligible effects on recreation. There could be localized disruption to recreation on Lawrence Lake during periods of operation; however, there are nearby sites that could serve as substitute areas during those times.

Isolation of Lawrence Lake with a dike would prevent direct access by boat from the Mississippi River. Alternative accesses would need to be provided for continued use of the lake for recreational activities requiring a boat.

Long-term benefits to recreationists would be expected, to the extent that improvements to fish and wildlife are realized. These effects are not defined well enough to be quantified.

Aesthetics

The construction of a dike across the lower end of Lawrence Lake would present a visual intrusion on a relatively undisturbed area. Boathouses and a marina are located immediately downstream of where the dike would be constructed, so there is some existing development in the area. The dike would be visible to the boathouse users, marina users, and from State Highway 26. The dike would also be visible to boaters on the Mississippi River from certain angles.

The drawing down of Lawrence Lake would create over 400 acres of mud flat. For the most part, this would not be visible to the general public unless they took specific efforts to view the area. Odors emitted from the exposed sediments and decaying vegetation would likely be detectable by the boathouse and marina users under conditions of northerly winds.

Cultural Resources

Lawrence Lake is the only large backwater area being considered for a mid-scale drawdown. To isolate the lake, a 2,000-foot-long dike would have to be built. Once the dike was built, the water would be drawn down 2 feet, although at main channel flows over 40,000 cfs, this would not be possible.

One mound is near Lawrence Lake and many prehistoric habitation sites lie in the river valley adjacent to the lake. Therefore, archeological surveys would need to be conducted prior to any ground-disturbing activities. If the lake were drawn down, an archeologist should survey the exposed shoreline for cultural resources and should report what effect the drawdown may be having on any sites found.

Implementation Procedure

Lawrence Lake is located within the Upper Mississippi River National Wildlife and Fish Refuge. Therefore, the U.S. Fish and Wildlife Service would be the lead agency in the implementation of any action involving the isolation and drawdown of Lawrence Lake. Because of the scope of such a project, implementation would require a coordinated effort involving the Service, the Corps of Engineers, the Minnesota and Wisconsin Departments of Natural Resources, and the public.

LARGE-SCALE MEASURES WITHIN THE PRESENT SYSTEM OF RIVER REGULATION

DISCONTINUE 0.25-FOOT WINTER DRAWDOWNS

Under this alternative, the St. Paul District would discontinue winter drawdowns of 0.25 foot at the primary control point. This alternative was implemented District-wide during the winter of 1995-96.

Hydrologic/Hydraulic Changes

Under low to moderate winter discharge levels, up to 0.25 foot more water would be present in the pool. This effect would be most pronounced near the dam, and less evident in the upriver portions of the pool.

Water Quality

Winter 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. While this effect probably occurred during the winter of 1995-96 in St. Paul District pools, it would be very difficult to measure the reduced extent or frequency of dissolved oxygen depletion due to elimination of the historically practiced 0.25-foot winter drawdowns of the navigation pools.

Ecological

Reduced 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 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 changes in winter water levels.

This alternative was implemented District-wide during the winter of 1995-96. At present, it is too early to determine the effects of discontinuing the winter drawdown.

Operations

Discontinuing winter drawdowns would have no effect on water control or the operation of Lock and Dam 8.

Channel Maintenance

Discontinuing winter drawdowns would have no effect on maintenance of the navigation channel in pool 8.

Commercial Navigation

Discontinuing winter drawdowns would have no effect on commercial navigation in pool 8.

Transportation Infrastructure

Discontinuing winter drawdowns would have no effect on the transportation infrastructure in pool 8.

Water Appropriations

Discontinuing winter drawdowns would have no effect on the water intake to the French Island generating station.

Real Estate

Discontinuing the 0.25-foot winter drawdown would require no real estate action because it is an operational modification within existing St. Paul District pool operation authority.

Recreation

Discontinuing winter drawdowns would have no effects on recreation during the periods of operation. Long-term benefits to recreationists would be expected, to the extent that improvements to fish and wildlife are realized. These effects are not defined well enough to be quantified.

Aesthetics

Discontinuing winter drawdowns would have no aesthetic effects.

Cultural Resources

Discontinuing the 0.25-foot winter drawdown would probably not have much effect on cultural resources in pool 8.

Implementation Procedure

The St. Paul District has the authority to implement this alternative and actually began implementation during the winter of 1995-96. At some point in the future, an evaluation will need to be conducted to determine whether to continue with this method of regulation.

REGULATION ON THE "HIGH" OR "LOW" SIDE OF THE REGULATING BAND

During the summer, a tolerance of ±0.2 foot is allowed at the pool control point, while during winter, the tolerance is ±0.3 foot. Under this alternative, pool regulation would be targeted toward keeping pool levels at the upper or the lower limits of the regulating band during the growing season as river discharge allows. During winter, pool regulation would be targeted toward keeping pool levels at the upper limits of the regulating band.

Hydrologic/Hydraulic Changes

Regulation at either the "high" side or "low" side of the operating band could require more frequent gate adjustments because water control personnel would be trying to regulate the pool within a narrower band. For example, if the goal was to operate on the "low" side of the band during the summer, water control personnel would, in effect, try to maintain the pool between project pool and -0.2 foot. This could be difficult to accomplish without frequent gate adjustments.

Water Quality

Slightly lower water levels during the growing season should not have any significant effect on water quality, other than to slightly reduce water exchange in backwater areas. This could result in minor increases in the density of algal blooms in some backwater areas. Slightly lower water surface elevation would increase the area of substrate subject to wind-driven sediment resuspension.

Slightly higher water levels during the winter would have essentially the same minor but positive effects on dissolved oxygen concentrations as described earlier for the elimination of winter pool drawdowns.

Ecological

Ecological effects of regulating on the high or low side of the regulating band would be minor, and likely not be measurable. Slightly lower water levels during the growing season would further isolate some backwater areas, result in somewhat denser or more frequent algal blooms, and somewhat increase the substrate area subject to wind-driven sediment resuspension. The slightly lower growing season water levels could result in some increase in emergent plants growing in the narrow band dewatered by this regulating strategy. Slightly higher winter water levels would have the same minor but positive effects as described for elimination of the winter pool drawdowns.

Operations

Regulation on the high side or the low side of the regulating band would have some effect on water control operations, as water control personnel would be required to try to regulate the pool to what, in effect, would be a narrower operation band. As noted earlier, this method of operation could require more frequent gate adjustments. At some point, the frequency of adjustments required may exceed the capabilities of the lock and dam personnel to implement them. The availability of lock and dam personnel to make gate changes is highly variable depending upon time of year, week day versus weekends, day shift versus night shift, and lock operation requirements to name a few. Further analysis would be required (see "Implementation Procedure" below) to determine the capabilities of lock and dam personnel to make additional gate changes.

Channel Maintenance

No significant effect on maintenance of the navigation channel would be expected from operating either on the high side or the low side of the operating band. If operation was on the high side of the band, knowing that there would be an additional 0.2 foot of water could in marginal instances delay the decision to dredge at a particular site to see if conditions improve naturally. Conversely, if operation was on the low side of the band, knowing that there would be 0.2 foot less water could in marginal instances precipitate a decision to dredge instead of delaying to see if conditions improve naturally.

Commercial Navigation

Intuitively, operation on the high side of the band should benefit commercial navigation by providing slightly greater water depths, and operation on the low side of the band should adversely affect commercial navigation by providing slightly lower water depths. The effects would be realized in minor differences in navigability and fuel efficiency. In neither instance, however, are the effects quantifiable.

Transportation Infrastructure

Regulating on the high side or the low side of the regulation band would have no effect on the transportation infrastructure in pool 8.

Water Appropriations

Regulating on the high side or the low side of the regulation band would have no effect on the water intake to the French Island generating station.

Real Estate

Regulation on the high or low side of the regulating band would require no real estate action because it is an operational modification within existing St. Paul District pool operation authority.

Recreation

Regulating on the high side or the low side of the regulation band would have negligible effects on recreation. Higher water levels could slightly improve access to some backwater areas, while lower levels could slightly hinder such access. In either case, the levels being considered are currently commonly experienced and would not dramatically change the quality or quantity of recreation in the pool.

Long-term benefits to recreationists would be expected, to the extent that improvements to fish and wildlife are realized. These effects are not defined well enough to be quantified.

Aesthetics

Regulating on the high or low side of the regulation band should have no aesthetic effects. These minor changes in water surface elevation would not be discernible.

Cultural Resources

Regulating the pool on the high or low side of the band would probably not have much effect on cultural resources in pool 8. However, the general issues of site inundation and erosion as discussed for the growing season drawdowns pertain here.

Implementation Procedure

The St. Paul District has the authority to implement regulation on the high or low side of the operating band. The most likely procedure would be to implement regulation on the high side or low side of the regulating band for a fixed period of time coupled with a monitoring plan designed to evaluate the effects of the selected method of regulation from all perspectives, including environmental benefits, operational costs, and other effects. At the end of the fixed period, the monitoring results would be evaluated to determine whether to continue with this method of regulation.

Changing to a wider regulating band would require an analysis of the effects of such a change and approval from Headquarters, U.S. Army Corps of Engineers.

INCREASE THE FREQUENCY OF GATE ADJUSTMENTS

Under this alternative, the frequency of gate adjustments would be increased to smooth out some of the more abrupt changes in flow through the dam gates. The current practice under most conditions is to make a single gate change in the morning. At certain times, if river conditions warrant, a morning and afternoon gate change may be made.

Hydrologic/Hydraulic Changes

Increasing the frequency of gate openings would smooth out short-term stage variations in headwater at the dam. Short-term variation for the period May 5 through August 13, 1996, is shown in figure 5-1. The variations during this period were generally 0.5 foot or less, and are considered typical of what would be expected during most summer periods.

Water Quality

Smoothing the discharge hydrograph through more frequent gate changes 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.

Ecological

Reducing the amplitude and frequency of water level fluctuations by more frequent gate changes 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.

Operations

Increasing the number of daily gate adjustments would require water control personnel to take this into account as part of making daily water control decisions. Additional effort required at the lock and dam to make additional gate adjustments would be highly variable depending upon the situation. Generally, lock and dam staffing levels are barely sufficient for current operational needs. More frequent gate adjustments would likely require an increase in lock and dam staff levels and/or automation of gate mechanisms and controls.

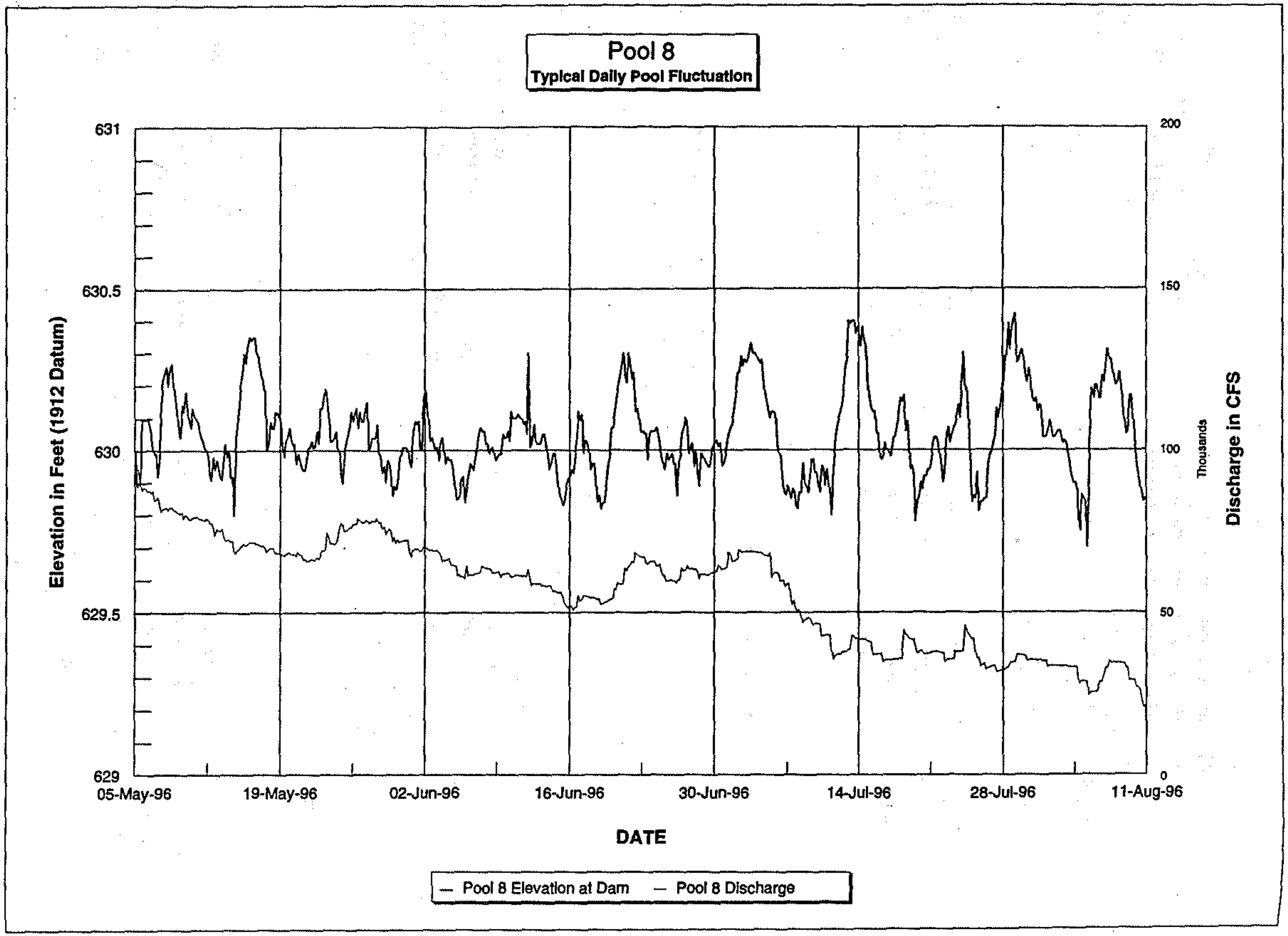


Figure 5-1. Typical Daily Variation in Pool Stages

Channel Maintenance

Increasing the frequency of gate adjustments at the dam would have no effect on maintenance of the navigation channel in pool 8.

Commercial Navigation

Increasing the frequency of gate adjustments at the dam would have no effect on commercial navigation in pool 8.

Transportation Infrastructure

Increasing the frequency of gate adjustments at the dam would have no effect on the transportation infrastructure in pool 8.

Water Appropriations

Increasing the frequency of gate adjustments at the dam would have no effect on the water intake to the French Island generating station.

Real Estate

Increasing the frequency of gate adjustments would require no real estate action because it is an operational modification within existing St. Paul District pool operation authority.

Recreation

Increasing the frequency of gate adjustments at the dam 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 recreationists would be expected, to the extent that improvements to fish and wildlife are realized. These effects are not defined well enough to be quantified.

Aesthetics

Increasing the frequency of gate adjustments would have no aesthetic effects. The changes would not be visually discernible to the average river user.

Cultural Resources

Increasing the frequency of gate adjustments would probably have no effect on cultural resources in pool 8.

Implementation Procedure

The St. Paul District has the authority to implement this alternative. Specific modifications to existing procedures would require further evaluation on a site-specific basis to determine if the benefits to be achieved warrant the additional costs.

The St. Paul District is currently conducting a study on the feasibility of automating gate operations from the lock and dam house. The study is using Lock and Dam 7 as the pilot location and is scheduled to be completed in 1997.

MODIFY DISTRIBUTION OF FLOWS THROUGH THE DAM GATES

Under this alternative, flows through the dam gates would be distributed through the dam gates to maximize tailwater habitat values, within limits that would avoid scour at the base of the dam.

Hydrologic/Hydraulic Changes

Small variations in distribution through the gates may be possible; however, past problems with large scour holes developing downstream of the dam may have been caused by inadvertent uneven gate openings.

Releases through the individual gate bays could be concentrated to the center of the dam or to one side or the other (within limits imposed by the need to avoid velocities that would cause scour at the base of the dam). This practice could reduce velocities along the banks and in the approaches to the lock.

Water Quality

Changing the distribution of flow through the dam gates would have no effect on water quality.

Ecological

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 the lock wall, perhaps increasing the number of fish that would be attracted into the lock for "locking through" fish.

These measures to improve tailwater habitat conditions could have a positive, although probably unquantifiable, effect of fish populations and sport fishing opportunity.

Operations

Modifying the distribution of flow through the dam gates would require minor additional consideration on the part of lock and dam personnel. 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.

Channel Maintenance

Modifying the distribution of flow through the dam gates would have no effect on maintenance of the navigation channel in pool 8.

Commercial Navigation

Modifying the distribution of flow through the dam gates would require an evaluation to insure that there were no effects on tows approaching or leaving the lock chamber. It is possible that modifying the pattern of releases through the dam gates could have some effect on navigability in the lock approaches, either negatively or positively, by affecting outdraft currents.

Transportation Infrastructure

Modifying the distribution of flow through the dam gates would have no effect on the transportation infrastructure in pool 8.

Water Appropriations

Modifying the distribution of flow through the dam gates would have no effect on the water supply intake to the French Island generating station.

Real Estate

Modifying the distribution of flow through the dam gates would require no real estate action because it is an operational modification within existing St. Paul District pool operation authority.

Recreation

Modifying the distribution of flow through the dam gates would have negligible effects on recreation. This change could affect fishing conditions in the tailwater areas, although the extent is unknown.

Long-term benefits to recreationists would be expected, to the extent that improvements to fish and wildlife are realized. These effects are not defined well enough to be quantified.

Aesthetics

Modifying the distribution of flow through the dam gates would have no effect on aesthetics. The changed flow distribution would not be visually discernible to the average river user.

Cultural Resources

Modifying the flow through the dam gates would probably have no effect on cultural resources in pool 8.

Implementation Procedure

The St. Paul District has the authority to implement this alternative. Further evaluation would be required to determine specific objectives for velocity patterns in tailwater areas. Two-dimensional hydraulic modeling would have to be employed to examine alternatives for achieving objectives for velocity patterns and habitat conditions in tailwater areas, to insure that unacceptable scour conditions below the dam are not created, and to evaluate potential effects on tow navigation in lock approaches.

LARGE-SCALE CHANGES TO THE PRESENT SYSTEM OF RIVER REGULATION

WINTER DRAWDOWN

Under this alternative, the pool would be drawn down to dewater backwater areas. For evaluation purposes, it was assumed that the pool would be drawn down prior to freeze-up; i.e., by December 1. To accomplish this, drawdown of the pool would have to begin by mid-November. The pool would be held at the target elevation throughout the winter. The pool would be refilled in March to insure adequate water for the opening of the navigation season in the spring.

A winter drawdown would enable use of wide-tracked excavation equipment (bulldozers with frost-rippers, backhoes) onto the dewatered and frozen bed of the backwater areas. Channels to allow more complete future drawdowns, berms to isolate and draw down smaller waterbodies, deepened areas, and islands could be readily constructed during a winter drawdown. These measures, in combination, could improve the quality and diversity of habitats following reflooding.

Hydrologic/Hydraulic Changes

Hydrologic/hydraulic changes for winter drawdown would be similar to drawdowns described later in this report for growing season drawdowns.

Water Quality

Mobilized sediment and oxygen-demanding materials draining from backwater areas would probably not greatly affect dissolved oxygen in the receiving channel parts of the river during drawdown, due to the prevailing cold water temperatures and high solubility of oxygen in cold water. Winter drawdown would dewater and greatly reduce the volume of backwater areas. Many backwater areas would become isolated from flow. The hydraulic exchange rate with remaining backwater areas would be greatly reduced. Many backwater areas with water remaining in them would be subject to ice contact (freezing to the bottom) and dissolved oxygen depletion.

Ecological

Winter drawdown would impose a major disturbance on a system that has had stable winter water levels for nearly 50 years. A winter drawdown to open-river conditions would dewater approximately 15,000 acres in pool 8. Some mobilization of sediment would occur, deepening shallow areas and filling deeper areas. Some headcutting (riverbed degradation) of tributaries could occur during the drawdown due to the reduced base elevation and increased gradient in the lower reaches of the tributaries. This could result in accelerated delta formation at tributary mouths. Some dissolved oxygen sag areas could occur where backwater areas drain into channels. Exposed sediments would dewater somewhat before freezing to a depth of about 6 inches.

Fish mostly would escape to channel areas or deeper backwaters that would not be subject to drawdown. Many of the remaining backwaters isolated by drawdown would be subject to oxygen depletion and fish kills over the winter. Most species of submersed aquatic plants in the drawdown zone would be killed, as would most macroinvertebrates and molluscs, including zebra mussels and any Federally endangered Lampsilis higginsi occurring in the drawdown zone. Bank- and hut-dwelling furbearers would be left stranded and exposed to predation. Depending on the timing of the start of a winter drawdown, migrating birds would be denied use of the drawdown zone habitats. Some migrating birds such as shorebirds, could be provided a greatly increased foraging habitat area for a short time before freeze-up.

A winter drawdown alone would probably not result in much consolidation of soft sediment. Following reflooding, fish, submersed aquatic plants and benthic macroinvertebrates would gradually recolonize the drawdown zone. This recolonization process could take several years to attain pre-winter drawdown conditions. Molluscs, especially Unionids, would require many years to repopulate the drawdown zone.

A winter drawdown, if conducted to allow for winter excavation for habitat project construction, and preceded or followed by a growing season drawdown to consolidate sediment, would provide conditions conducive to the establishment of emergent aquatic vegetation.

Operations

A winter drawdown would require minor additional efforts by water control personnel during the drawdowns and refilling of the pool to minimize the effects on the rest of the system.

Winter drawdown could require additional effort of the lock and dam staff. Winter drawdown may require additional measures at the locks and dams to account for freeze-up of the gates and other equipment that would normally be submerged. In addition, refilling of the pool in time for the navigation season may require operations at the lock and dam during the late winter that would normally not take place until spring.

Channel Maintenance

Assuming the pool would be refilled before the opening of the navigation season, no adverse effects on maintenance of the navigation channel in pool 8 would be expected.

Commercial Navigation

Winter drawdown would require closing the navigation season in pool 8 by November 15. This would result in an early closing of the navigation season throughout the St. Paul District above pool 8 except for local traffic. An evaluation of early closure indicates that a November 15 closing could result in economic losses of up to $6 to $7 million to the commercial navigation industry. The effects would be highly variable depending upon the year and when ice conditions would close the channel naturally.

Transportation Infrastructure

Winter drawdown should have no effect on the highway and railroad bridges in pool 8. These bridges are located in the upper end of the pool above river mile 697 where the maximum drawdown would be 4 feet or less below normal pool elevation.

Railroads run adjacent to pool 8 on both sides of the river. A potential stability concern with a drawdown (especially a large drawdown) would be if large areas of water were trapped landward of the railroad embankment. This trapped water would apply lateral forces to the embankment that could lead to failure. A review indicates there are no large areas of water lying landward of the railroad embankments in pool 8, especially in the lower portion of the pool where the largest drawdowns would occur.

Water Appropriations

Winter drawdowns should have no adverse effect on water supply at the French Island generating station. Even if the pool were fully drawn down, Black River flows passing the Lake Onalaska spillway would still be in the 500 to 800 cfs range which would more than suffice for the station's needs. The station's intake pipes would still be submerged by more than 6 feet even under low flow conditions.

Real Estate

The Government would not have to acquire additional real estate rights to draw the pool down. Non-Government riparian owners may claim their property values or the property itself is being adversely affected due to aesthetic effects, lost recreational opportunities, the need for cross fences on pastures, etc. These would have to be evaluated on a case-by-case basis.

Conversely, improvements in habitat quality could increase property values for riparian owners.

Recreation

Winter drawdowns could have negative effects on ice fishing, to the extent that available areas for fishing would be reduced. Long-term benefits to recreationists would be expected, to the extent that improvements to fish and wildlife are realized. These effects are not defined well enough to be quantified.

Aesthetics

The aesthetic effects of a winter drawdown would be highly variable depending upon the extent of the drawdown and winter weather conditions. The larger the drawdown, the more exposed area there would be. If the drawdown occurred during a winter with little or no snow, it would be more visually evident. Conversely, a heavy snow cover would tend to mask the drawdown.

Cultural Resources

A significant winter drawdown has the potential to affect cultural resources in pool 8. The general issues of site inundation and erosion as discussed later in this report for growing season drawdowns pertain here. Any fluctuations in the pool's levels should be accompanied by site monitoring and a mitigation plan. The use of heavy equipment to build berms or excavate channels or ponds would require cultural resources surveys in advance of any work. The potential to affect cultural sites increases with the level of ground disturbance and the extent of drawdown.

Implementation Procedure

Implementation of a winter drawdown would require a feasibility level study and approval through Corps of Engineers channels. Congressional action would be required because use of this management technique would not be in compliance with the Anti-Drawdown Law.

The "Anti-Drawdown Law" passed by Congress on March 10, 1934 prevents drawdowns of the pool for flood control purposes. The act, entitled "An act to promote the conservation of wildlife, fish and game, and for other purposes," was amended by Public Law 732 on August 14, 1946 and by Public Law 697 on June 19, 1948 to include the following new section.

16 U.S.C. 665a applies directly to the St. Paul District in its provision that:

> **In the management of existing facilities (including locks, dams, and pools) in the Mississippi River between Rock Island, Illinois, and Minneapolis, Minnesota, administered by the United States Corps of Engineers of the Department of the Army, that Department is hereby directed to give full consideration and recognition to the needs of fish and other wildlife resources and their habitat dependent on such waters, without increasing additional liability to the Government, and, to the maximum extent possible without causing damage to levee and drainage districts, adjacent railroads and highways, farm lands, and dam structures, shall generally operate and maintain pool levels as though navigation was carried on throughout the year.**

SPRING POOL RAISES

In years of low spring flow, water levels would be raised to benefit species that make use of flooded habitats.

Hydrologic/Hydraulic Changes

The existing fixed crest spillways at Lock and Dam 8 are at elevation 631.0. Raising the pool above this elevation at the dam would require adding flashboards for a small temporary pool raise. Annual raises of the pool or a raise that is more than 1 foot above the existing fixed crest spillway may require permanent modifications to the fixed crest spillways and stilling basins. Pool raises above 2 to 3 feet may not be possible to maintain for low discharges without major modification to the tainter gates, roller gates and gate sills.

Water Quality

An intentional spring pool raise would inundate some floodplain terrestrial areas. Suspended materials would settle out in the overbank areas, and dissolved organic materials would be leached into the water from the flooded vegetation and soils. Large quantities of leaves and woody debris would be transported from the floodplain into backwater and channel areas. These phenomena occur during natural spring floods and would not impose any adverse effects.

Ecological

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.

Operations

An intentional raise of water level during spring above project pool level would require modifications to the overflow spillway and perhaps the dam gates, such as flashboards, in order to attain the higher pool levels.

Additional efforts required of the lock and dam staff could be substantial, if expendable flashboards were used along the crest of the overflow spillway and on the top of the dam gates.

Implementation of this alternative would likely require additional effort on the part of water control personnel to minimize the effects on the remainder of the system.

Channel Maintenance

No adverse effects on channel maintenance would be expected from a spring pool raise.

Commercial Navigation

No adverse effects on commercial navigation would be expected from a spring pool raise.

Transportation Infrastructure

Increasing spring water levels would not be expected to have any effects on the transportation infrastructure in pool 8.

Water Appropriations

Increasing spring water levels would not be expected to have any effects on the water intake to the French Island generating station.

Real Estate

Spring 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 would require obtaining real estate rights of use, either flowage easements or agreements with landowners. In addition to the actual cost of the real estate rights, there would be surveying and administrative costs associated with the acquisition. These costs cannot be quantified without further detailed study.

Recreation

Increasing spring water levels would have no noticeable effects on recreation. Long-term benefits to recreationists would be expected, to the extent that improvements to fish and wildlife are realized. These effects are not defined well enough to be quantified.

Aesthetics

Spring pool raises would not be expected to have any appreciable visual effects. Spring high water is a normal condition on the river, and most river users, unless made aware of it, would probably not even realize the high water was a managed condition and not a natural event.

Cultural Resources

Raising the pool level in the spring has the potential to affect cultural resources in pool 8. As Lock and Dam 8 is eligible for the National Register, any modifications to the dam would have to be coordinated with the Wisconsin State Historic Preservation Office and the Advisory Council on Historic Preservation.

Implementation Procedure

A feasibility study would be needed to establish the parameters that would trigger a spring pool raise, its limits, and duration, properties affected, real estate rights of use that need to be acquired, modifications to the dam needed, and river regulation strategy. A plan to conduct intentional spring pool raises would have to be approved by Corps of Engineers Headquarters. Congressional action could be needed depending on the magnitude of the proposed operational modification.

CHANGE THE PRIMARY CONTROL POINT FROM MID-POOL TO THE DAM

Currently, when flows are less than 23,000 cfs, the pool is regulated to maintain an elevation of 631.0 at the primary control point at La Crosse, Wisconsin. At flows from 23,000 cfs through 95,000 cfs, the pool is in secondary control with an elevation of 630.0 maintained at Lock and Dam 8. At flows over 95,000 cfs, pool 8 is unregulated by the dam.

Under this alternative, there would be no primary and secondary control points for pool 8. The pool would be regulated at the dam at elevation 631.0 for all flows up to the point where the gates are pulled and the pool becomes unregulated. This is the method of pool regulation used for pool 10 and for the navigation pools in the Rock Island District.

The alternative of regulating the pool at the dam at elevation 630.0 would be an option identified during the study by the WLMTF. This option was not evaluated under this alternative because regulating the pool at elevation 630.0 would be a "drawdown" in comparison to existing conditions. The 1-foot drawdown evaluated under the growing season drawdown alternatives generally depicts conditions where the pool is regulated at elevation 630.0.

Hydrologic/Hydraulic Changes

Changing the primary control point from mid-pool to the dam would require changing the primary and secondary pool elevation to 631.0. Changes in water surface profiles for three levels of discharge are shown on figure 5-2. Under this method of operation, the gates would not have to be lifted out of the water until a discharge of 105,000 cfs was reached, as compared to 95,000 cfs under current operating procedures.

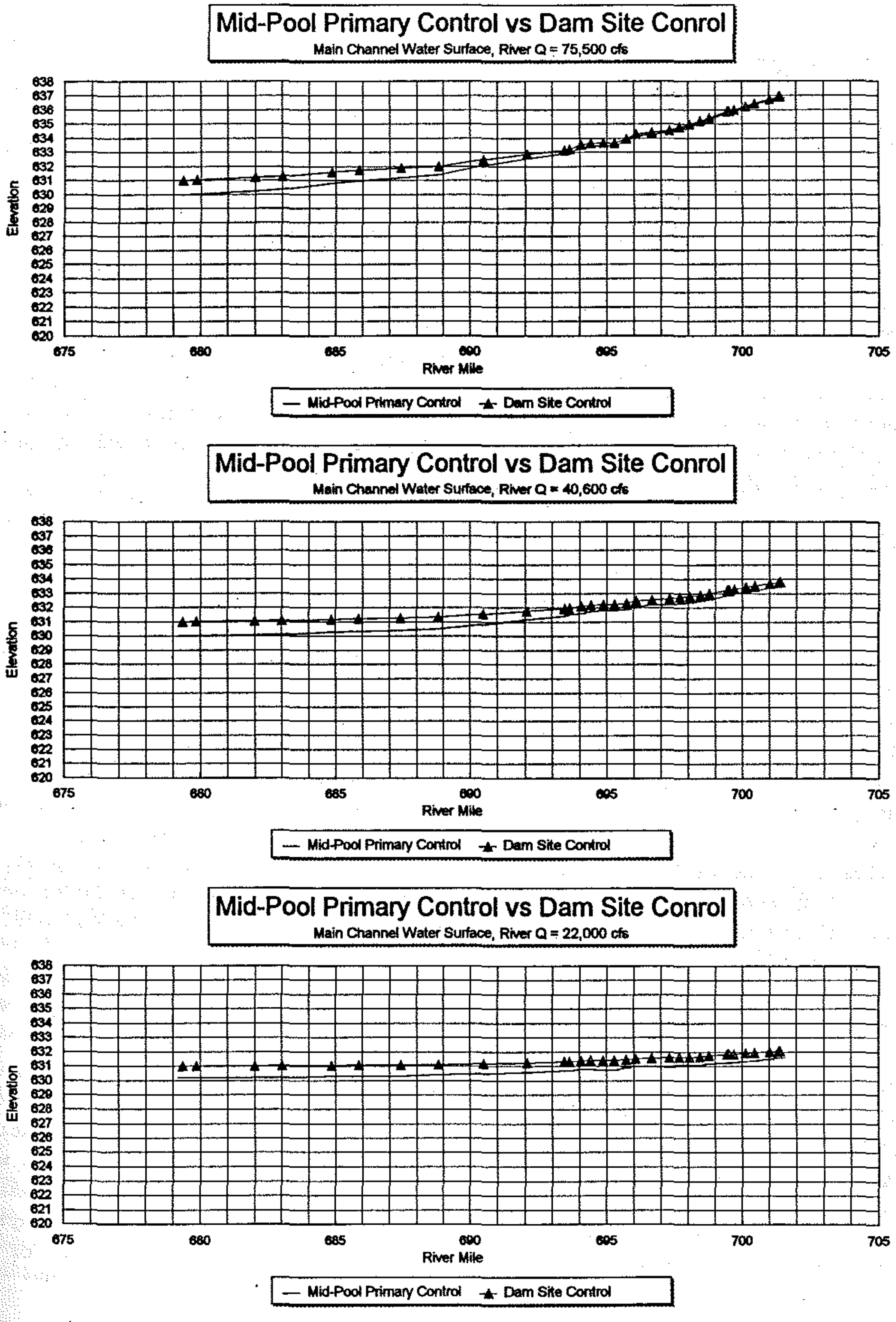


Figure 5-2. Mid-Pool Primary Control vs. Dam Site Control

Water Quality

A change in the control point to the dam and the associated rise in water levels in the downriver 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 senescing vegetation into the water. This effect would occur during the first month or two following change in pool regulation, but would probably not be noticeable. 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.

Ecological

Changing to control at the dam would result in a rise in water levels of from 1 foot at the dam to less than 0.5 foot in the upper reaches of the pool. The area affected by increased water levels could not be quantified within the limits of this study. However, a rough approximation of the area that could potentially be affected can be made as follows. The change in water levels with a 1-foot drawdown at 22,000 cfs is nearly the mirror image of the change in water levels associated with a change in the primary control point at 22,000 cfs. A 1-foot drawdown at 22,000 cfs would expose about 4,600 acres. If the assumption is made that the rate of change in pool topography and bathymetry is relatively constant in the range of ±1 foot of project pool, then the change in primary control point could increase water levels to cover an additional 4,000 to 5,000 acres in pool 8 when flows are at 22,000 cfs.

The area within the routine 1-foot drawdown zone in pool 8 includes about 2,800 acres of submersed vegetation and 1,200 acres of emergent aquatic vegetation. Changing to control point at the dam would make this zone continuously inundated to at least elevation 631.0 at all times. 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 will 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 accompanying rise in water level and floodplain groundwater level would kill a band of floodplain forest trees in the lower half of pool 8. The species composition of the rest of the pool 8 floodplain forest would probably change as a result of the increased water level.

A change to control at the dam would also change the littoral processes of wind and wave action, shoreline erosion, and sediment transport. The few remaining islands in the impounded southern part of pool 8 would be subject to increased wave attack and would rapidly disappear. The islands constructed under the UMRS-EMP habitat rehabilitation and enhancement projects program in the southern part of the pool would also be subject to increased water levels and wave attack. Shoreline erosion associated with a rise in pool level would probably stabilize within several decades.

The reduced water level fluctuations in the lower portion of the pool associated with change to dam control would have some minor long-term benefit in reducing the frequency of disturbance in littoral areas. The direct relationship between river discharge and water level would be restored in the downriver portion of the pool. The overall ecological benefits from a change to dam control in pool 8 would be difficult to quantify.

Operations

Once the new method of operation was put into effect, no additional effort would be required of water control or lock and dam personnel to regulate pool 8.

Channel Maintenance

Initially, the higher water levels may reduce channel maintenance requirements. The change in pool operation would reduce the gradient in the pool which, 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 channel maintenance requirements would decrease under this alternative.

Commercial Navigation

The slightly higher water levels would probably provide some initial benefits to commercial navigation by providing additional depth of water for navigation. As the river adjusted to the new water management regime, channel conditions for commercial navigation would likely return to nearly the present situation.

Transportation Infrastructure

Because the change in water levels would be less than 1 foot over most of the pool, no adverse effects on the transportation infrastructure would be expected.

Water Appropriations

Changing the pool control point would not be expected to have any effects on the water supply intake to the French Island generating station.

Real Estate

Changing the primary control point in pool 8 from mid-pool to the lock and dam would have the general effect of raising pool levels in pool 8 (figure 5-2). At flows of 22,000 cfs, the pool would be raised about 0.8 foot at the dam and 0.5 foot in the upper reaches of the pool. At 40,600 cfs, the corresponding increases would be 1.0 foot and 0.3 foot. At 75,500 cfs, they would be 1.0 and 0.1 foot, respectively.

Below river mile 696.85, the additional area affected by changing the primary control point may or may not be within the limits acquired in fee title or by flowage easement by the Federal Government. It is readily evident from flowage survey maps and real estate maps that the Corps of Engineers acquired property above the project pool elevation of 631.0. Much of this appears to be the result of "squaring off" parcels when they were purchased. Determining how much additional property may have to be acquired downstream of river mile 696.85 is beyond the scope of this study.

A worst case analysis was performed by determining how much of the floodplain in pool 8 below river mile 696.85 is in non-Federal ownership. Based on the Land Use Allocation Plan, it appears that less than 700 acres are not owned either by the Corps of Engineers or the U.S. Fish and Wildlife Service. Therefore, the "worst case" scenario is that changing the pool control point would require the Federal real estate rights of use, or flowage easements, for an additional 700 acres in pool 8 below river mile 696.85.

As noted earlier, the Corps of Engineers did not acquire any real estate or flowage easements above the primary control point. In the 5.4-mile reach between the primary control point and Lock and Dam 7, the U.S. Fish and Wildlife Service acquired a considerable amount of land in the floodplain. Based on the Land Use Allocation Plan, there is, at maximum, approximately

1,000 acres in the pool 8 floodplain above river mile 696.85 that is not federally owned. From a worst case perspective, this would be the maximum amount of land the Federal Government would have to acquire in fee title or flowage easement above river mile 696.85 with a change in pool control point. The actual figure would probably be considerably less.

In summary, changing the primary control point in pool 8 from mid-pool to Lock and Dam 8 would likely require the acquisition of additional fee title lands or flowage easements by the Federal Government. In the worst case, fee title acquisition or flowage easements could be required on as much as 1,700 acres. In actuality, the requirements would probably be considerably less. The change in water surface elevation on the land peripheral to the pool associated with a change to control at the dam would impose only limited further restrictions on real estate use by private landowners, and would convey some improvements in the way of reduced water level fluctuations. Landowners aware of this potential for change may be willing to sell or donate flowage easements, thereby avoiding the high cost of fee title acquisition.

The U.S. Fish and Wildlife Service is acquiring some additional tracts of floodplain habitat in lower pool 8. Current appraisals place the land values at $400 to $500 per acre (Nissen, 1996). Using the worst case approach, acquiring 1,700 acres at $500 per acre would cost approximately $850,000. Real estate acquisition procedures can be costly, requiring appraisals, surveys, and possibly condemnation. It is not considered unreasonable to assume that administration costs would approach the actual land costs, especially if minor flowage easements would have to be obtained on a multitude of individual riverfront properties in the La Crosse area. For purposes of comparison with other alternatives in this report, it is assumed that total real estate costs associated with this alternative would be about $1,500,000.

Recreation

Changing the primary control point from mid-pool to the dam could have positive effects for boaters to the extent that the higher water improves access to backwater areas. Conversely, increasing water levels encourages boaters to attempt to navigate areas where there may be submerged safety hazards such as stumps and snags. Since the water level increases are all 1 foot or less, these effects would be relatively minor.

Long-term benefits to recreationists would be expected, to the extent that improvements to fish and wildlife are realized. These effects are not defined well enough to be quantified.

Aesthetics

Changing the location of the control point would not be expected to have any effects on aesthetics. In most locations, the change in water levels would not be discernible to most river users. Over time, the new water levels would be accepted as the norm.

Cultural Resources

Changing the water surface profile by changing the primary control point from mid-pool to the dam could affect cultural resources in pool 8. The general discussions of site inundation and erosion with growing season drawdowns pertain here.

Implementation Procedure

Changing the primary control point from mid-pool to the lock and dam would require a feasibility study and approval through Corps of Engineers channels. Congressional approval could be required for the acquisition of additonal Federal real estate interests.

SUMMER GROWING SEASON DRAWDOWNS

The Water Level Management Task Force considered a variety of drawdown alternatives for pool 8. The primary factors that would define a drawdown alternative are (1) the depth of drawdown, (2) the duration of the drawdown, and (3) river flows at the time of the drawdown. River regulation has control over factors (1) and (2), and little control over factor (3). The Water Level Management Task Force agreed to evaluate three depths of drawdown under four different flow conditions, and to evaluate three different durations of drawdown. The drawdowns and associated flow conditions that were evaluated are as follows:

Depth of Drawdown

1 Foot - A pool drawdown of 1 foot at Lock and Dam 8.
3 Feet - A pool drawdown of 3 feet at Lock and Dam 8.
Open River - No regulation; i.e., removal of the gates from the water.

Flow Conditions

9,900 cfs - A flow level characteristic of late summer in a dry year.
22,000 cfs - A flow level characteristic of late summer in an average to dry year.
40,600 cfs - A flow level characteristic of late summer in an average to wet year.
75,500 cfs - Approximate upper limit of drawdown capabilities.

Drawdown Durations

Partial growing season (July 1 - August 15)
Growing season (June 15 - September 30)
Two growing seasons (June 15 of year 1 - September 30 of year 2)

The dates of the potential drawdowns evaluated are arbitrary. River discharge in any year a drawdown might be attempted would influence the start and ending dates. In many years, river discharge would be too high early in the growing season (late April/May) to be able to initiate a pool drawdown. June 15 was selected as a starting date that would coincide with lower river discharges that would allow a drawdown to be implemented, and have weather conditions conducive to germination of plant propagules in a drawdown zone.

Hydrologic/Hydraulic Changes

From a historical perspective, lower water levels or drawdowns are not without precedent. When the locks and dams were first constructed, the allowable drawdown was greater than it is today. Over time, the allowable drawdown was reduced in response to river resource management agency and public concerns with lower water levels, especially during the winter. Table 5-5 shows the allowable drawdown at the dams in the St. Paul District along with the year in which the allowable drawdown was reduced.

Table 5-5
Allowable Drawdown at St. Paul District Locks and Dams

L/D	Normal Pool Elev.	Original Drawdown	Interim Changes with Date Approved		Present Drawdown
2	687.2	3.2 (1938)		2.0 (1960)	0.7 (1970)
3	675.0	2.0 (1939)			1.0 (1971)
4	667.0	4.0 (1941)	2.5 (1943)	1.5 (1960)	0.5 (1971)
5	660.0	2.5 (1936)		1.5 (1960)	0.5 (1970)
5A	651.0	2.5 (1936)			1.0 (1959)
6	645.5	2.5 (1935)			1.0 (1959)
7	639.0	none			none
8	631.0	3.5 (1936)	2.0 (1941)	1.5 (1963)	1.0 (1971)
9	620.0	2.5 (1937)			1.0 (1971)
10	611.0	2.0 (1936)			1.0 (1971)

Changes in Water Surface Profiles

Summer growing season drawdowns were modeled using HEC-2, a one-dimensional steady state gradually varied flow model. The model Manning's 'N' values were adjusted by comparing the computed water surface profiles with water surface profiles used for operating pool 8. The Manning's 'N' values for the channel varied between 0.018 and 0.020. The Manning's 'N' values for areas away from the main channel varied between 0.035 in the lower end of pool 8 and 0.080 in the wooded areas of the upper end of pool 8. Actual variation of water surface profiles is up to 1 foot as shown on the rating curve on plate 2. The variations in the actual water surface are due to seasonal variations of water temperature, bed forms, and vegetation.

Water surface profiles for each alternative were computed for four discharges. The computed water surface profile data is summarized in table 5-6 for recognizable locations in pool 8. The hydraulic effects of the alternative operating plans are limited to 95,000 cfs, when the gates are lifted out of the water; therefore, the discharges 9,900, 22,000, 40,600, and 75,500 cfs were chosen. The annual duration the total river discharge at Lock and Dam 8 is above these discharges is 95 percent, 70 percent, 35 percent, and 15 percent, respectively. Water surface profiles for the various drawdown alternatives are shown on figures 5-3 through 5-6.

Table 5-6
Summary of Drawdown at Recognizable Locations in Pool 8

Discharge = 9,900 cfs

Location	X-Sect. RM	Routine Reg.	1-foot Draw.	3-foot Draw.	Open River	Diff. from Routine Reg.			Diff. from Project Pool Elev. 631.0			
						1-foot Draw.	3-foot Draw.	Open River	Routine Reg.	1-foot Draw.	3-foot Draw.	Open River
Lock and Dam 8	679.35	630.8	629.8	627.8	620.9	-1.0	-3.0	-9.9	-0.2	-1.2	-3.2	-10.1
Stoddard	684.84	630.8	629.8	627.8	621.7	-1.0	-3.0	-9.1	-0.2	-1.2	-3.2	-9.3
Brownsville	688.82	630.8	629.9	628.1	625.6	-0.9	-2.7	-5.2	-0.2	-1.1	-2.9	-5.4
Root River Mouth	693.64	631.0	630.1	628.5	626.6	-0.9	-2.5	-4.4	0.0	-0.9	-2.5	-4.4
Black River Mouth	698.45	631.1	630.2	628.7	627.0	-0.9	-2.4	-4.1	0.1	-0.8	-2.3	-4.0
Upper End of Pool 8	701.91	631.1	630.3	628.8	627.2	-0.8	-2.3	-3.9	0.1	-0.7	-2.2	-3.8

Discharge = 22,000 cfs

Location	X-Sect. RM	Routine Reg.	1-foot Draw.	3-foot Draw.	Open River	Diff. from Routine Reg.			Diff. from Project Pool Elev. 631.0			
						1-foot Draw.	3-foot Draw.	Open River	Routine Reg.	1-foot Draw.	3-foot Draw.	Open River
Lock and Dam 8	679.35	630.2	629.2	627.2	622.3	-1.0	-3.0	-7.9	-0.8	-1.8	-3.8	-8.7
Stoddard	684.84	630.3	629.3	627.4	623.4	-1.0	-2.9	-6.9	-0.7	-1.7	-3.6	-7.6
Brownsville	688.82	630.4	629.4	627.9	626.5	-1.0	-2.5	-3.9	-0.6	-1.6	-3.1	-4.5
Root River Mouth	693.64	630.7	630.0	628.8	628.0	-0.7	-1.9	-2.7	-0.3	-1.0	-2.2	-3.0
Black River Mouth	698.45	631.1	630.5	629.5	628.9	-0.6	-1.6	-2.2	0.1	-0.5	-1.5	-2.1
Upper End of Pool 8	701.91	631.6	631.1	630.2	629.8	-0.5	-1.4	-1.8	0.6	0.1	-0.8	-1.2

Discharge = 40,600 cfs

Location	X-Sect. RM	Routine Reg.	1-foot Draw.	3-foot Draw.	Open River	Diff. from Routine Reg.			Diff. from Project Pool Elev. 631.0			
						1-foot Draw.	3-foot Draw.	Open River	Routine Reg.	1-foot Draw.	3-foot Draw.	Open River
Lock and Dam 8	679.35	630.0	629.0	627.0	624.5	-1.0	-3.0	-5.5	-1.0	-2.0	-4.0	-6.5
Stoddard	684.84	630.3	629.4	627.8	626.3	-0.9	-2.5	-4.0	-0.7	-1.6	-3.2	-4.7
Brownsville	688.82	630.5	629.8	628.7	627.7	-0.7	-1.8	-2.8	-0.5	-1.2	-2.3	-3.3
Root River Mouth	693.64	631.4	631.1	630.6	630.4	-0.3	-0.8	-1.0	0.4	0.1	-0.4	-0.6
Black River Mouth	698.45	632.5	632.2	631.9	631.8	-0.3	-0.6	-0.7	1.5	1.2	0.9	0.8
Upper End of Pool 8	701.91	633.6	633.4	633.2	633.1	-0.2	-0.4	-0.5	2.6	2.4	2.2	2.1

Discharge = 75,500 cfs

Location	X-Sect. RM	Routine Reg.	1-foot Draw.	3-foot Draw.	Open River	Diff. from Routine Reg.			Diff. from Project Pool Elev. 631.0			
						1-foot Draw.	3-foot Draw.	Open River	Routine Reg.	1-foot Draw.	3-foot Draw.	Open River
Lock and Dam 8	679.35	630.0	629.0	628.1	628.1	-1.0	-1.9	-1.9	-1.0	-2.0	-2.9	-2.9
Stoddard	684.84	630.8	630.1	629.5	629.5	-0.7	-1.3	-1.3	-0.2	-0.9	-1.5	-1.5
Brownsville	688.82	631.4	630.9	630.6	630.6	-0.5	-0.8	-0.8	0.4	-0.1	-0.4	-0.4
Root River Mouth	693.64	633.0	632.8	632.7	632.7	-0.2	-0.3	-0.3	2.0	1.8	1.7	1.7
Black River Mouth	698.45	635.1	635.0	635.0	635.0	-0.1	-0.1	-0.1	4.1	4.0	4.0	4.0
Upper End of Pool 8	701.91	637.1	637.0	637.0	637.0	-0.1	-0.1	-0.1	6.1	6.0	6.0	6.0

Table 5–6
Summary of Drawdown at Recognizable Locations in Pool 8

Discharge = 9,900 cfs

Location	X-Sect. RM	Routine Reg.	1-foot Draw.	3-foot Draw.	Open River	Diff. from Routine Reg.			Diff. from Project Pool Elev. 631.0			
						1-foot Draw.	3-foot Draw.	Open River	Routine Reg.	1-foot Draw.	3-foot Draw.	Open River
Lock and Dam 8	679.35	630.8	629.8	627.8	620.9	–1.0	–3.0	–9.9	–0.2	–1.2	–3.2	–10.1
Stoddard	684.84	630.8	629.8	627.8	621.7	–1.0	–3.0	–9.1	–0.2	–1.2	–3.2	–9.3
Brownsville	688.82	630.8	629.9	628.1	625.6	–0.9	–2.7	–5.2	–0.2	–1.1	–2.9	–5.4
Root River Mouth	693.64	631.0	630.1	628.5	626.6	–0.9	–2.5	–4.4	0.0	–0.9	–2.5	–4.4
Black River Mouth	698.45	631.1	630.2	628.7	627.0	–0.9	–2.4	–4.1	0.1	–0.8	–2.3	–4.0
Upper End of Pool 8	701.91	631.1	630.3	628.8	627.2	–0.8	–2.3	–3.9	0.1	–0.7	–2.2	–3.8

Discharge = 22,000 cfs

Location	X-Sect. RM	Routine Reg.	1-foot Draw.	3-foot Draw.	Open River	Diff. from Routine Reg.			Diff. from Project Pool Elev. 631.0			
						1-foot Draw.	3-foot Draw.	Open River	Routine Reg.	1-foot Draw.	3-foot Draw.	Open River
Lock and Dam 8	679.35	630.2	629.2	627.2	622.3	–1.0	–3.0	–7.9	–0.8	–1.8	–3.8	–8.7
Stoddard	684.84	630.3	629.3	627.4	623.4	–1.0	–2.9	–6.9	–0.7	–1.7	–3.6	–7.6
Brownsville	688.82	630.4	629.4	627.9	626.5	–1.0	–2.5	–3.9	–0.6	–1.6	–3.1	–4.5
Root River Mouth	693.64	630.7	630.0	628.8	628.0	–0.7	–1.9	–2.7	–0.3	–1.0	–2.2	–3.0
Black River Mouth	698.45	631.1	630.5	629.5	628.9	–0.6	–1.6	–2.2	0.1	–0.5	–1.5	–2.1
Upper End of Pool 8	701.91	631.6	631.1	630.2	629.8	–0.5	–1.4	–1.8	0.6	0.1	–0.8	–1.2

Discharge = 40,600 cfs

Location	X-Sect. RM	Routine Reg.	1-foot Draw.	3-foot Draw.	Open River	Diff. from Routine Reg.			Diff. from Project Pool Elev. 631.0			
						1-foot Draw.	3-foot Draw.	Open River	Routine Reg.	1-foot Draw.	3-foot Draw.	Open River
Lock and Dam 8	679.35	630.0	629.0	627.0	624.5	–1.0	–3.0	–5.5	–1.0	–2.0	–4.0	–6.5
Stoddard	684.84	630.3	629.4	627.8	626.3	–0.9	–2.5	–4.0	–0.7	–1.6	–3.2	–4.7
Brownsville	688.82	630.5	629.8	628.7	627.7	–0.7	–1.8	–2.8	–0.5	–1.2	–2.3	–3.3
Root River Mouth	693.64	631.4	631.1	630.6	630.4	–0.3	–0.8	–1.0	0.4	0.1	–0.4	–0.6
Black River Mouth	698.45	632.5	632.2	631.9	631.8	–0.3	–0.6	–0.7	1.5	1.2	0.9	0.8
Upper End of Pool 8	701.91	633.6	633.4	633.2	633.1	–0.2	–0.4	–0.5	2.6	2.4	2.2	2.1

Discharge = 75,500 cfs

Location	X-Sect. RM	Routine Reg.	1-foot Draw.	3-foot Draw.	Open River	Diff. from Routine Reg.			Diff. from Project Pool Elev. 631.0			
						1-foot Draw.	3-foot Draw.	Open River	Routine Reg.	1-foot Draw.	3-foot Draw.	Open River
Lock and Dam 8	679.35	630.0	629.0	628.1	628.1	–1.0	–1.9	–1.9	–1.0	–2.0	–2.9	–2.9
Stoddard	684.84	630.8	630.1	629.5	629.5	–0.7	–1.3	–1.3	–0.2	–0.9	–1.5	–1.5
Brownsville	688.82	631.4	630.9	630.6	630.6	–0.5	–0.8	–0.8	0.4	–0.1	–0.4	–0.4
Root River Mouth	693.64	633.0	632.8	632.7	632.7	–0.2	–0.3	–0.3	2.0	1.8	1.7	1.7
Black River Mouth	698.45	635.1	635.0	635.0	635.0	–0.1	–0.1	–0.1	4.1	4.0	4.0	4.0
Upper End of Pool 8	701.91	637.1	637.0	637.0	637.0	–0.1	–0.1	–0.1	6.1	6.0	6.0	6.0

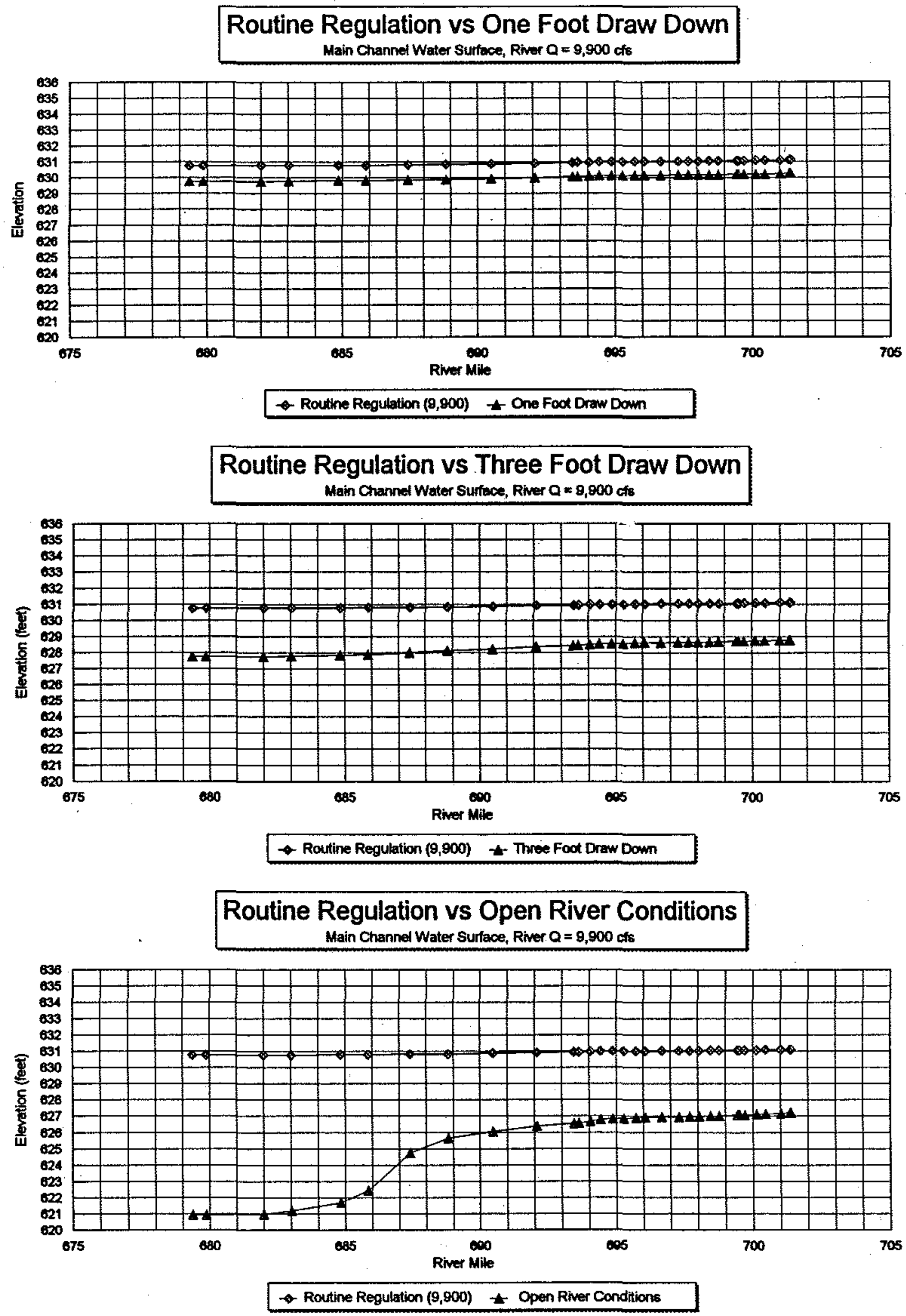


Figure 5-3. Routine Regulation vs. Drawdown (Q=9,900 cfs)

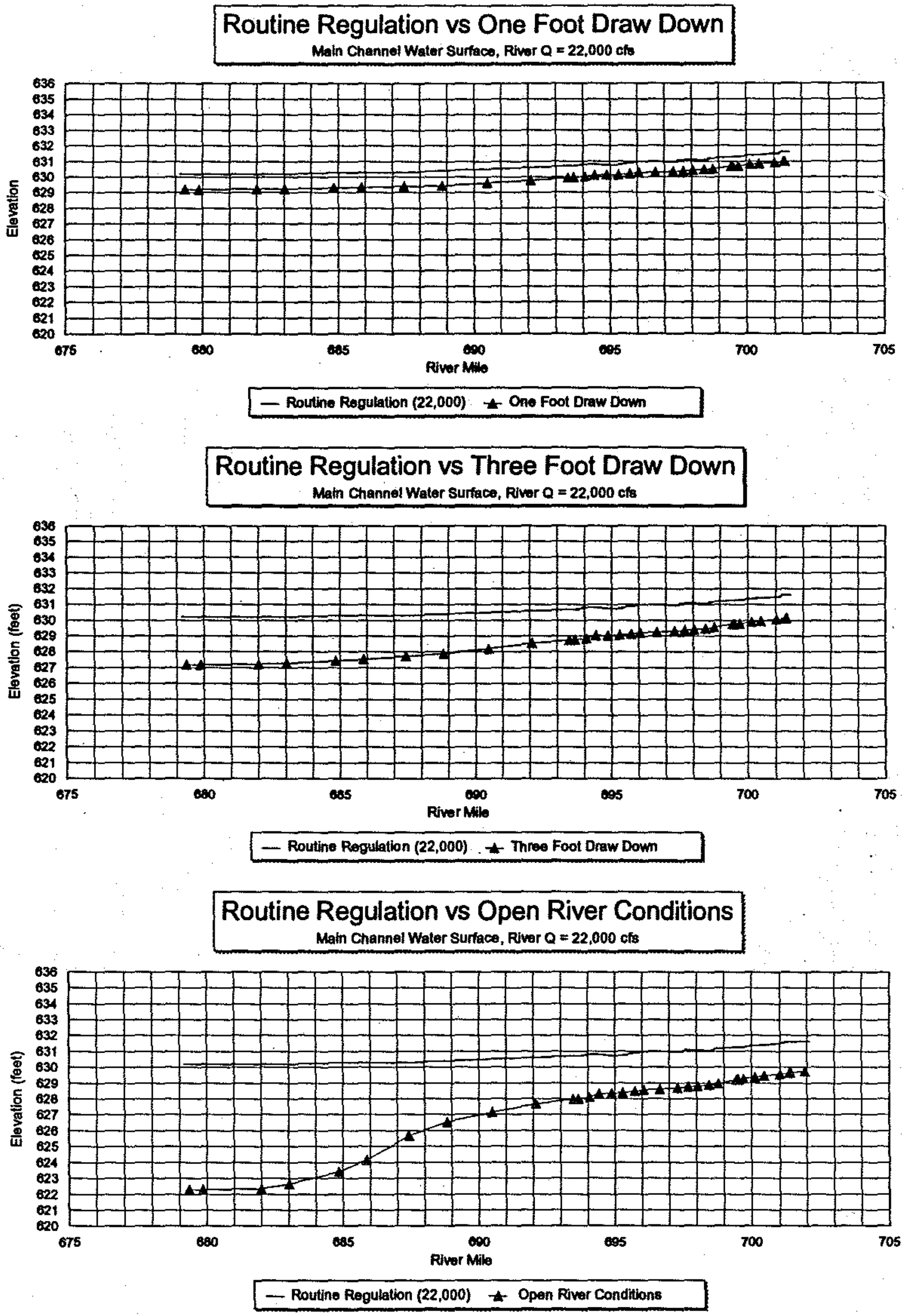


Figure 5-4. Routine Regulation vs. Drawdown (Q=22,000 cfs)

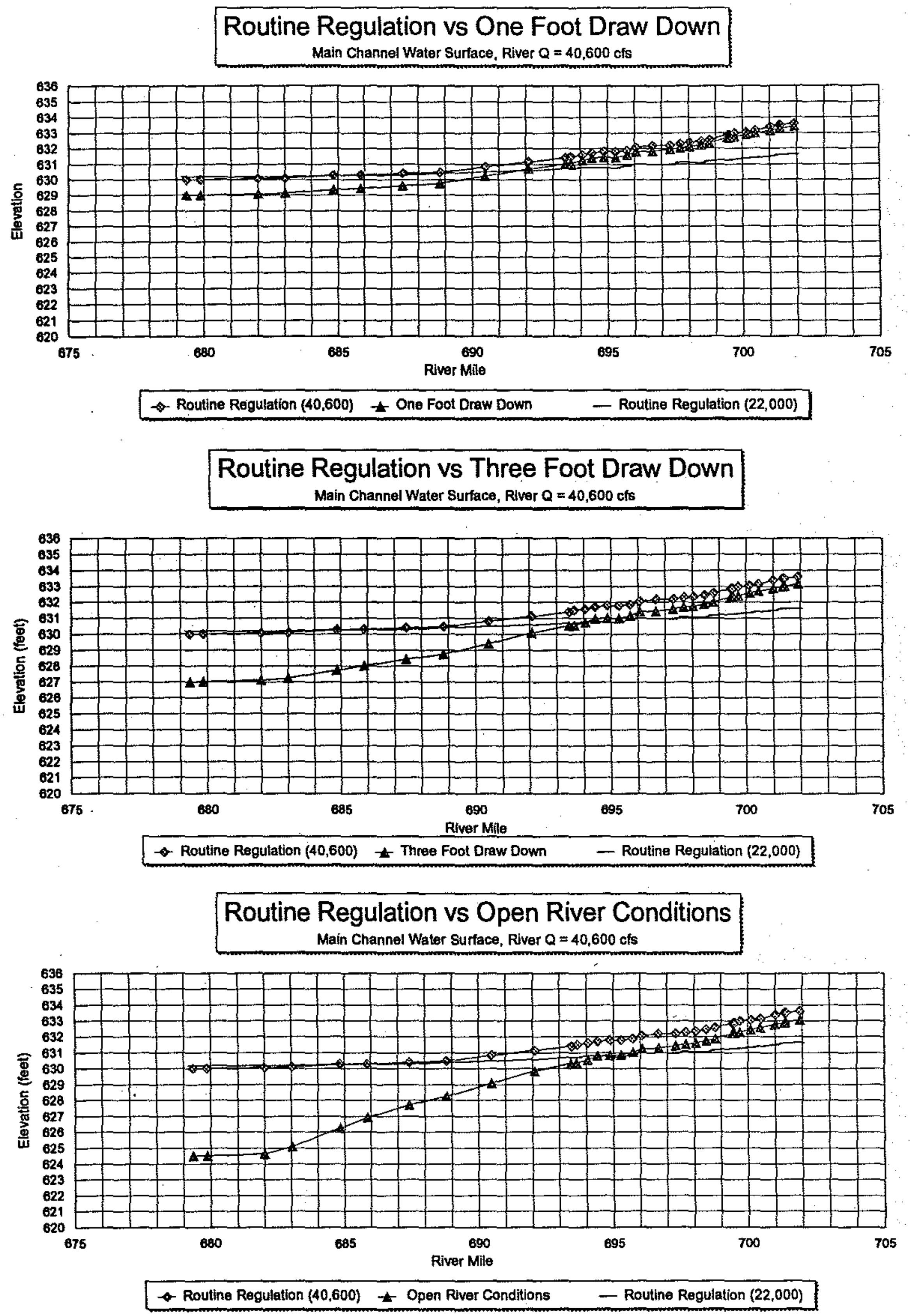
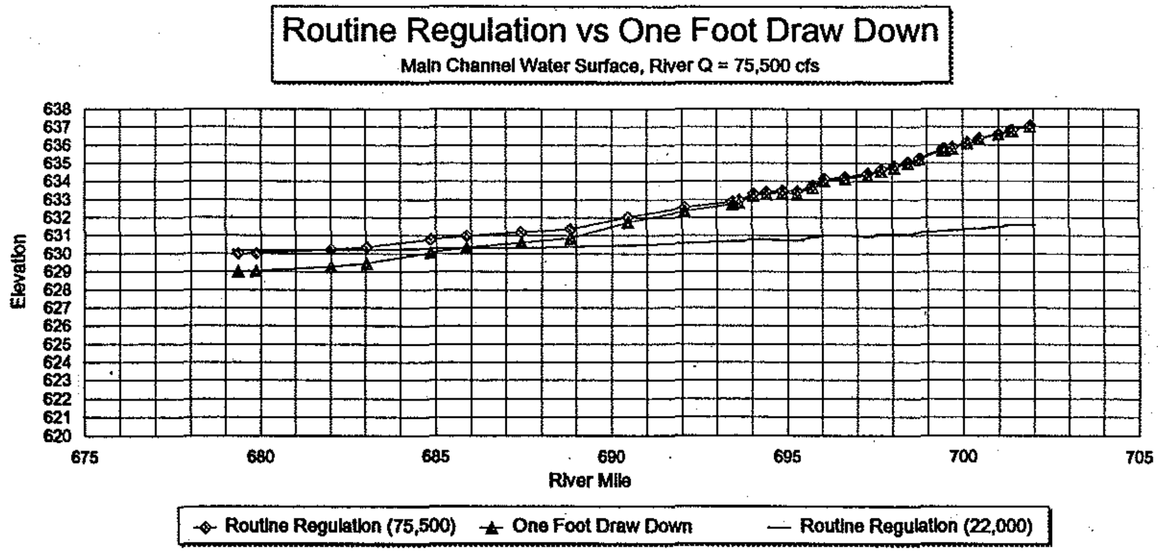
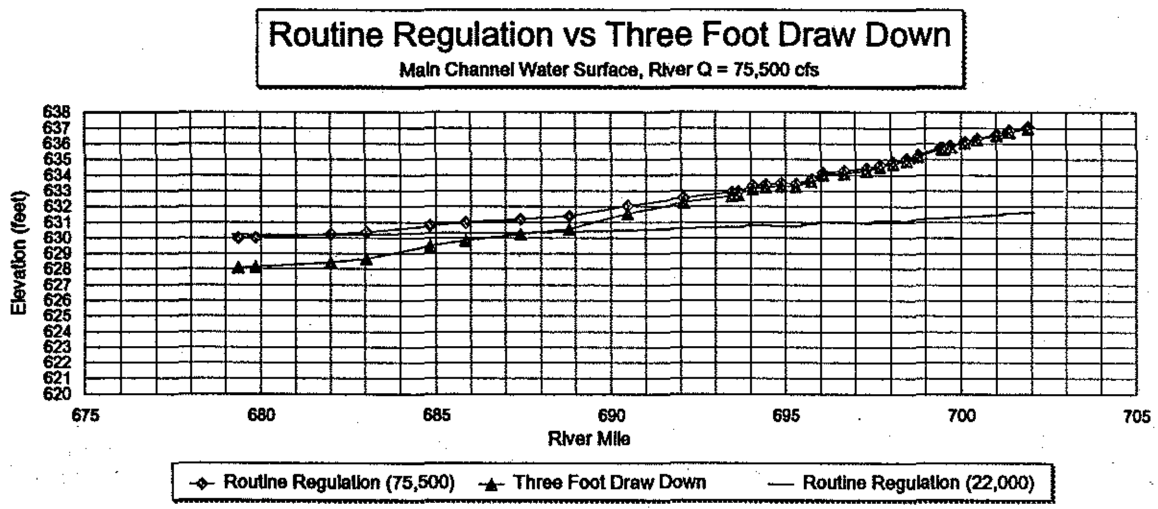


Figure 5-5. Routine Regulation vs. Drawdown (Q=40,600 cfs)





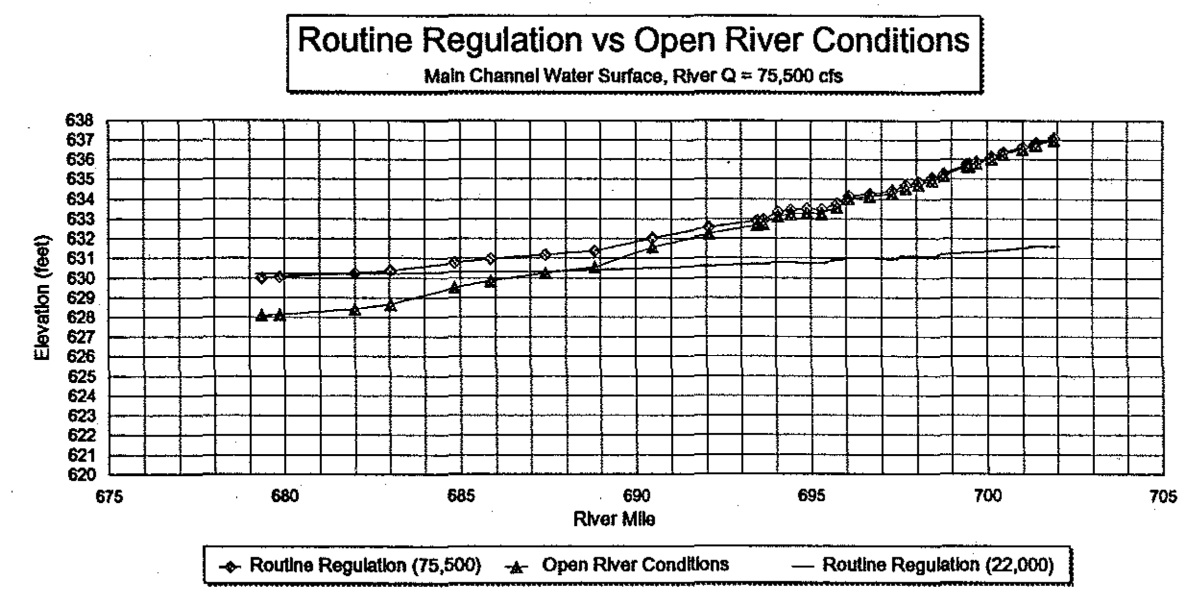


Figure 5-6. Routine Regulation vs. Drawdown (Q=75,500 cfs)

Sediment Transport

Pool drawdown alternatives should result in a long-term increase in the sediment transport capacity of the navigation channel. The increased transport capacity of the navigation channel would result from two expected changes in the hydrodynamics as shown in the HEC-2 analysis. A lower water surface throughout the pool will decrease depths over closing dams and wing dams, reduce flow into side channels, and correspondingly increase flow in the main channel. Lower water surface profiles result in increased velocities in the main channel due to a decrease in channel area. The resulting increases in navigation channel velocities will increase sediment transport competency of the main channel. The changes will not result in immediate changes in the profile of the channel bottom, so additional dredging will be required during the first year of a change in operating plans. Since the whole system will not have an increased sediment carrying capacity, overall dredging quantities may not decrease, but the locations of the dredging cuts are likely to change. A more detailed estimate of changes would require a two-dimensional hydraulic model analysis.

The sediment transport analysis for this report assumed the channel bed would respond slowly to changes in water level management. Channel maintenance costs assumed that dredging would be required in advance of pool drawdown to minimize impacts on navigation. Although this assumption is not entirely correct it does provide costs dredging that should be close enough for this level of study. Other maintenance costs may result from additional sediment that is mobilized from upstream or adjacent sites. These costs are unknown at this time and may be better identified with more detailed studies. After normal water levels are reestablished, dredging quantities may be reduced because the advanced dredging. These cost savings were not accounted for in this study. Future studies would need to look closer at changes in dredging quantities and changes is dredging locations.

Lowering pool elevations will also have an effect on tributary sediment sources. The magnitude of the effect will vary with the change in pool elevations at the tributaries. For Pool 8 the major tributaries are the Root River and the Black River. For a one foot draw down the change in stage at the Root River is 0.4 feet and at the Black River 0.3 feet. For a three foot draw down, the change in stage is 0.9 feet at the Root River and 0.7 feet at the Black River. These changes are expected to very little impact on increasing channel maintenance costs. Future studies would need to further evaluate these impacts.

Water Quality

Drawdowns conducted from the dam during the summer growing season would produce many of the same effects as would drawdowns of small-scale areas. The primary effect during drawdown would be mobilization of sediments, resulting in increased suspended solids draining from backwater areas through advective flow and wind. These sediment flows could exert some dissolved oxygen demand on the remaining backwater and channel areas. Sediment would also be mobilized from tributaries through the process of headcutting during drawdown.

Exposed sediments would consolidate during drawdown, oxidize, and change chemically. Areas exposed by different depths of pool 8 drawdown range from approximately 490 acres under a 1-foot drawdown at 75,500 cfs to 16,600 acres under open river drawdown at 9,900 cfs. 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 wide swings in day-to-night water temperature, pH, dissolved oxygen, and possibly unionized ammonia. These conditions would be stressful to aquatic life, and fish would be forced out of many of the remaining backwater areas during the warmer parts of the summer.

Upon reflooding, drawdown zone sediments may release phosphorus, triggering an algae bloom if conditions allow. Flooded standing vegetation releases considerable dissolved organic matter which 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.

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 reducing effective wind fetch for wave-driven resuspension.

Ecological

Growing season drawdowns would expose varying amounts of pool 8 substrate, depending on the intended depth of drawdown and river discharge (table 5-7). The area exposed by drawdown could range from near zero acres at river discharges over 75,500 cfs to over 16,000 acres at low flow with open river conditions. Most of the area in pool 8 that would be affected by drawdown is in the lower one-half of the pool. The 50-percent flow duration at Lock and Dam 8 for the growing season months falls in the range of 30,000 to 45,000 cfs (see table 2-1). Thus, the acres exposed at 22,000 cfs and 40,600 cfs would be most indicative of the range of substrate exposure that may be expected during a typical growing season. One general pattern is evident from table 5-7. Approximately twice the total area would be exposed with a 3-foot drawdown as would be exposed with a 1-foot drawdown. The area exposed nearly doubles again with open river conditions, at least for flows of 40,600 cfs or less.

Tables 5-8 and 5-9 show the aquatic areas exposed by drawdown by unvegetated, submersed aquatic vegetation, and emergent aquatic vegetation cover types. Table 5-8 is based on 1989 vegetation data, while table 5-9 uses 1991 vegetation data. The data for 1989 reflects a year when aquatic vegetation growth in pool 8 was relatively good, while 1991 was a year in which aquatic vegetation growth in pool 8 was relatively sparse. The unvegetated acres displayed for both years may not be unvegetated now or in the future. The classification was based primarily on air photo interpretation, and areas classified as open water may have had submersed vegetation that was not detected by the air photos.

If 1989 and 1991 are typical of the range of vegetation cover that can be expected in pool 8, a 1-foot drawdown would expose two to ten times the acreage of vegetated area (emergent and submersed vegetation areas combined) compared to unvegetated area. Given that some of the unvegetated area may actually contain vegetation, the ratios could be even greater. With a 3-foot drawdown, the ratio of vegetated acres exposed to unvegetated acres would probably range from 1:1 to 4:1 depending on annual conditions. A drawdown to open river conditions would expose a substantially larger area of unvegetated habitat. This would be expected because the depth of drawdown would be substantially greater in the downriver portion of the pool.

The areas exposed with the drawdown alternatives being evaluated are shown in figures 5-7 through 5-18. Figures 5-19 through 5-22 graphically display the relationships between depth of drawdown and vegetated/unvegetated cover types for the drawdown alternatives under evaluation.

Table 5-7
Acres* Exposed by Depth of Exposure

Draw-down	Flow	Depth Exposed (ft) 0-1 ft	1-2 ft	2-3 ft	3-5 ft	> 5 ft	Total
1-foot	9,900 cfs	3600	700				4300
	22,000 cfs	3200	1400				4600
	40,600 cfs	2000	400				2400
	75,500 cfs	500					500
3-foot	9,900 cfs	3000	2200	3200	100		8500
	22,000 cfs	4000	2900	2100	400		9400
	40,600 cfs	3500	1600	400	100		5600
	75,500 cfs	600	200				800
open river	9,900 cfs	1100	1500	2500	7200	4300	16600
	22,000 cfs	1900	3000	4000	5100	1100	15100
	40,600 cfs	3900	3000	1800	700	100	9500
	75,500 cfs	600	200				800

* rounded to nearest 100 acres

Table 5-8
Acres* Exposed Unvegetated vs. Vegetated - 1989

Draw-down	Flow	Unvegetated Acres Exposed	Submergent** Vegetation Acres Exposed	Emergent*** Vegetation Acres Exposed	Total Aquatic Acres Exposed	Approx. Ratio of Vegetated to Unvegetated	Percent Aquatic Area Exposed
1-foot	9,900 cfs	600	2500	1200	4300	6:1	20
	22,000 cfs	600	2800	.1200	4600	7:1	22
	40,600 cfs	200	1400	700	2300	10:1	11
	75,500 cfs	100	300	100	500	4:1	2
3-foot	9,900 cfs	1900	5300	1400	8600	4:1	41
	22,000 cfs	2200	5700	1400	9300	3:1	44
	40,600 cfs	1100	3500	1000	5600	4:1	26
	75,500 cfs	100	500	100	700	6:1	3
open river	9,900 cfs	8600	6600	1400	16600	1:1	78
	22,000 cfs	7400	6400	1400	15200	1:1	72
	40,600 cfs	3800	4500	1100	9400	1:1	44
	75,500 cfs	100	500	100	700	6:1	3

* rounded to nearest 100 acres
** EMTC cover types 2-6
*** EMTC cover types 7-9

Table 5-9
Acres* Exposed Unvegetated vs. Vegetated - 1991

Draw-down	Flow	Unvegetated Acres Exposed	Submergent** Vegetation Acres Exposed	Emergent*** Vegetation Acres Exposed	Total Aquatic Acres Exposed	Approx. Ratio of Vegetated to Unvegetated	Percent Aquatic Area Exposed
1-foot	9,900 cfs	1100	1800	1400	4300	3:1	20
	22,000 cfs	1300	1900	1400	4600	2:1	22
	40,600 cfs	700	900	800	2400	2:1	11
	75,500 cfs	200	100	200	500	2:1	2
3-foot	9,900 cfs	4100	2800	1700	8600	1:1	41
	22,000 cfs	4800	2900	1600	9300	1:1	44
	40,600 cfs	2800	1700	1100	5600	1:1	26
	75,500 cfs	300	200	200	700	1:1	3
open river	9,900 cfs	11800	3100	1700	16600	1:2	78
	22,000 cfs	10400	3000	1600	15000	1:2	71
	40,600 cfs	6200	2000	1200	9400	1:2	44
	75,500 cfs	300	200	200	700	1:1	3

* rounded to nearest 100 acres
** EMTC cover types 2-6
*** EMTC cover types 7-9

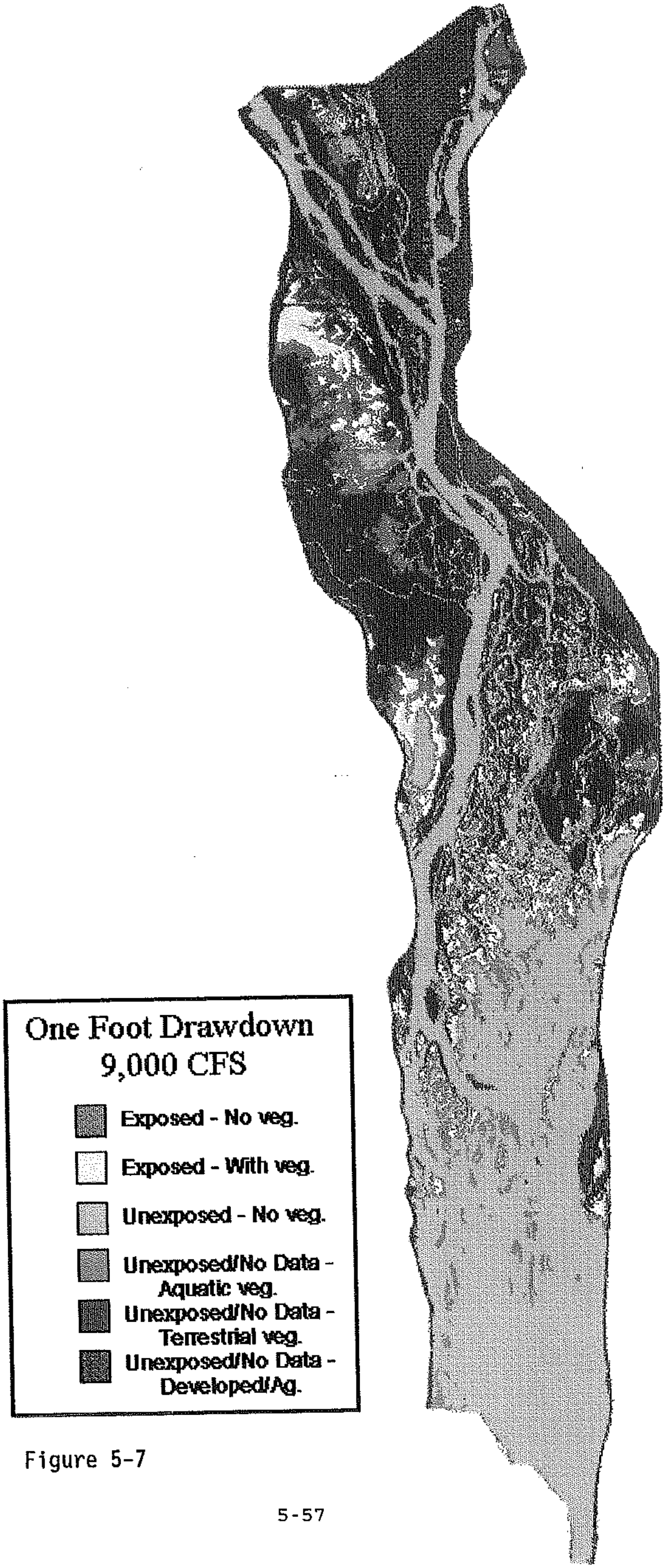

One Foot Drawdown
9,000 CFS
Exposed - No veg.
Exposed - With veg.
Unexposed - No veg.
Unexposed/No Data - Aquatic veg.
Unexposed/No Data - Terrestrial veg.
Unexposed/No Data - Developed/Ag.

Figure 5-7

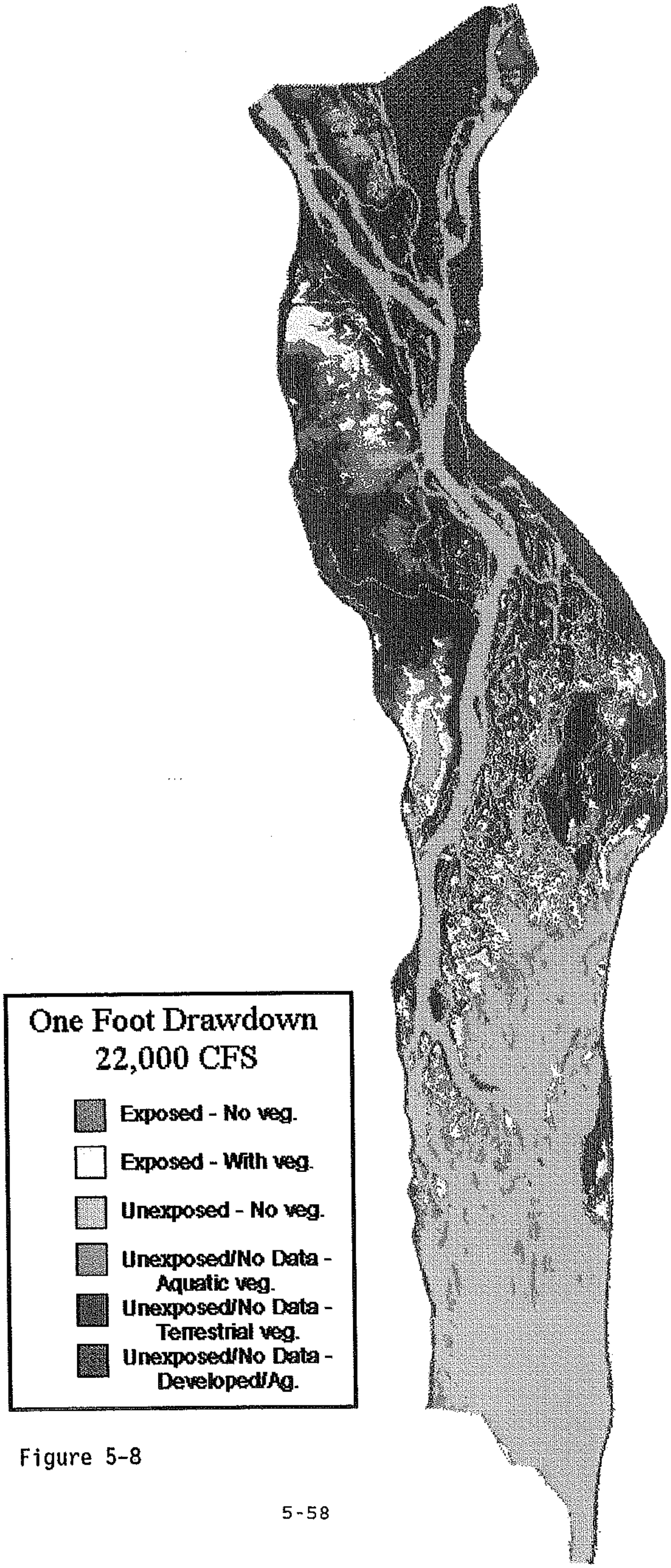

One Foot Drawdown
22,000 CFS
Exposed - No veg.
Exposed - With veg.
Unexposed - No veg.
Unexposed/No Data - Aquatic veg.
Unexposed/No Data - Terrestrial veg.
Unexposed/No Data - Developed/Ag.

Figure 5-8

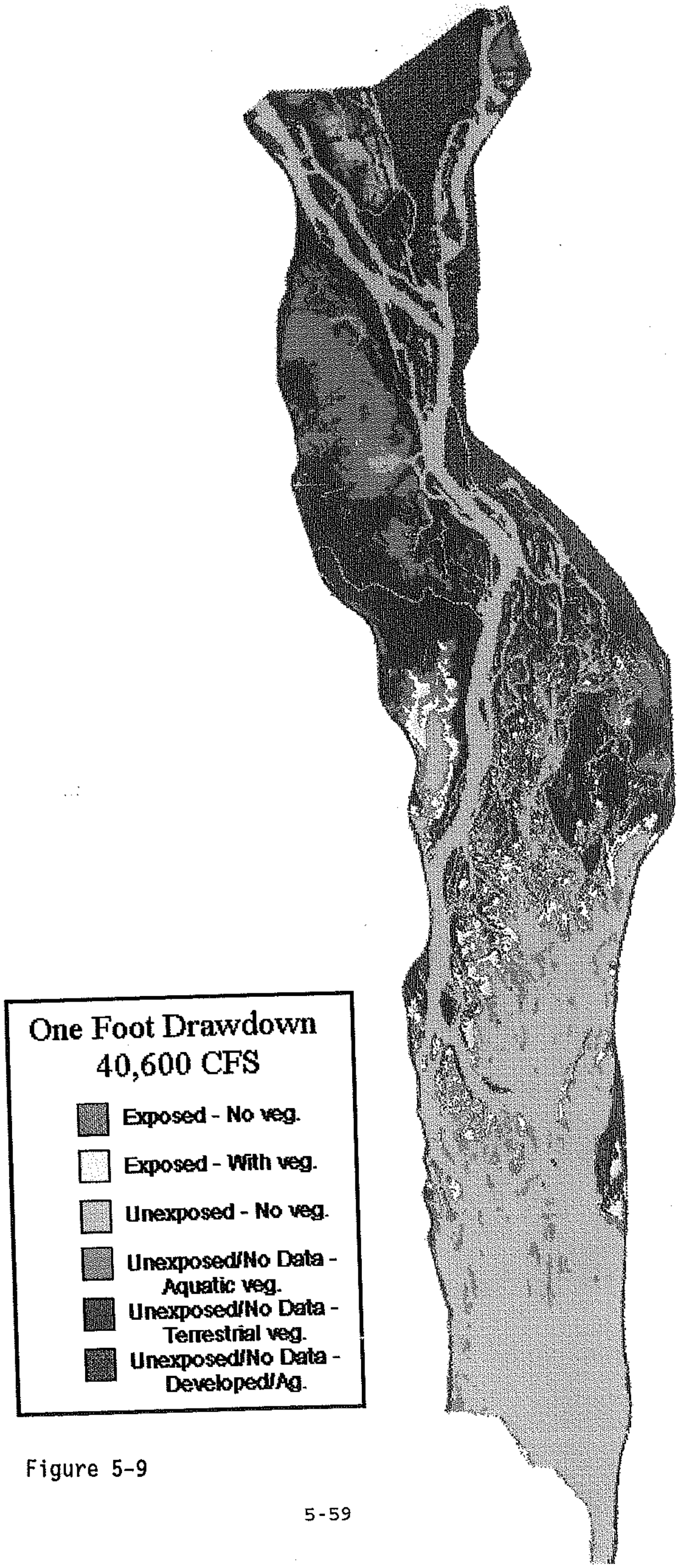

One Foot Drawdown
40,600 CFS
Exposed - No veg.
Exposed - With veg.
Unexposed - No veg.
Unexposed/No Data - Aquatic veg.
Unexposed/No Data - Terrestrial veg.
Unexposed/No Data - Developed/Ag.

Figure 5-9

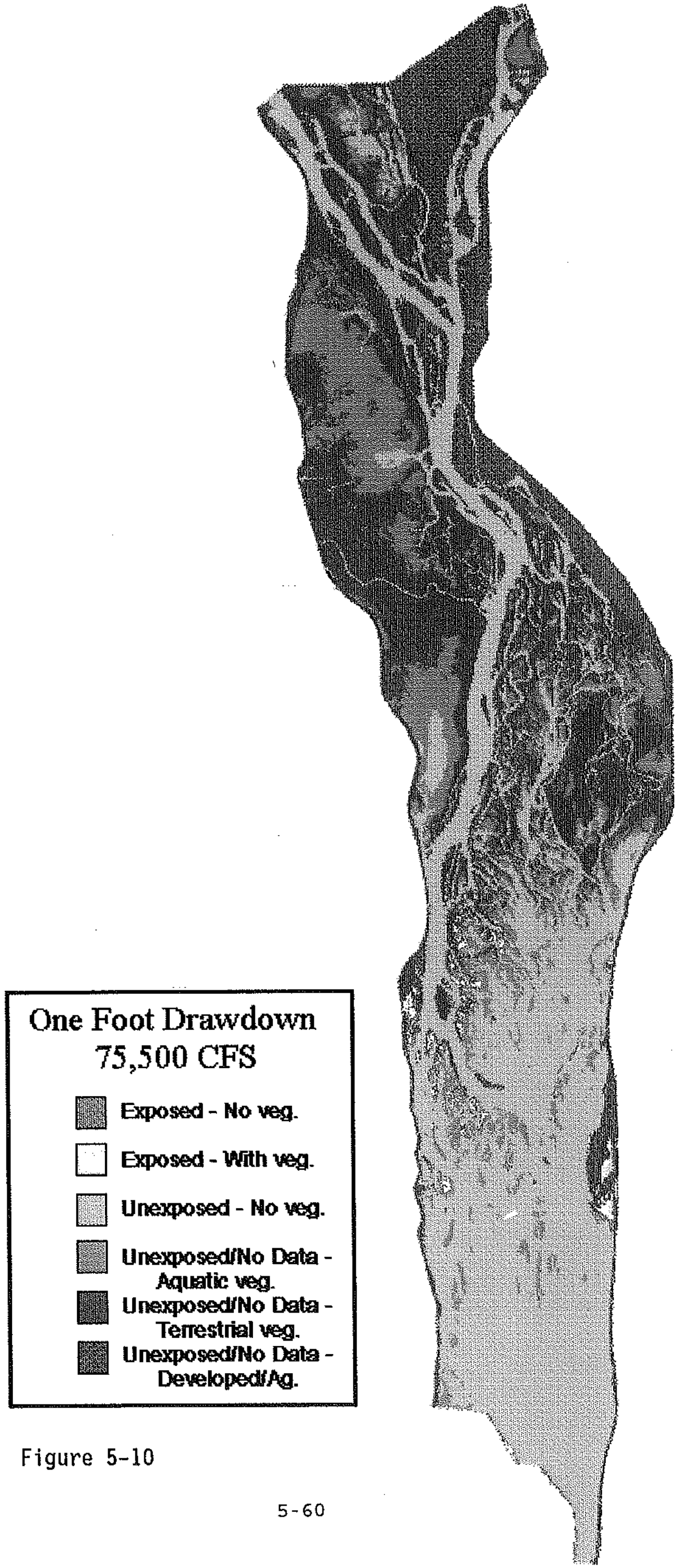

One Foot Drawdown
75,500 CFS
Exposed - No veg.
Exposed - With veg.
Unexposed - No veg.
Unexposed/No Data - Aquatic veg.
Unexposed/No Data - Terrestrial veg.
Unexposed/No Data - Developed/Ag.

Figure 5-10

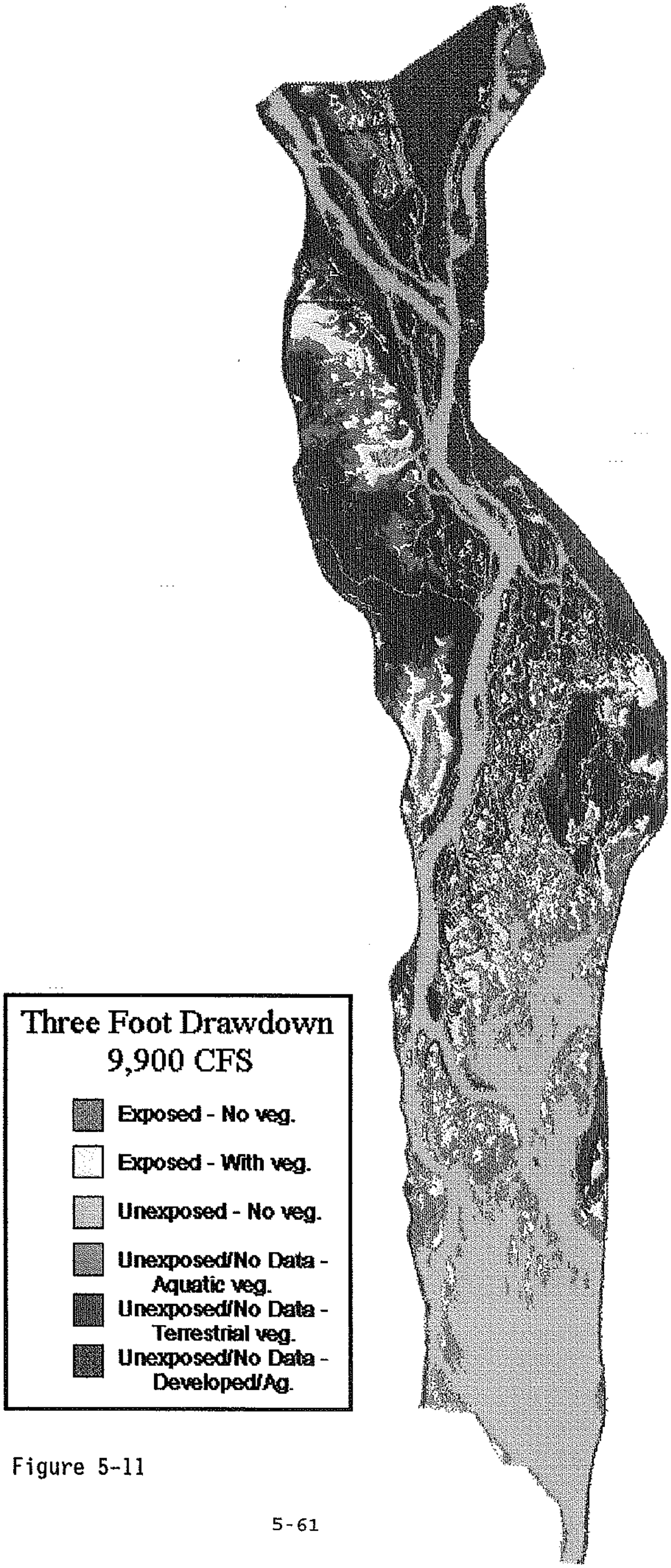

Three Foot Drawdown
9,900 CFS
Exposed - No veg.
Exposed - With veg.
Unexposed - No veg.
Unexposed/No Data - Aquatic veg.
Unexposed/No Data - Terrestrial veg.
Unexposed/No Data - Developed/Ag.

Figure 5-11

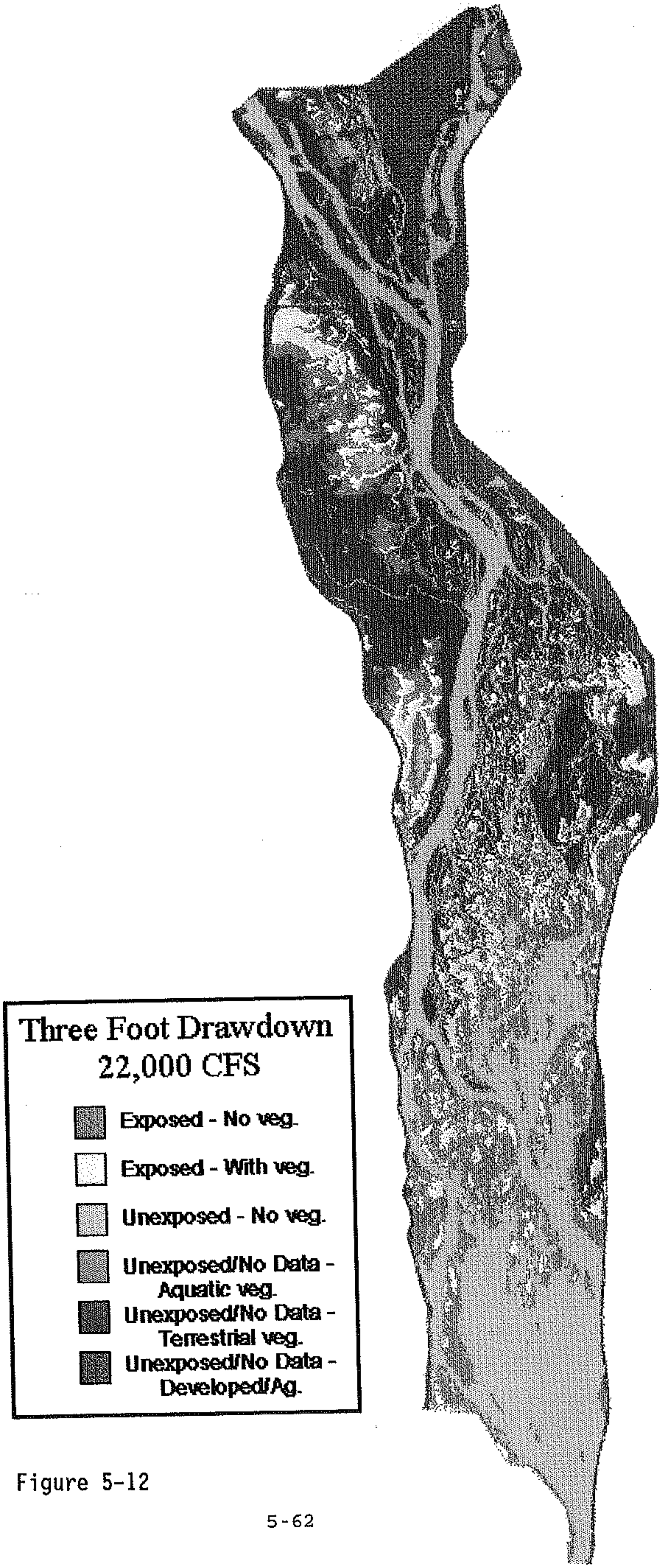

Three Foot Drawdown
22,000 CFS
Exposed - No veg.
Exposed - With veg.
Unexposed - No veg.
Unexposed/No Data - Aquatic veg.
Unexposed/No Data - Terrestrial veg.
Unexposed/No Data - Developed/Ag.

Figure 5-12

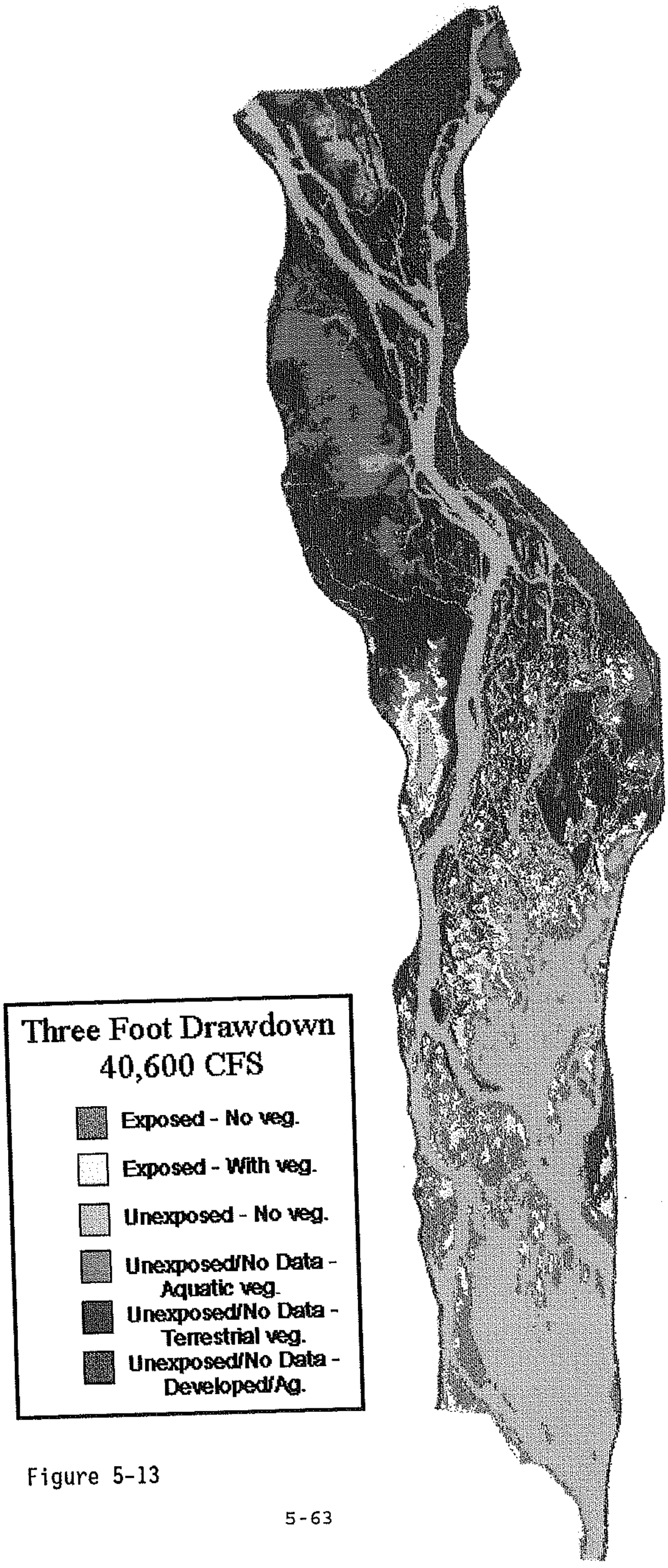

Three Foot Drawdown
40,600 CFS
Exposed - No veg.
Exposed - With veg.
Unexposed - No veg.
Unexposed/No Data - Aquatic veg.
Unexposed/No Data - Terrestrial veg.
Unexposed/No Data - Developed/Ag.

Figure 5-13

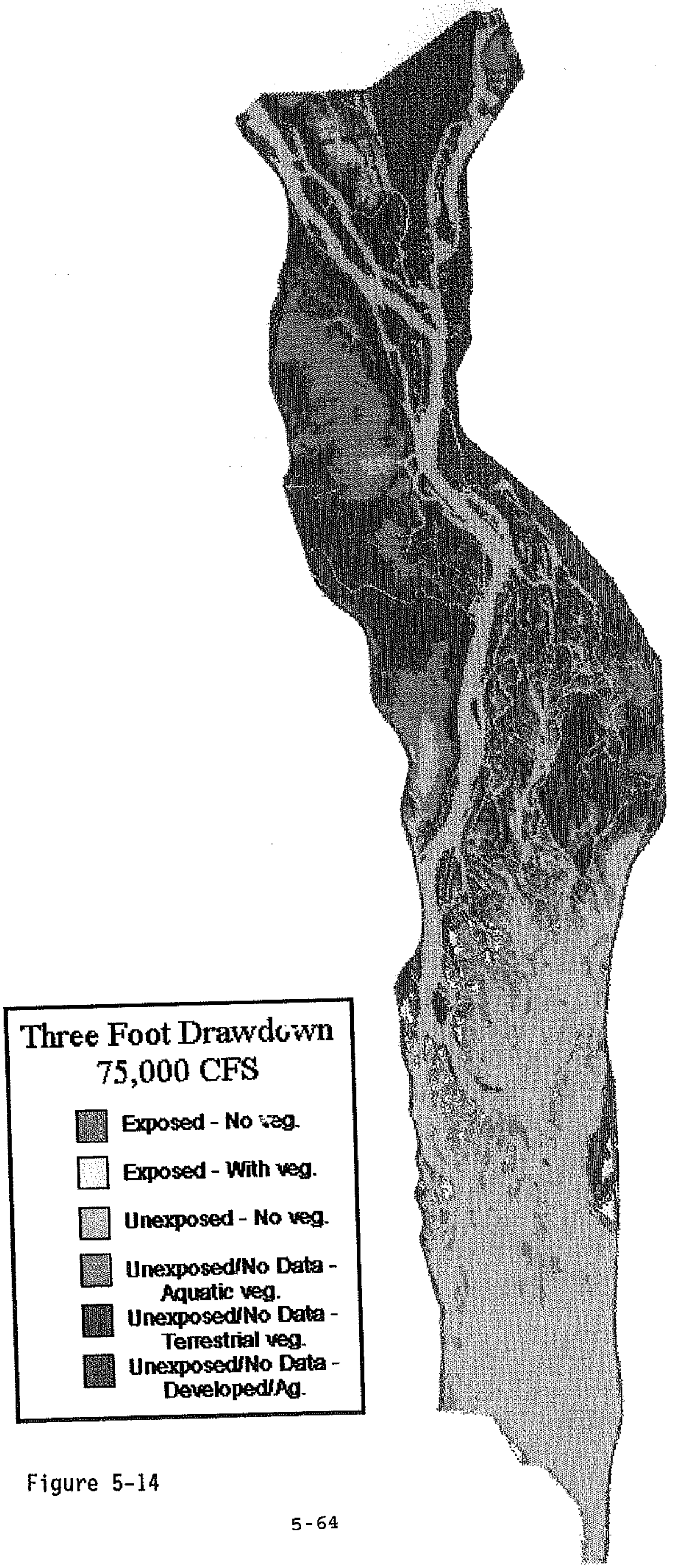

Three Foot Drawdown
75,000 CFS
Exposed - No veg.
Exposed - With veg.
Unexposed - No veg.
Unexposed/No Data - Aquatic veg.
Unexposed/No Data - Terrestrial veg.
Unexposed/No Data - Developed/Ag.

Figure 5-14

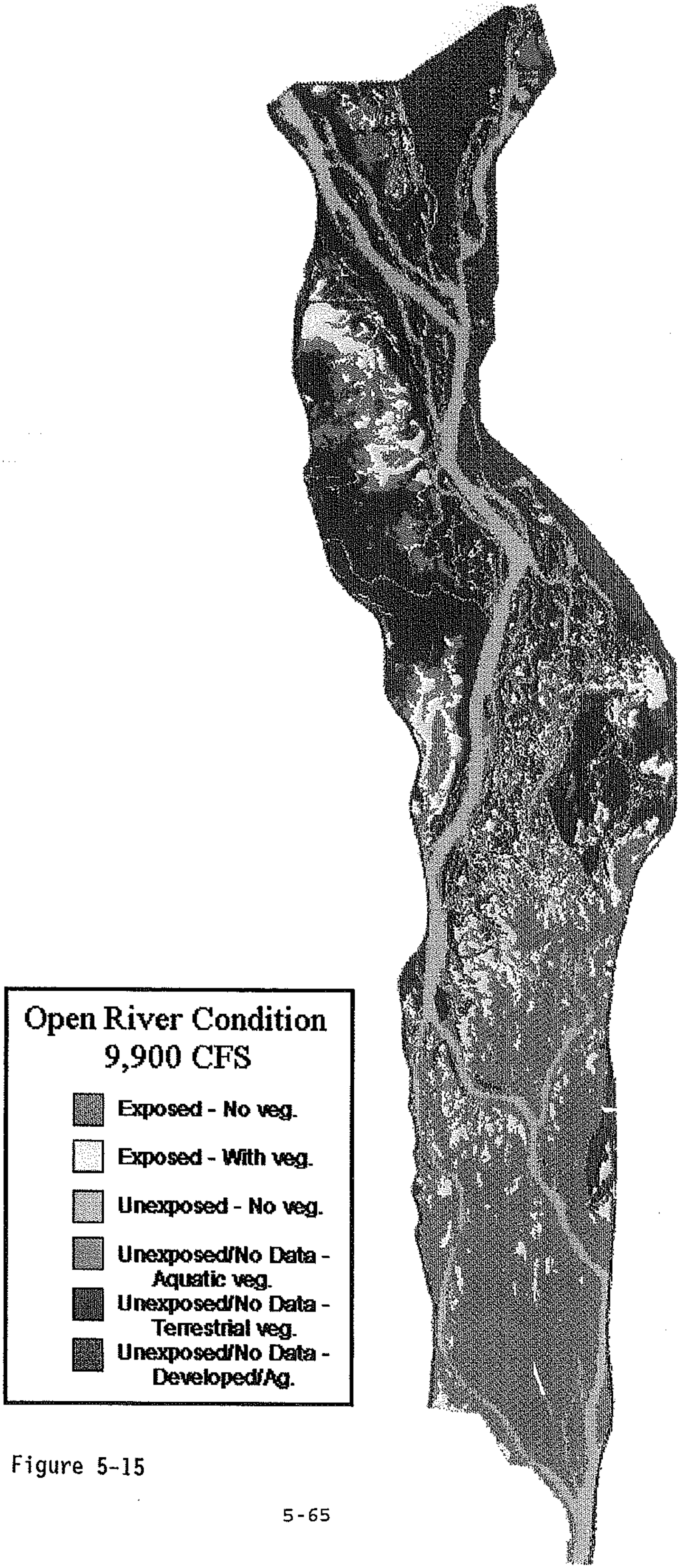

Open River Condition
9,900 CFS
Exposed - No veg.
Exposed - With veg.
Unexposed - No veg.
Unexposed/No Data - Aquatic veg.
Unexposed/No Data - Terrestrial veg.
Unexposed/No Data - Developed/Ag.

Figure 5-15

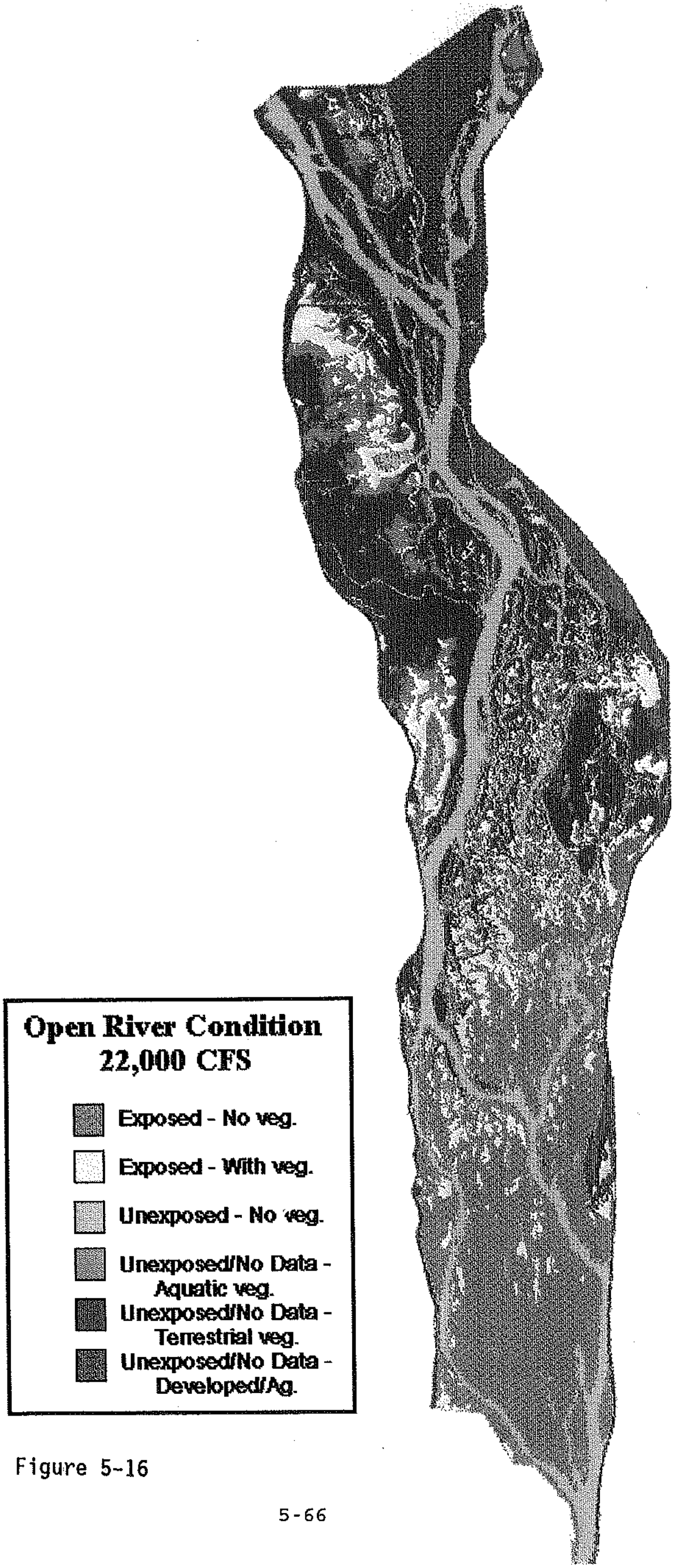

Open River Condition
22,000 CFS
Exposed - No veg.
Exposed - With veg.
Unexposed - No veg.
Unexposed/No Data - Aquatic veg.
Unexposed/No Data - Terrestrial veg.
Unexposed/No Data - Developed/Ag.

Figure 5-16


Open River Condition
40,600 CFS
Exposed - No veg.
Exposed - With veg.
Unexposed - No veg.
Unexposed/No Data - Aquatic veg.
Unexposed/No Data - Terrestrial veg.
Unexposed/No Data - Developed/Ag.

Figure 5-17

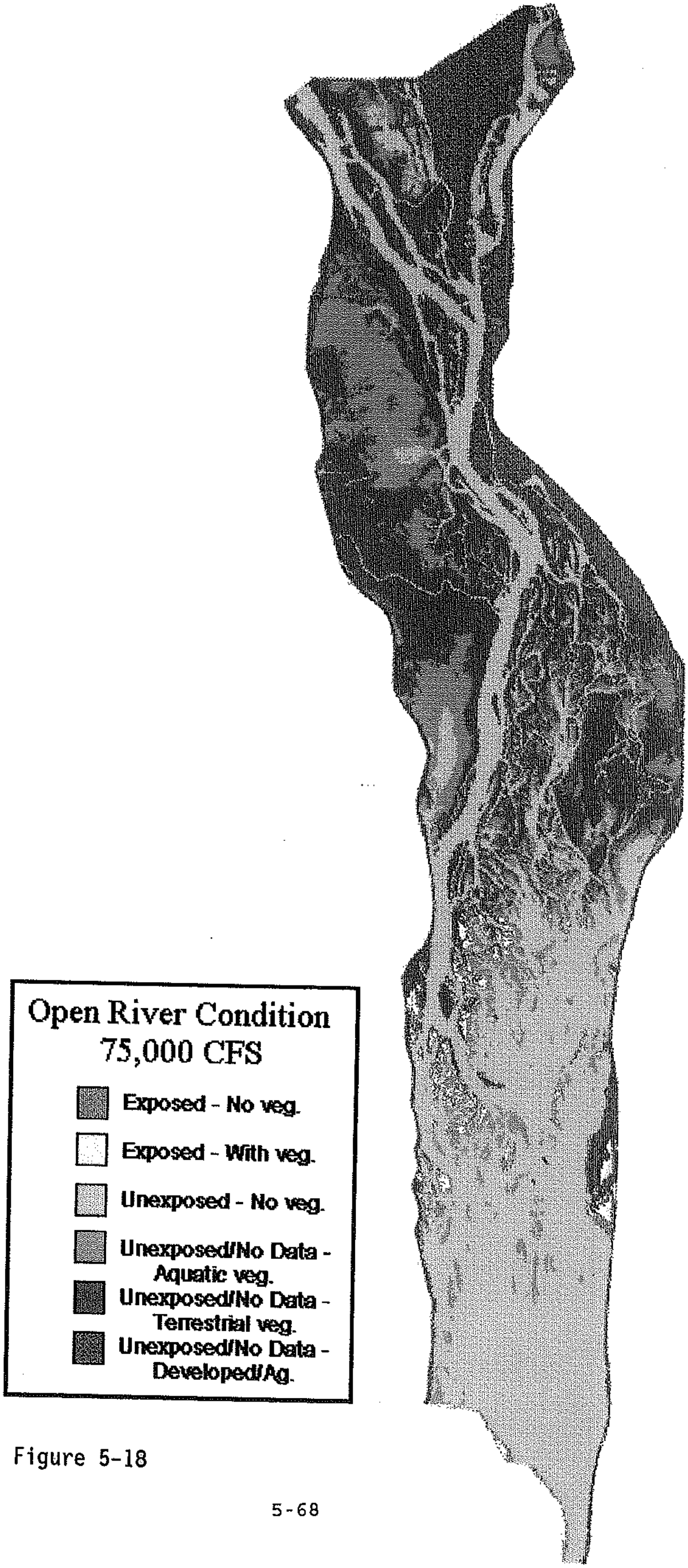

Open River Condition
75,000 CFS
Exposed - No veg.
Exposed - With veg.
Unexposed - No veg.
Unexposed/No Data - Aquatic veg.
Unexposed/No Data - Terrestrial veg.
Unexposed/No Data - Developed/Ag.

Figure 5-18

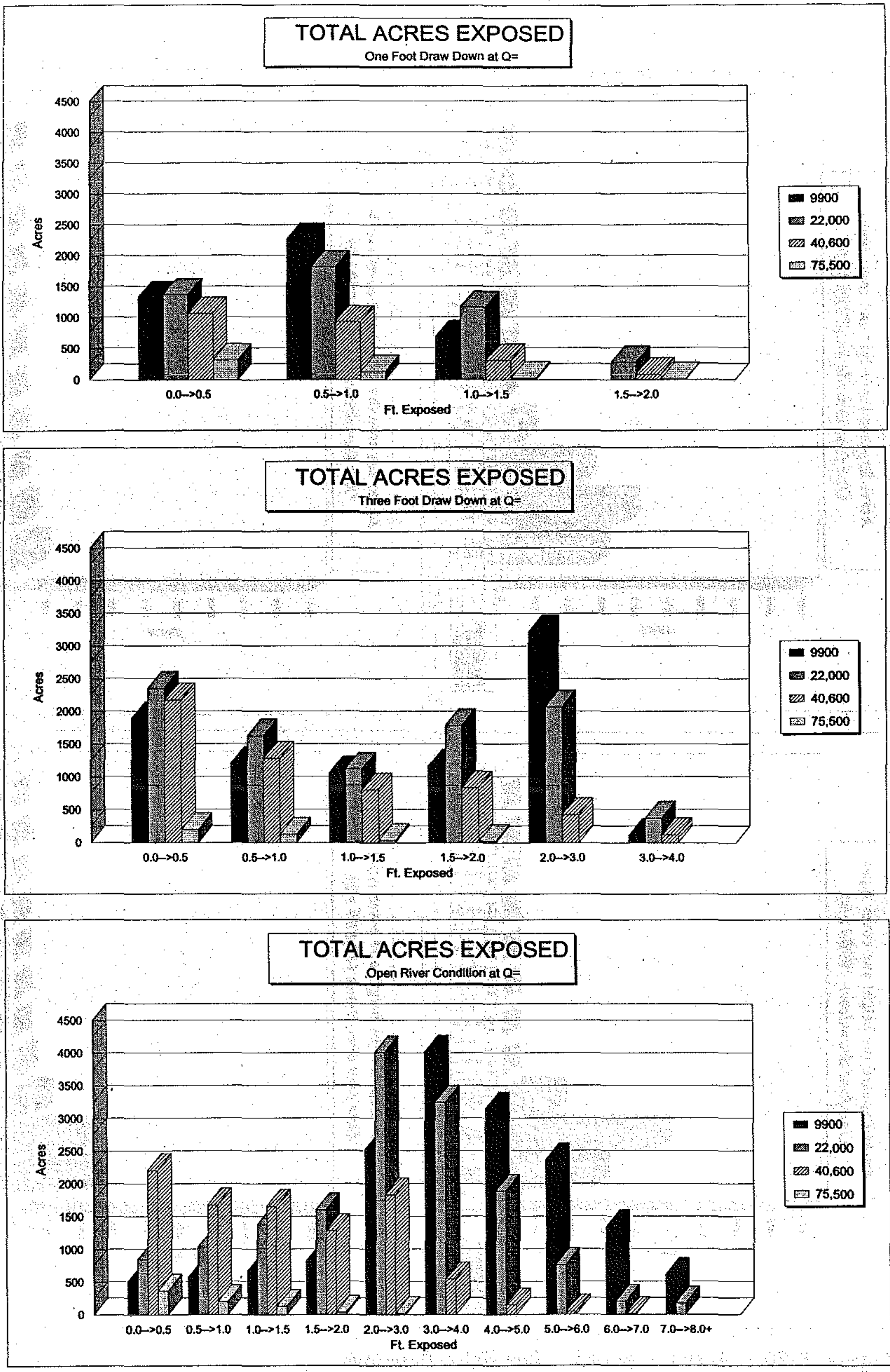
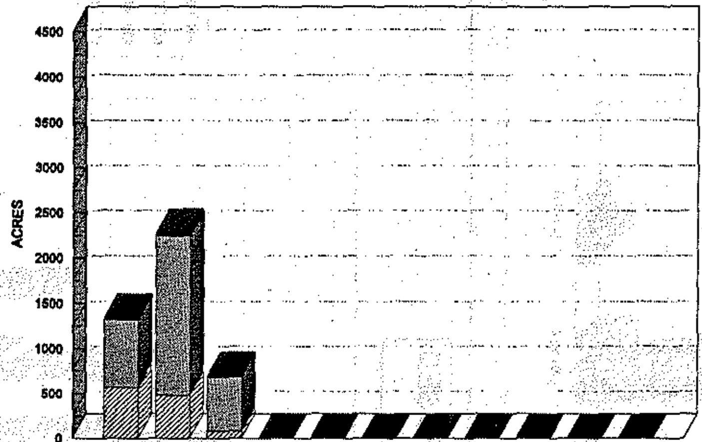


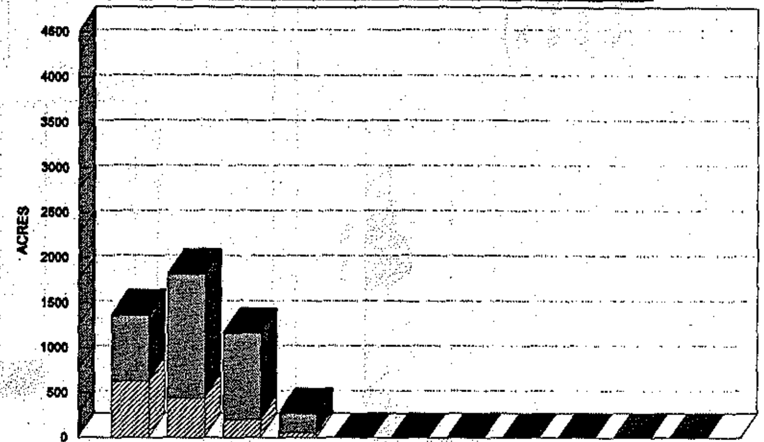
Figure 5-19. Total Acres Exposed for all Drawdown Conditions

Acres Exposed (by height and cover type)
One foot drawdown (9900 cfs)



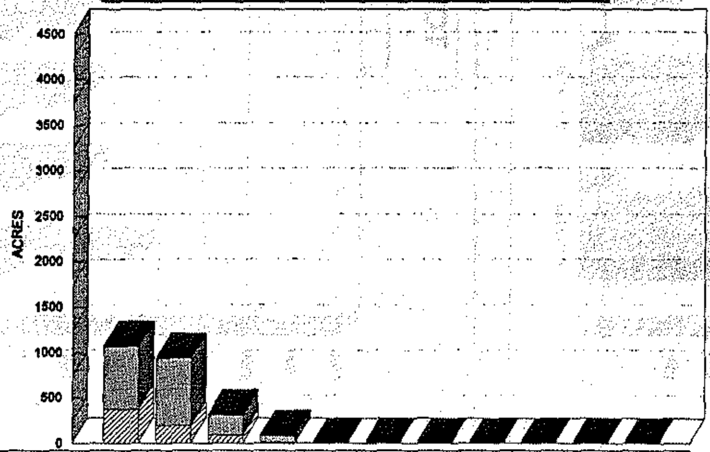
	0->0.5	0.5->1	1->1.5	1.5->2	2->3	3->4	4->5	5->6	6->7	7->8	8+
Unvegetated	588	481	81	0	0	0	0	0	0	0	0
Vegetated	756	1765	604	0	0	0	0	0	0	0	0
Devloped	6	25	6	0	0	0	0	0	0	0	0

Acres Exposed (by height and cover type)
One foot drawdown (22,000 cfs)



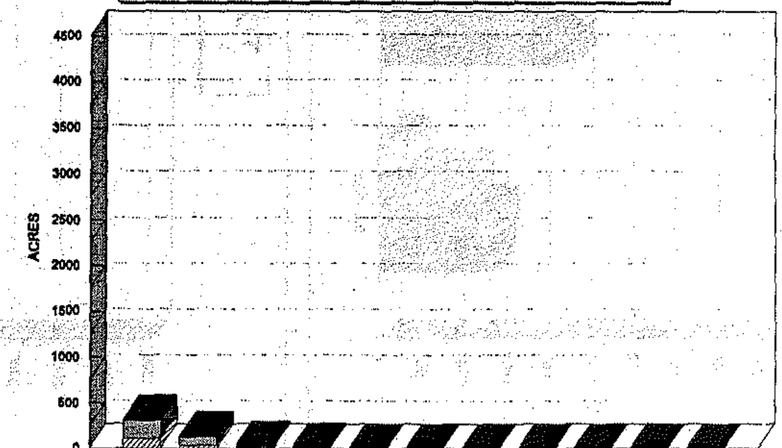
	0->0.5	0.5->1	1->1.5	1.5->2	2->3	3->4	4->5	5->6	6->7	7->8	8+
Unvegetated	626	442	201	51	0	0	0	0	0	0	0
Vegetated	730	1373	964	220	0	0	0	0	0	0	0
Devloped	17	7	4	6	0	0	0	0	0	0	0

Acres Exposed (by height and cover type)
One foot drawdown (40,600 cfs)



	0->0.5	0.5->1	1->1.5	1.5->2	2->3	3->4	4->5	5->6	6->7	7->8	8+
Unvegetated	373	193	69	12	0	0	0	0	0	0	0
Vegetated	692	740	219	74	0	0	0	0	0	0	0
Devloped	4	1	6	1	0	0	0	0	0	0	0

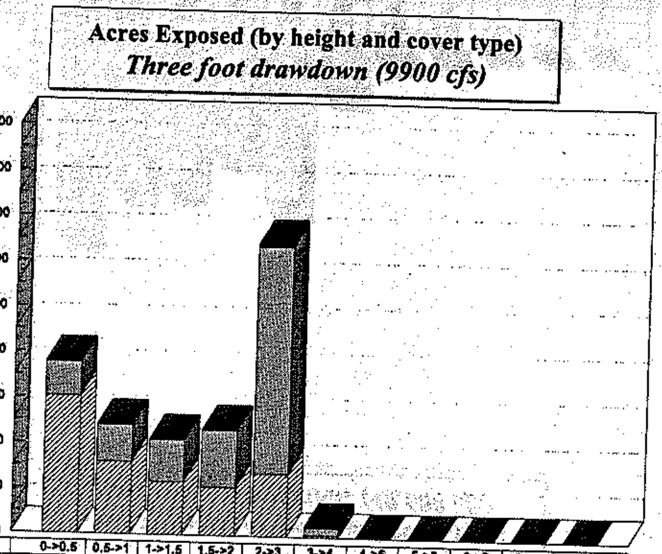
Acres Exposed (by height and cover type)
One foot drawdown (75,500 cfs)



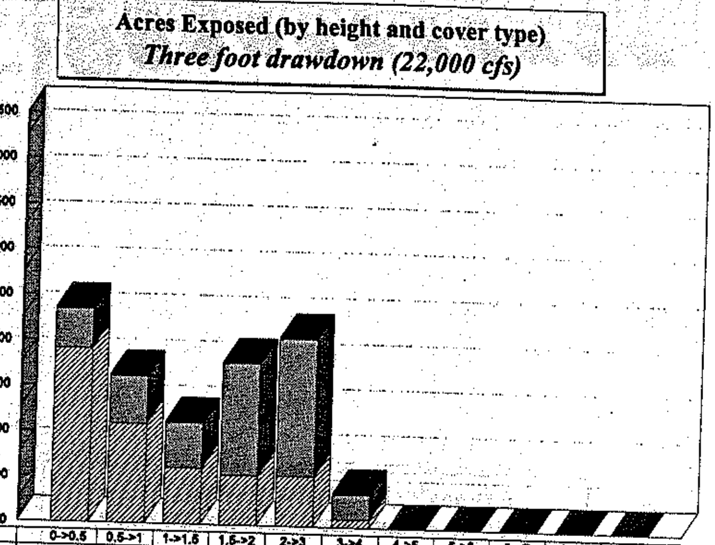
	0->0.5	0.5->1	1->1.5	1.5->2	2->3	3->4	4->5	5->6	6->7	7->8	8+
Unvegetated	111	36	8	6	0	0	0	0	0	0	0
Vegetated	198	97	16	3	0	0	0	0	0	0	0
Devloped	6	1	0	1	0	0	0	0	0	0	0

Figure 5-20. Acres Exposed - One-foot Drawdown

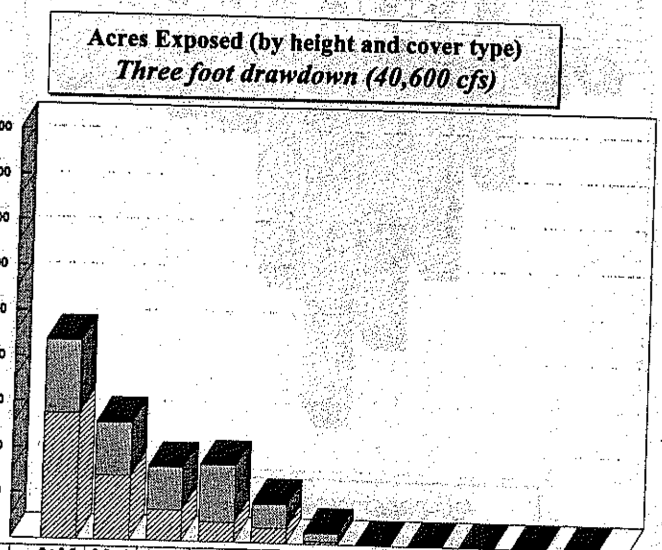
Figure 5-21. Acres Exposed - Three-foot Drawdown



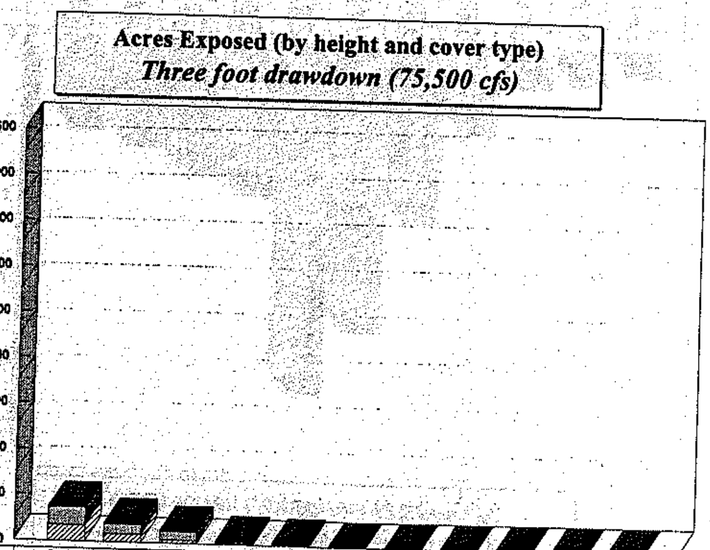
	0->0.5	0.5->1	1->1.5	1.5->2	2->3	3->4	4->5	5->6	6->7	7->8	8+
Unvegetated	1515	796	582	531	690	20	0	0	0	0	0
Vegetated	374	408	465	629	2500	69	0	0	0	0	0
Devloped	5	5	5	7	31	1	0	0	0	0	0



	0->0.5	0.5->1	1->1.5	1.5->2	2->3	3->4	4->5	5->6	6->7	7->8	8+
Unvegetated	1915	1092	617	549	555	92	0	0	0	0	0
Vegetated	435	523	495	1234	1512	276	0	0	0	0	0
Devloped	6	13	11	5	7	7	0	0	0	0	0



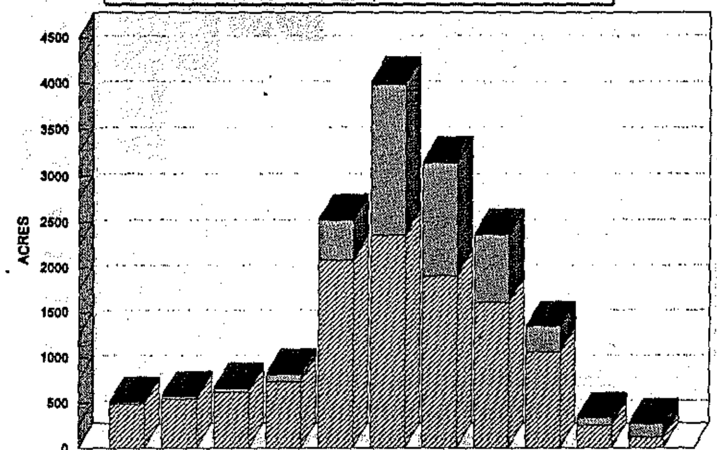
	0->0.5	0.5->1	1->1.5	1.5->2	2->3	3->4	4->5	5->6	6->7	7->8	8+
Unvegetated	1375	697	334	214	164	26	0	0	0	0	0
Vegetated	798	585	470	624	257	93	0	0	0	0	0
Devloped	4	3	1	1	6	1	0	0	0	0	0



	0->0.5	0.5->1	1->1.5	1.5->2	2->3	3->4	4->5	5->6	6->7	7->8	8+
Unvegetated	171	66	36	12	12	0	0	0	0	0	0
Vegetated	194	107	91	23	9	0	0	0	0	0	0
Devloped	2	5	1	0	1	0	0	0	0	0	0

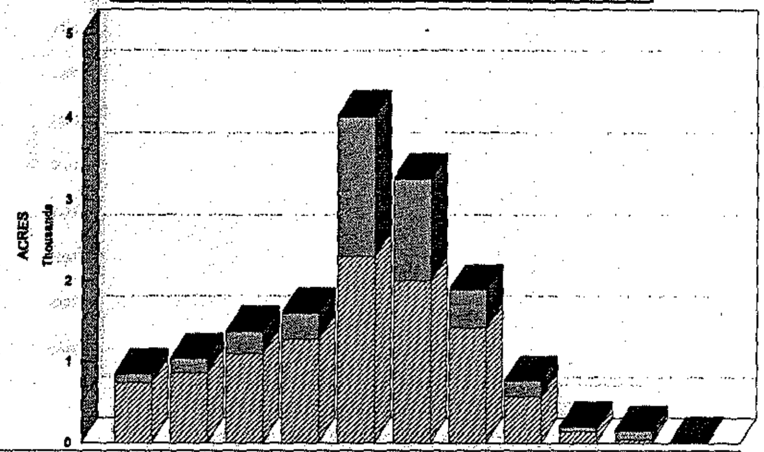
Figure 5-22. Acres Exposed - Open River Conditions

Acres Exposed (by height and cover type)
Open River Conditions (9900 cfs)



	0->0.5	0.5->1	1->1.5	1.5->2	2->3	3->4	4->5	5->6	6->7	7->8	8+
Unvegetated	489	542	618	732	2074	2355	1907	1608	1060	251	117
Vegetated	19	28	46	64	441	1635	1235	754	266	68	151
Devloped	4	3	4	4	10	27	7	5	1	1	2

Acres Exposed (by height and cover type)
Open River Conditions (22,000 cfs)

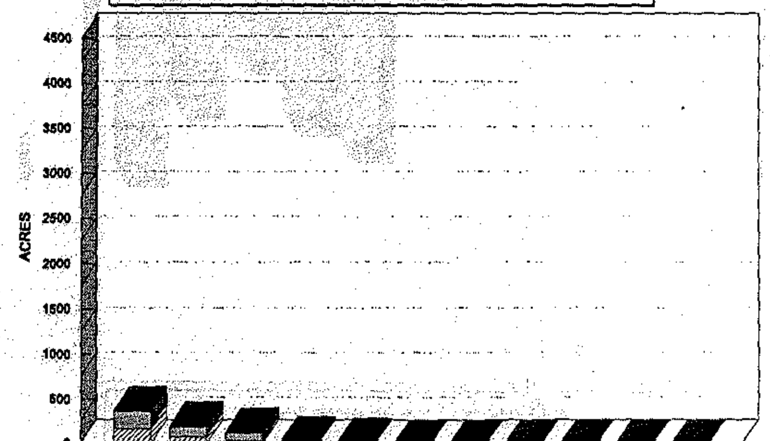


	0->0.5	0.5->1	1->1.5	1.5->2	2->3	3->4	4->5	5->6	6->7	7->8	8+
Unvegetated	739	855	1093	1272	2299	1998	1413	583	142	46	11
Vegetated	107	179	275	322	1704	1248	472	198	60	108	8
Devloped	5	6	12	11	10	3	5	1	1	1	1

Acres Exposed (by height and cover type)
Open River Conditions (40,600 cfs)

	0->0.5	0.5->1	1->1.5	1.5->2	2->3	3->4	4->5	5->6	6->7	7->8	8+
Unvegetated	1662	1210	1155	821	938	368	58	19	7	0	0
Vegetated	543	468	501	465	894	175	92	28	5	0	0
Devloped	3	3	2	1	2	5	1	0	1	0	0

Acres Exposed (by height and cover type)
Open River Conditions (75,500 cfs)



	0->0.5	0.5->1	1->1.5	1.5->2	2->3	3->4	4->5	5->6	6->7	7->8	8+
Unvegetated	171	86	36	12	12	0	0	0	0	0	0
Vegetated	194	107	91	23	9	0	0	0	0	0	0
Devloped	2	5	1	0	1	0	0	0	0	0	0

As described earlier for small-scale drawdowns, depth, seasonal timing, and duration of drawdown would greatly affect attainment of objectives for establishing vegetation and consolidation of sediment.

During drawdown and dewatering of the sediments, most species of submersed aquatic plants in the drawdown zone would be killed, but their seeds are resistant to dessication. Submersed aquatic plants would rapidly recolonize the drawdown zone upon reflooding. Most species of emergent aquatic plants present in the drawdown zones would survive the drawdown period. The undesired exotic purple loosestrife would survive and probably colonize further during a drawdown.

Annual plants and seedlings of emergent aquatic plants, willows and cottonwoods would develop in about a month and a half in areas of the drawdown zone that dewater sufficiently to trigger seed germination. Germination may not occur in much of the drawdown zone due to a limited seed bank, or high moisture conditions due to rain, undrained water, seeps, or reflooding. Drying and crust formation at the substrate surface can also prevent seedling emergence. The species composition and density of new vegetation that would develop would depend on a variety of factors, including the plant propagules (seeds, tubers, and rhizomes) present in the sediment, the seasonal timing of drawdown, and the degree of sediment dewatering that occurs as mediated by weather conditions, seepage, and reflooding, and weather conditions.

Most species of submersed aquatic plants in the drawdown zone would be killed, as would most macroinvertebrates and molluscs, including zebra mussels and any Federally endangered Lampsilis higginsi occurring in the drawdown zone. Although most fish would escape thte drawdown zone, some would become stranded and fall prey to piscivorous birds and mammals.

Despite the uncertainties in vegetation response, if the drawdown zone is maintained in a dewatered condition for a good part of the growing season, some part of the drawdown zone can be expected to become vegetated with a combination of annual terrestrial plants, moist soil species such as smartweed (Polygonum spp.), tree seedlings, and seedlings of emergent aquatic plants.

Reflooding of the drawdown zone can be expected to occur due to changes in river discharge. At low levels of river discharge, drawdown at the dam must be reduced if adequate depth for commercial navigation (10 feet) is to be maintained over the lower sill at Lock and Dam 7. At high levels of river discharge, the drawdown area would be reduced to the point where at over 75,500 cfs, no drawdown at the dam can be maintained. The potential for an ecologically effective drawdown (good vegetation response) is determined by the depth, duration, and recurrence of reflooding of the drawdown zone during the growing season. Although there are wide differences in flooding tolerance between plant species, developing seedlings generally cannot survive more than about a week or two of total inundation. The potential for maintaining a continuous drawdown in pool 8 is primarily affected by the occurrence of low levels of river discharge. High levels of river discharge during the growing season are infrequent. The hydrologic record was examined to determine the degree to which growing season drawdowns can be maintained in Pool 8. Criteria for an ecologically effective drawdown were established:

Drawdown during growing season June 15 - September 30
Less than 1 week of reflooding
Less than 2 reflooding events during growing season

A 1-foot drawdown of pool 8 and commercial navigation over the lower sill of Lock and Dam 7 could not be maintained with river discharge of less than 15,000 cfs. A 3-foot drawdown of pool 8 could not be maintained with river discharge less than 23,000 cfs. For the period of record examined (1960 through 1995), an ecologically effective 1-foot drawdown could have been achieved during about two out of three years. An ecologically effective 3-foot drawdown could have been achieved about one out of three years (table 5-10).

In most of the years where the above criteria were not met, it is likely that a drawdown of lesser depth or duration could have been implemented. The only years which had sustained high summer flows which would have made a drawdown ineffective or impossible to implement were 1967, 1984, and 1993.

Table 5-10
Estimated Potential for Successful Drawdown

Year	1-Foot Drawdown	3-Foot Drawdown	Year	1-Foot Drawdown	3-Foot Drawdown
1960	No	No	1980	Yes	No
1961	No	No	1981	Yes	Yes
1962	Yes	Yes	1982	Yes	No
1963	No	No	1983	Yes	Yes
1964	No	No	1984	No	No
1965	Yes	No	1985	Yes	Yes
1966	Yes	No	1986	Yes	Yes
1967	No	No	1987	Yes	No
1968	Yes	No	1988	No	No
1969	No	Yes	1989	No	No
1970	No	No	1990	Yes	Yes
1971	Yes	No	1991	Yes	Yes
1972	Yes	Yes	1992	Yes	Yes
1973	Yes	No	1993	No	No
1974	Yes	No	1994	Yes	Yes
1975	Yes	No	1995	Yes	Yes
1976	No	No	1996	Yes	No
1977	No	No			
1978	Yes	Yes			
1979	Yes	Yes			

Yes = drawdown could have been maintained without excessive reflooding of the drawdown zone

No = drawdown could not have been maintained without excessive reflooding of the drawdown zone

Summary

Period	1-Foot Drawdown	3-Foot Drawdown
1960-1969	4 of 10 years (40%)	2 of 10 years (20%)
1970-1979	7 of 10 years (70%)	3 of 10 years (30%)
1980-1989	7 of 10 years (70%)	4 of 10 years (40%)
1990-1996	6 of 7 years (86%)	5 of 7 years (71%)
1960-1996	24 of 37 years (65%)	14 of 37 years (38%)

If the drawdown area is reflooded in the fall to the normal pool level, the terrestrial woody and herbaceous plants would be killed within about 1 month, along with most of the seedlings of emergent aquatic plants. Some emergent aquatic plants could become established in the shallowest depth (less than about 1 foot) areas of the drawdown zones. At a summer low flow discharge of 22,000 cfs, up to about 3,400 acres of annual vegetation would become established in pool 8 with a 1-foot growing season drawdown. Up to about 7,900 acres of annual vegetation would become established with a 3-foot drawdown. If the pool was refilled to normal pool level in the fall, the extensive terrestrial vegetation would be flooded and killed, along with most of the seedlings of emergent aquatic plants. Some perennial emergent aquatic plants such as cattail, bulrush, and arrowhead could become established in the 3,400-acre <1-foot drawdown zone.

Consolidation of the sediments during drawdown should persist for some time following reflooding, limiting sediment resuspension by wave action and bioturbation, and creating good conditions for recolonization by submersed aquatic plants. In addition, the expanded area with aquatic vegetation would reduce effective wind fetch and sediment resuspension by wave action. The presence of aquatic vegetation also promotes the settling of suspended materials in the river water, leading to improved water clarity. Most benthic macroinvertebrate species present prior to drawdown would probably recolonize the drawdown areas the year following refilling.

If the pool was kept drawn down into winter or refilled in fall following plant dormancy, and was drawn down again at least partially following the spring flood for the next growing season, perennial emergent aquatic plants could become established in much of the drawdown zones where seedlings germinated during the first growing season of drawdown. This water level management regime would approximate an extended period of low river discharge in an unregulated river. Many species of emergent aquatic plants can become established only under dewatered substrate conditions followed by a long and gradual increase in water level, allowing germination of propagules and survival of seedlings without deep reflooding before they attain sufficient height.

Establishment of perennial emergent aquatic plants would be desirable in many areas in pool 8, to provide habitat for fish and wildlife. Once emergent plants were established, high water and grazing by muskrats would reduce the extent and density of the plants over a number of years to the point where another drawdown would be appropriate management.

Under an extended drawdown management regime as described above, with a 3-foot drawdown the first year, followed by a shallower drawdown the second year, the areas in pool 8 that can be expected to develop perennial emergent vegetation cover about 5,000 acres, in the shallower than about 2-foot portion of the drawdown zone. Of this area, about 800 acres of previously unvegetated area might become vegetated with emergent aquatic plants.

A variety of ecological benefits can be attributed to the effects of drawdown. Flooded vegetation in the drawdown zone in the fall and winter following drawdown would provide good habitat for small fish. The flooded vegetation would also provide an abundant food source for migrating waterfowl and spawning habitat for fish the following spring. Establishment of perennial emergent aquatic plants would improve habitat conditions and the vegetation would probably persist for a number of years. Increased extent and abundance of vegetation could in turn, contribute to increased abundance of macroinvertebrates, fish, wildlife, recreational opportunities, and aesthetic beauty of the river. These benefits are difficult to quantitatively forecast, given the uncertainties of the ecological response to any drawdown event and the uncertainties in relationships between habitat availability and animal populations. Experience with drawdowns of other regulated shallow freshwater systems clearly indicates that such benefits can be expected, however.

Operations

Planning for implementation of a drawdown would require additional effort by water control personnel. Actual implementation would also require additional effort in the day-to-day regulation of the system, as a drawdown would probably require closer monitoring, both because it would be an abnormal water control situation and because of the high public visibility associated with such an event.

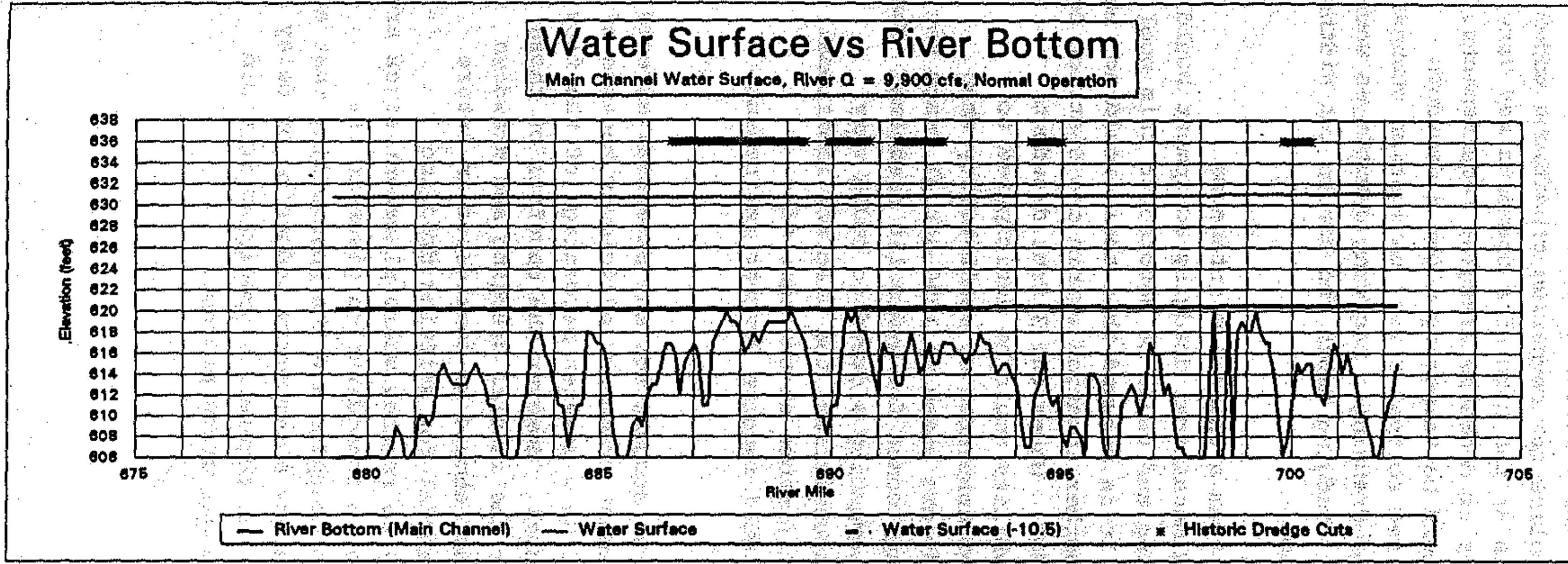
Channel Maintenance

Maintenance dredging is required to maintain a 9-foot navigation channel in pool 8. Most channel maintenance dredging in pool 8 occurs in two reaches, one in the upper portion of the pool in the area of the La Crosse railroad bridge (river miles 699.8-700.4) and the other in the Brownsville, Minnesota, area. In the Brownsville area, channel maintenance dredging occurs regularly over a 3.3-mile reach from about river mile 687.5 to river mile 690.8.

The 12 drawdown/flow combinations were reviewed to determine the potential effects on depths and the need for additional dredging in the navigation channel. Figure 5-23 shows riverbed elevation (1989 Environmental Management Technical Center (EMTC) bathymetry data); water surface elevations for normal operation at low flows (9,900 cfs and 22,000 cfs); and water surface elevations minus 10.5 feet (w.s. -10.5 ft). The riverbed is shown only for areas where the water is 25 feet deep or less. All areas deeper than 25 feet are shown as being 25 feet deep (elevation 606).

To analyze potential dredging requirements under a drawdown scenario, hydrographic surveys from 1996 or the most recent surveys available were adjusted to reflect the corresponding change in water depth. The evaluation process concentrated on historic dredging locations, although surveys throughout the pool were reviewed for potential navigation problems under a drawdown scenario. According to standard practices, depths less than 10.5 feet below low control pool elevation were considered the basis for programming dredging.

Estimates were made of the additional quantities of dredged material necessary to maintain the navigation channel for the 22,000-cfs 1-foot and 3-foot drawdown scenarios. The 22,000-cfs flow is considered most applicable of those modeled for projecting additional dredging that could be required with drawdown.



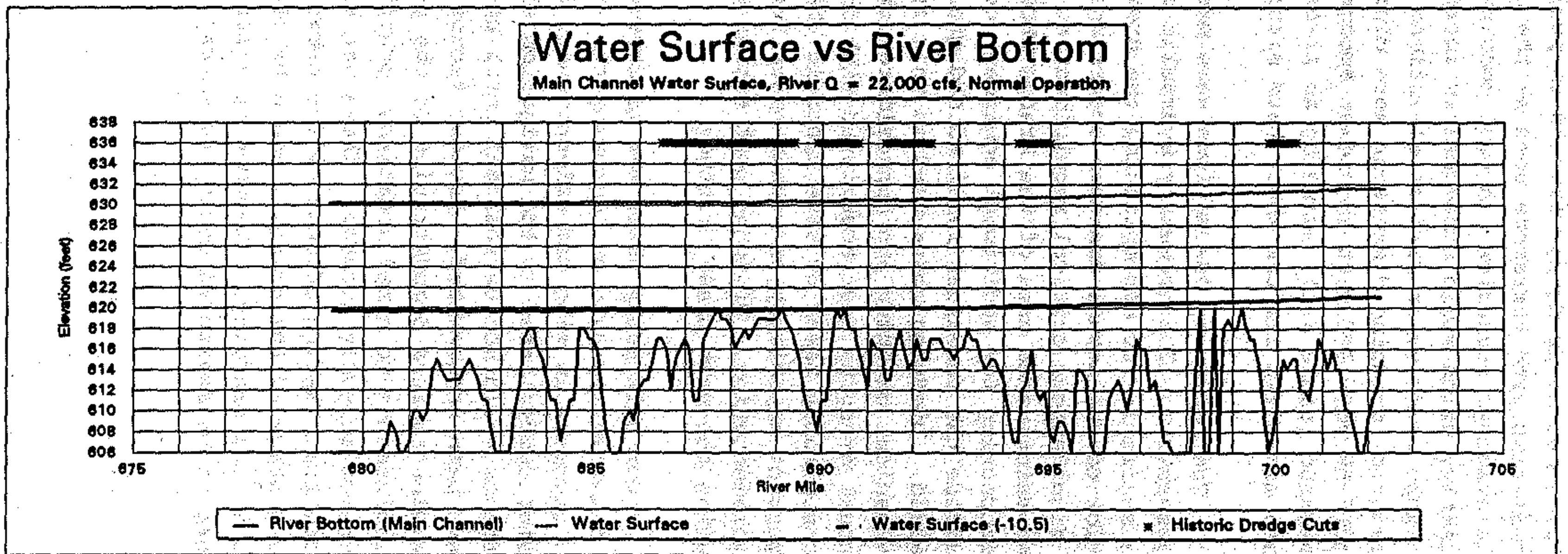


Figure 5-23. Water Surface vs. River Bottom - Normal Operation

For the purpose of this study, the 1996 hydrographic surveys and corresponding dredging workload in pool 8 was considered typical of annual conditions, and therefore used as the baseline for comparing conditions under the drawdown scenarios. Actual conditions at the time of a drawdown may vary greatly, which would subsequently increase or decrease dredging requirements. Because lower water surface elevations would be temporary under a drawdown scenario, dredging dimensions were minimized so that a safe navigation channel would be provided with the least amount of dredging. Dredging quantities were computed (table 5-11) assuming an 11-foot dredging depth and dredge cut widths were minimized for the short term situation.

The following assumptions were made from a channel maintenance perspective. The necessary hydraulic and mechanical dredging equipment would be available for accomplishing the dredging and could be devoted to this pool prior to the actual drawdown occurring. It is assumed that there would not be a simultaneous critical requirement at another location within the District or the maintenance area of the Dredge THOMPSON. Under the 3-foot drawdown, contracting for additional equipment capability would be anticipated to provide the resources required and greater assurance of availability when needed. Dredging costs used in this study are based on 1996 actual costs for mechanical dredging and approximate average costs for hydraulic dredging. The actual dredging cost associated with implementing a drawdown could vary considerably based on site specific characteristics, the need for additional contract capability and other operational factors at the time of implementation. Dredging cost estimates will require further refinement during the next phase of study.

For this study there was no attempt to account for any potential effects a drawdown may have on improving the sediment transport efficiency because of an increase in wing dam effectiveness due to a greater percentage of the flow being concentrated in the navigation channel. However the benefits of those effects would not be realized until after the initial dredging and drawdown have been implemented. Another factor that should be considered in future studies or in a demonstration is the potential for shifting dredging requirements to other locations, possibly to reaches where placement sites are not conveniently located. There was also no consideration given to the potential lasting effects of the drawdown dredging and the possibility that a percentage of the dredging would be offset by a temporary reduction or delay in future dredging. Because this cannot be accurately predicted it would need to be monitored during an actual demonstration project.

Table 5-11
Impacts Of Pool 8 Drawdown On Dredging Requirements

Dredging Location (UMR Mile)	Survey Date	Dredging Method	1996 12' Dredging Depth		1-Foot Drawdown 11' Dredging Depth		3-Foot Drawdown 11' Dredging Depth	
			Quantity	Cost	Quantity	Cost	Quantity	Cost
1. Below La Crosse RR Bridge (698.5 – 699.	Jun 96	Mech	0	$0	12,600	$62,118	32,600	$160,718
2. Root River (693.1 – 693.3)	May 93	Mech	0	$0	0	$0	7,500	$36,975
3. Picayune Island (691.3 – 691.6)	May 93	Mech	0	$0	0	$0	7,200	$35,496
4. Above Brownsville (689.8 – 690.7)	May 96	Hyd/Hyd	21,500	$91,375	31,300	$133,025	136,400	$579,700
5. Brownsville (688.4 – 689.3)	May 96	Hyd	74,600	$205,150	45,800	$125,950	108,500	$298,375
6. Head of Raft Channel (687.2 – 688.4)	May 96	Hyd	34,900	$95,975	24,700	$67,925	87,400	$240,350
7. Deadman's Slough (686.5 – 686.7)	May 96	Mech	0	$0	18,500	$91,205	28,700	$141,491
8. Lower Crosby Slough (684.6 – 685.0)	Apr 94	Mech	0	$0	0	$0	10,400	$51,272
9. Warners Landing (683.3 – 683.7)	Aug 94	Mech	0	$0	0	$0	6,800	$33,524
TOTAL			131,000	$392,500	132,900	$480,223	425,500	$1,577,901
DIFFERENCE FROM 1996			0	$0	1,900	$87,723	294,500	$1,185,401

ESTIMATED DREDGING COST

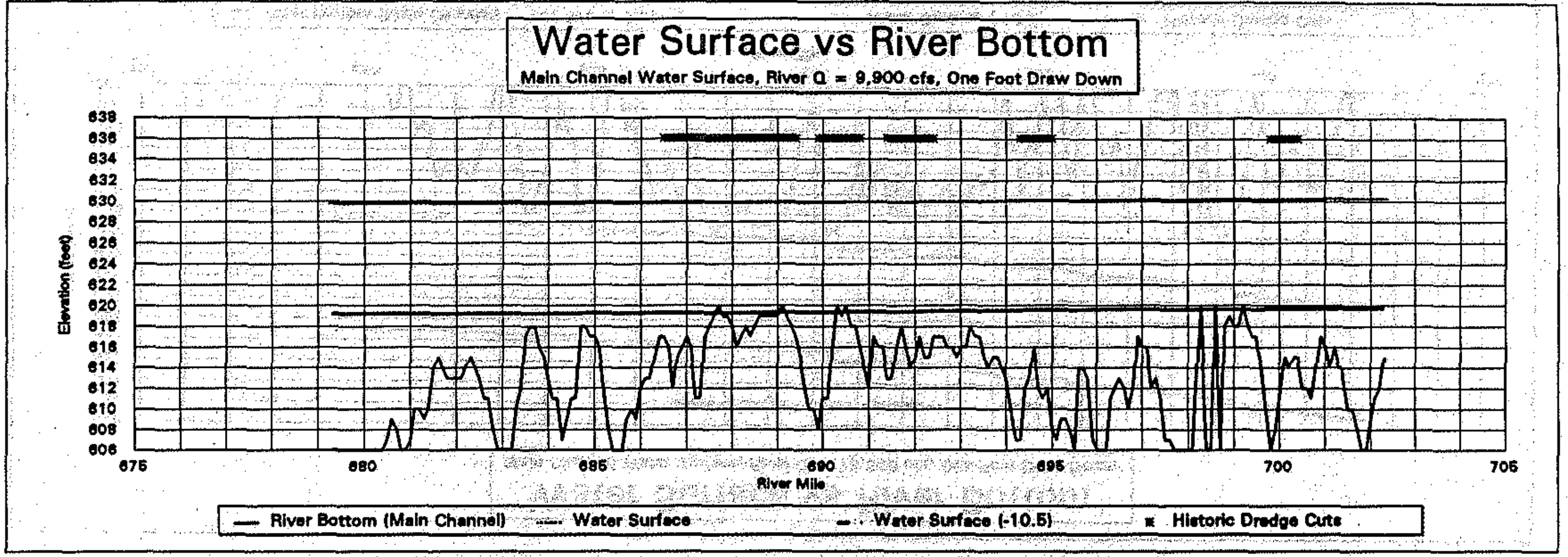
Hydraulic Dredging	$2.75 per CY
Mechanical Dredging	$4.93 per CY
Hydraulic Dredging w/Hyd Excavation	$4.25 per CY

NOTES
1. Drawdowns are based on 22,000 cfs discharge scenario.
2. Projected dredging requirements are based on conditions on date of survey. Actual requirements will vary based on conditions at the time.
3. Assumes availability of one each hydraulic and mechanical dredging plant.
4. 3-Foot scenario will require 30-45 days of dredging to establish channel conditions.
   It is anticipated that navigation will be severely restricted or suspended during the dredging period.
5. Dredging requirements for 1-Foot and 3-Foot scenarios are considered minimal to assure continued navigation during study period.
6. Estimated dredging costs are generalized figures based on 1996 approximate costs. Actual costs will vary due to site specific conditions.

One-Foot Drawdown

Figures 5-24 and 5-25 show water surface profiles in comparison to the river bottom for a 1-foot drawdown under four discharge conditions. Under the 1-foot drawdown scenario, total dredging quantities in pool 8 would not be significantly greater than what was required in 1996, about 2,000 additional cubic yards. However the area requiring dredging more than doubles from 235,000 SY in 1996 to 500,000 SY under the 1-foot scenario. In 1996 dredging was required at 3 different locations in the pool. The 1-foot drawdown would require dredging at those sites and at 2 additional locations, both requiring the use of mechanical equipment. The additional dredging area and locations would suggest that a more refined cost estimating procedure will result in higher dredging costs than what has been used for this level of study because the setup and effective dredging time will increase, yet the overall yardage remains relatively constant.

The area of greatest concern for maintaining navigation is the Brownsville cut, UMR mile 688.4-689.3, where the drawdown would result in depths less than 10.5 feet across the channel for several thousand lineal feet. Dredging in advance of the drawdown at this location and at the Above Brownsville cut, UMR mile 689.8-690.7, would be necessary to reduce the risk of a grounding. Advance dredging at the other locations would be desirable but could likely be accomplished as the drawdown is being implemented without restricting navigation. Designated placement sites at La Crosse and Brownsville would be used for the dredging and should not be impacted by the 1-foot drawdown scenario.



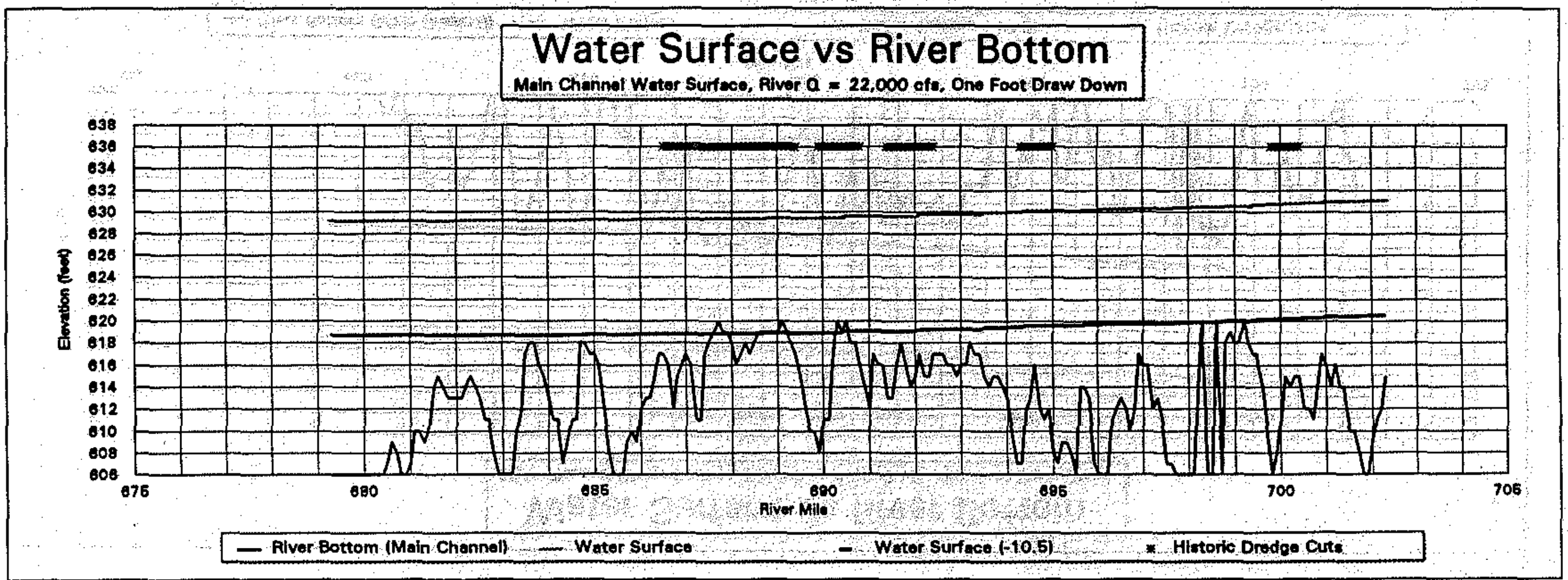
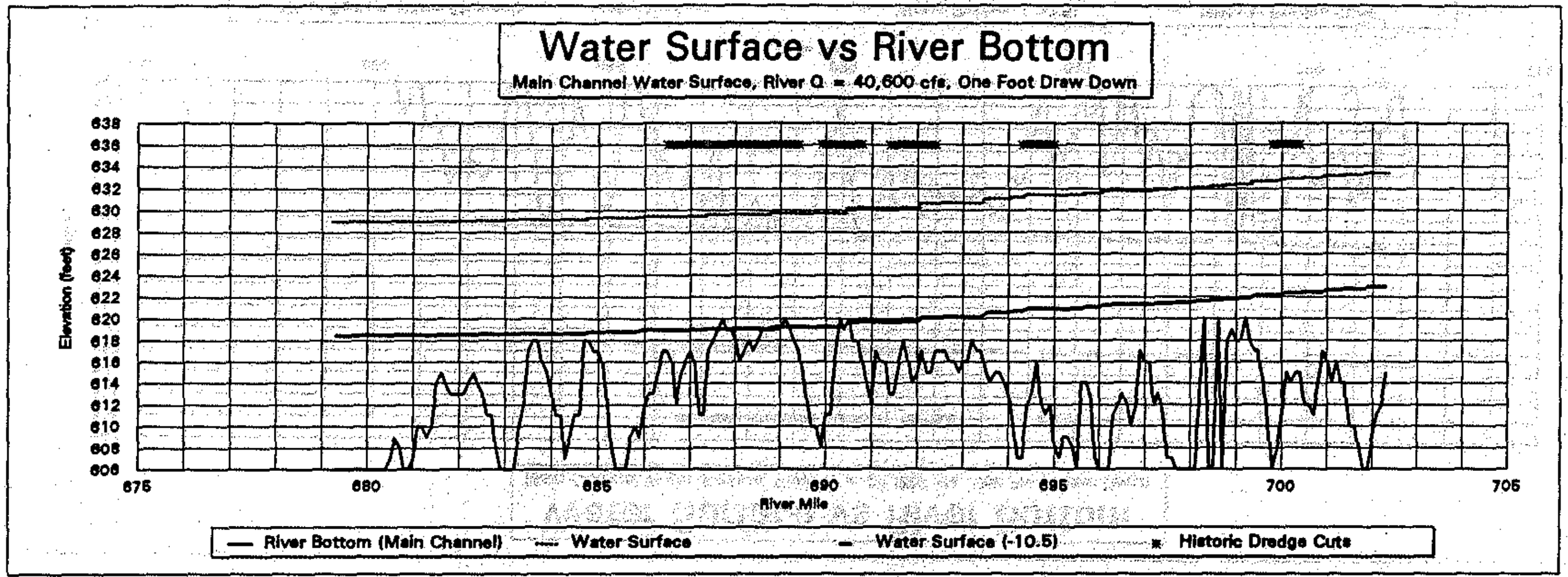
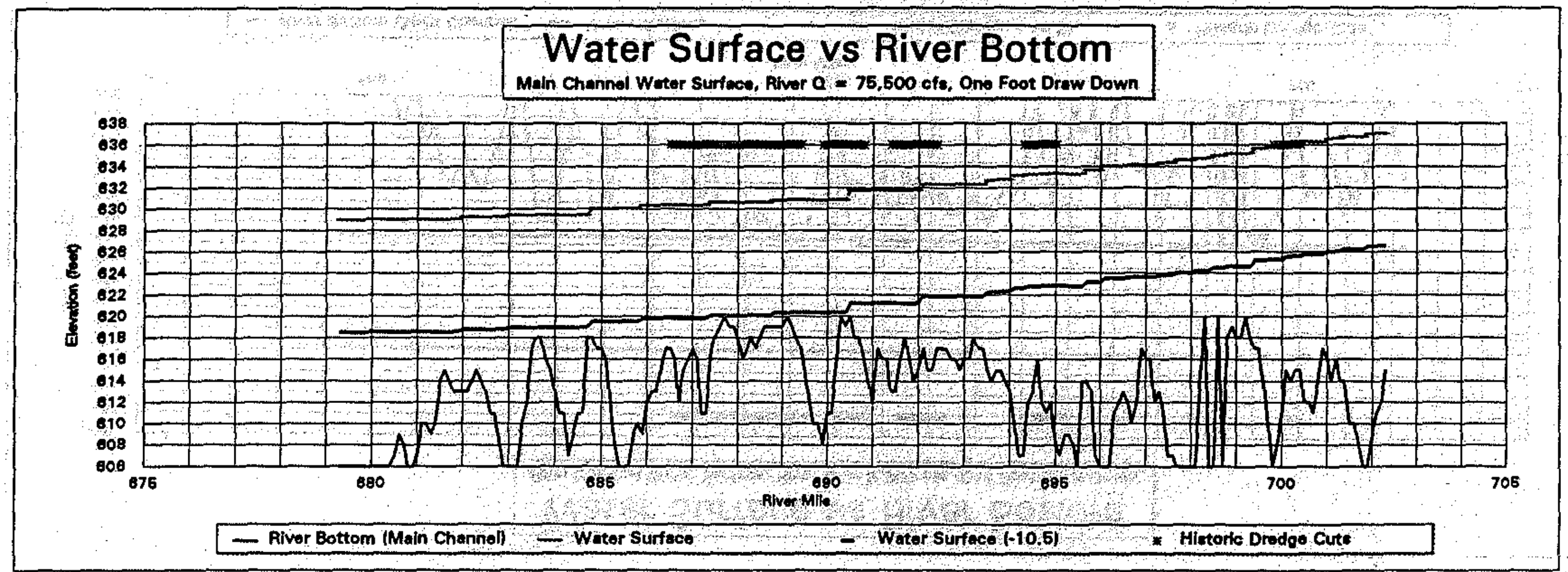


Figure 5-24. Water Surface vs. River Bottom - One-foot Drawdown
Q = 9,900 cfs and 22,000 cfs

Figure 5-25. Water Surface vs. River Bottom - One-foot Drawdown
Q = 40,600 cfs and 75,500 cfs





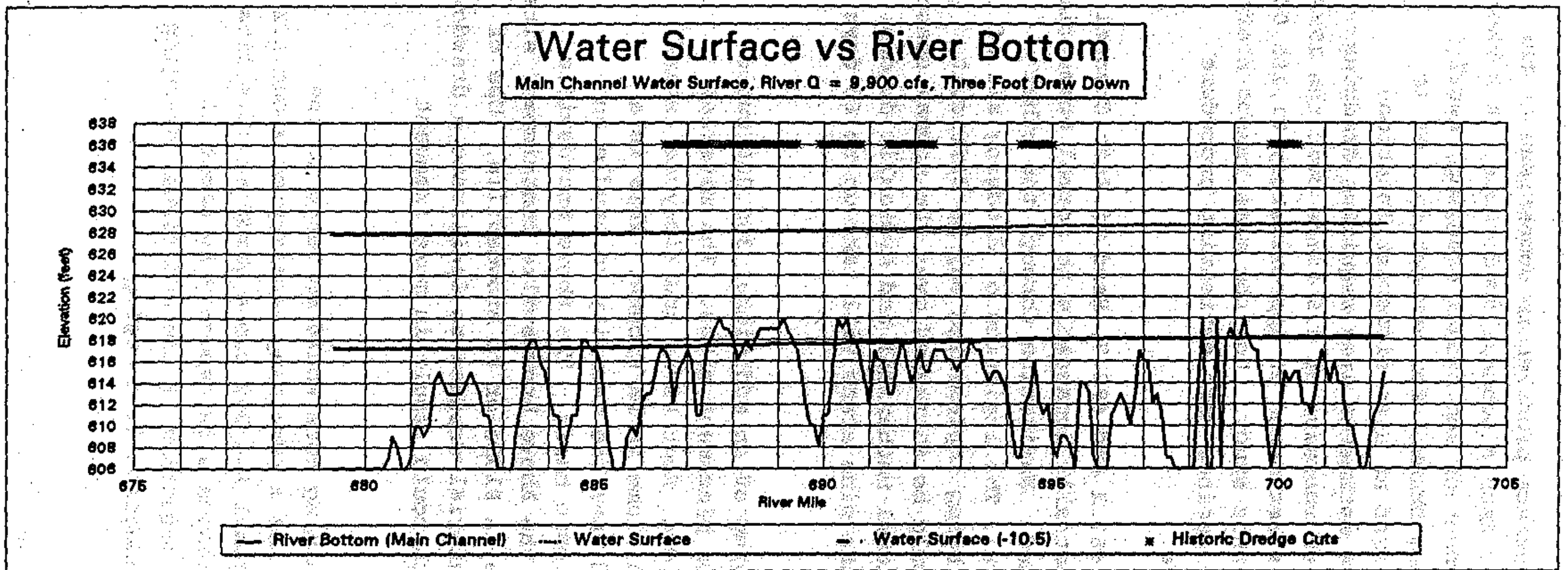
Three-Foot Drawdown

Figures 5-26 and 5-27 show water surface profiles in comparison to the river bottom for a 3-foot drawdown under four discharge conditions. A 3-foot drawdown would require a substantial amount of additional dredging, nearly 300,000 cubic yards, to provide a minimum channel for navigation. It is anticipated that dredging would be required at nine different locations compared to the three cuts in 1996. The estimated area requiring dredging under a 3-foot drawdown is 870,000 SY, an increase of 3.6 times over the 1996 area for pool 8. The additional cost is estimated at approximately $1,185,000 based on the general approach used for this study. For the same reason stated in the 1-foot drawdown scenario, a more refined cost estimating procedure would likely result in a higher estimate.

The entire reach between UMR mile 687.2 and 690.7, Head of Raft Channel through Above Brownsville would be essentially impassable to normal commercial navigation until dredging is accomplished. Navigation through the other reaches before dredging would be marginal. The logistics of dredging all of the critical areas prior to a drawdown being implemented may be difficult. It is assumed that equipment capability would be increased over the normal season complement by contracting for an additional mechanical and hydraulic dredge. With dedicated plant, dredging all of the nine areas will take up to 60 days to accomplish.

A factor associated with the dredging of an additional 300,000 cubic yards of material is the requirement for placement sites. The material dredged from the Below La Crosse RR Bridge, Root River and Picayune Island cuts would be taken directly to Isle la Plume in La Crosse. This is a beneficial use removal site that should have the capacity to handle an additional 50,000 cubic yards on a periodic basis. The Above Brownsville dredge cut material would be placed in the Above Brownsville containment site and then eventually transferred to Isle la Plume or to Brownsville. Use of this containment site for additional material dredged to facilitate a drawdown could shorten the life of the site which could result in more frequent unloading of the site.

The material dredged from the remaining cuts would be taken to the Brownsville placement site. This site has a remaining capacity of about 1.1 million cubic yards. Placing an additional 130,000 cubic yards at this site to facilitate a 3-foot drawdown could reduce site capacity by about 10 percent. This may be only a temporary reduction if the additional dredging for the drawdown results in a future reduction in dredging.



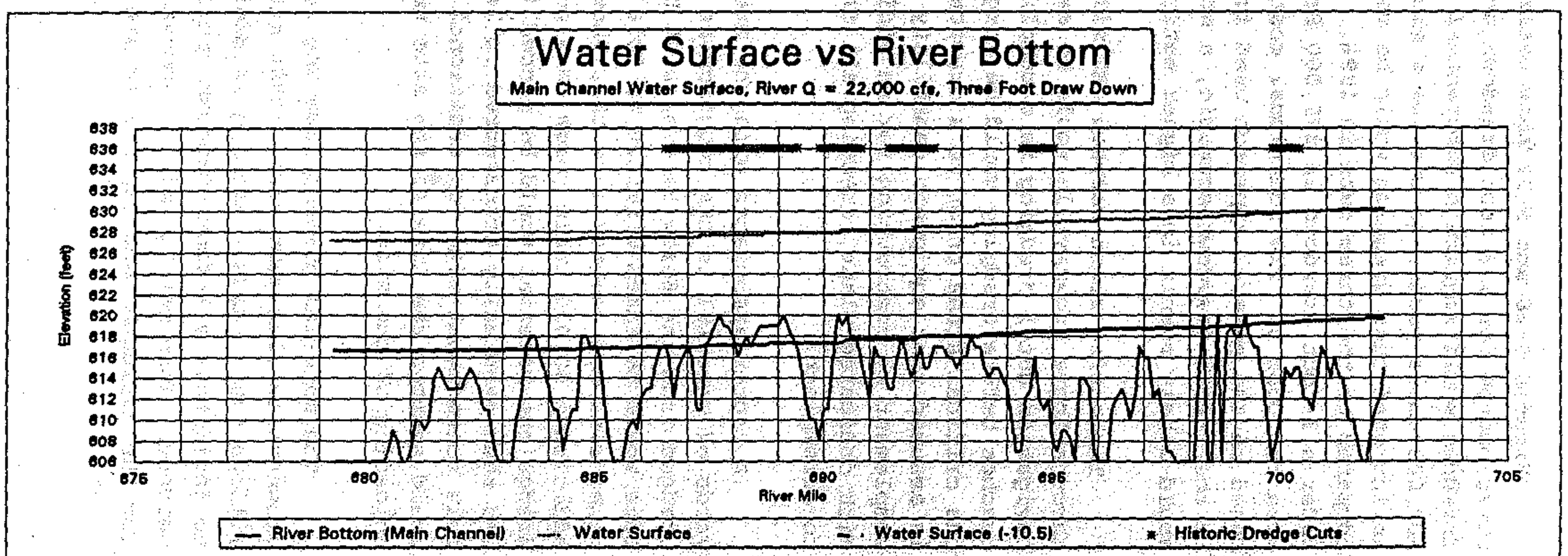
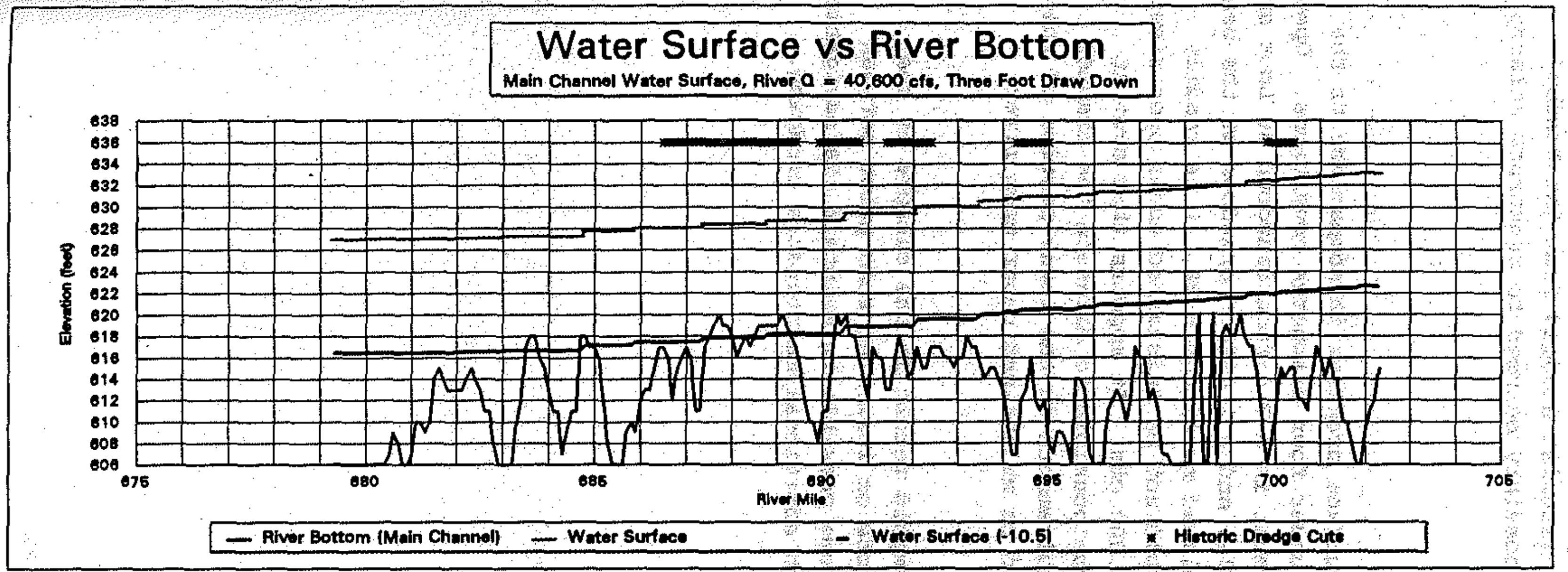


Figure 5-26. Water Surface vs. River Bottom - Three-foot Drawdown
Q = 9,900 cfs and 22,000 cfs



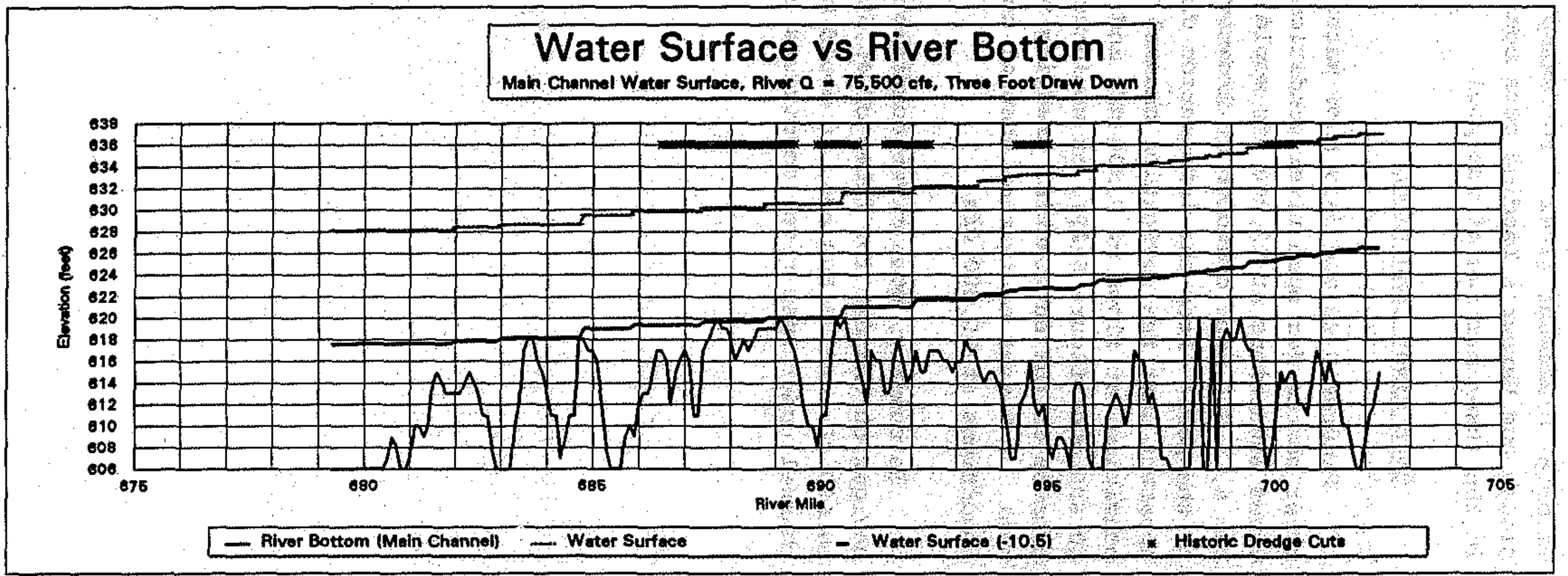


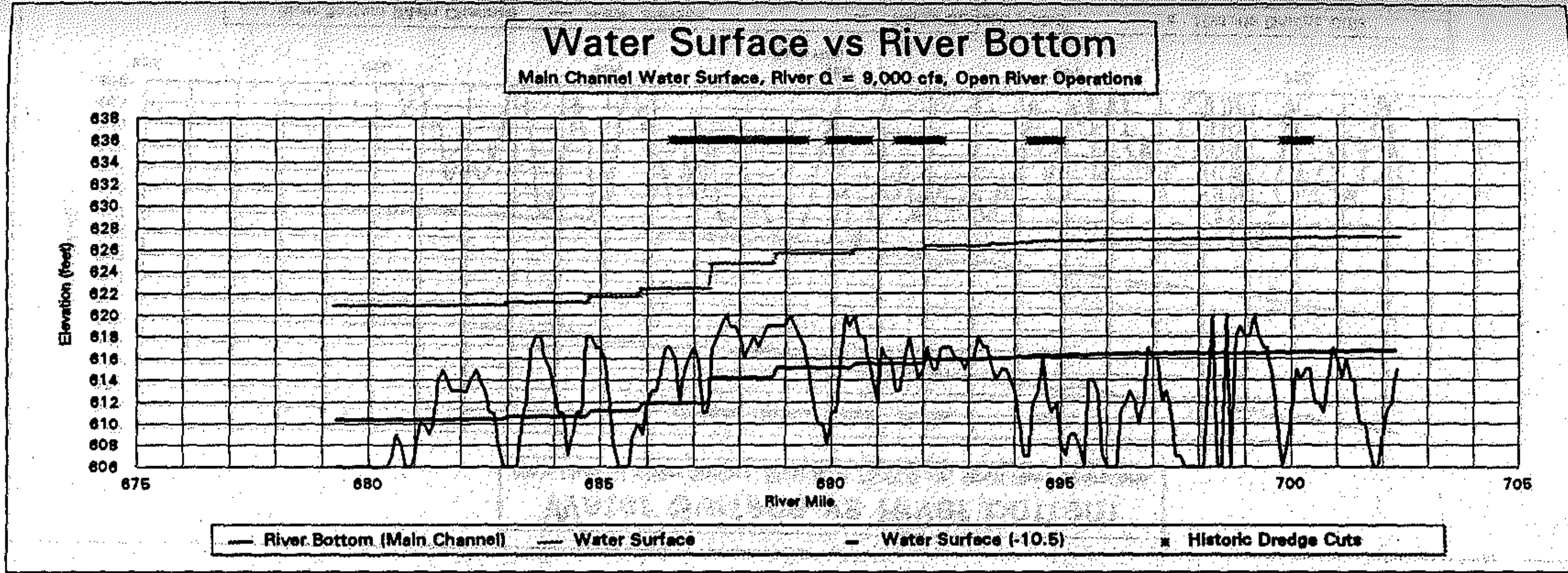
Figure 5-27. Water Surface vs. River Bottom - Three-foot Drawdown
Q = 40,600 cfs and 75,500 cfs

If a 3-foot drawdown were proposed, it would be possible to explore alternative placement options to reduce the impact on existing dredged material placement sites. For example, material dredged from the Crosby Slough and Warner's Landing cuts could possibly be used to construct islands in the lower portion of the pool.

Open River Conditions

Figures 5-28 and 5-29 show water surface profiles in comparison to the river bottom for open river conditions under four discharge conditions. Open river conditions at 22,000 cfs would result in a 7.9-foot drawdown at Lock and Dam 8, a 3.9-foot drawdown at Brownsville, and a 1.4-foot drawdown at the head of the pool. From the information displayed on figure 5-28, it is readily apparent that the navigation channel could not be maintained under open river conditions at flows of 9,900 cfs and 22,000 cfs. It appears that even at 40,600 cfs (figure 5-29), it would not be possible to maintain the channel because of the substantial dredging requirements in the lower portion of the pool. A 9-foot navigation channel could be maintained under open river conditions at 75,500 cfs.

In summary, open river conditions would result in the closure of the navigation channel for flows of 40,600 cfs or less. At some point between 40,600 cfs and 75,500 cfs, it would become possible to maintain the navigation channel under open river conditions with additional maintenance dredging.



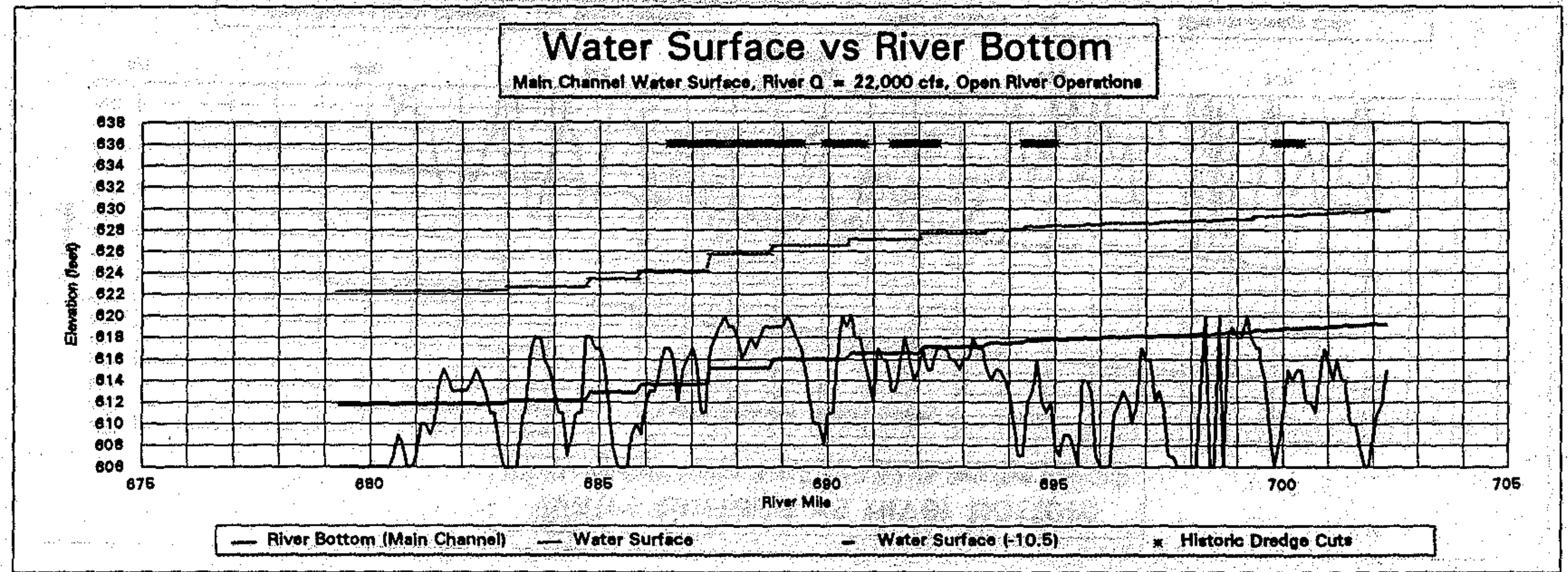
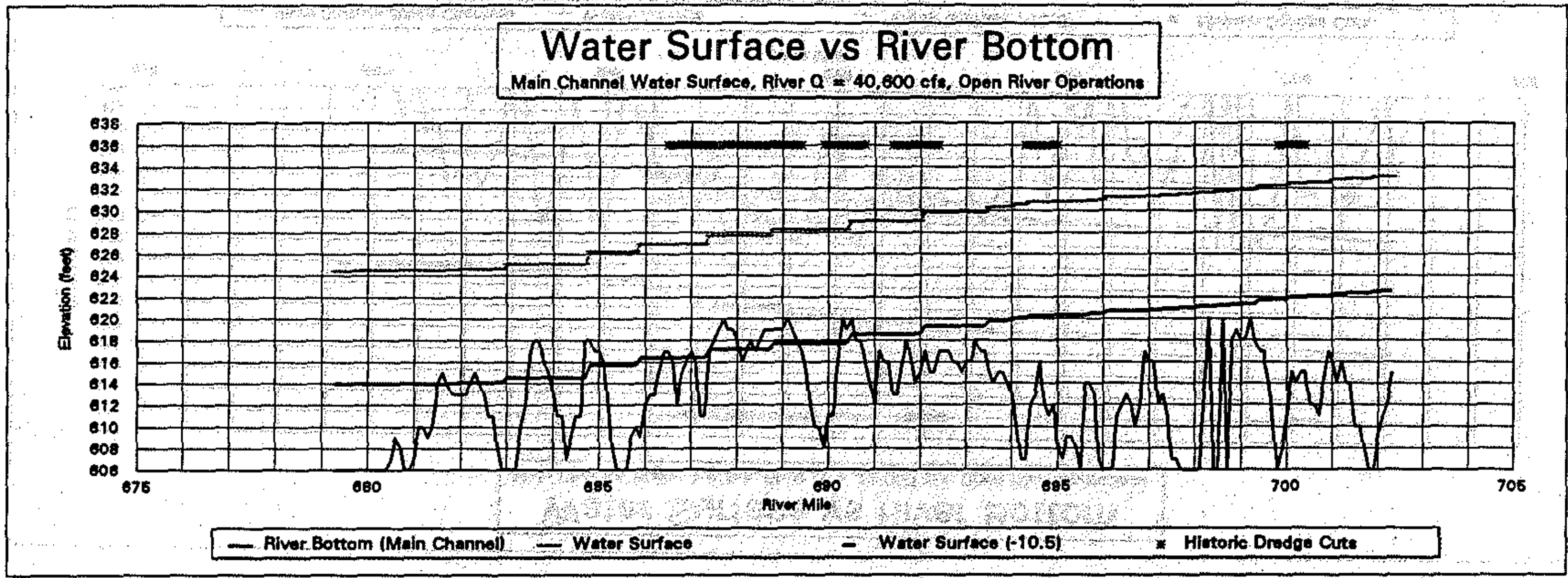


Figure 5-28. Water Surface vs. River Bottom - Open River Conditions
Q = 9,900 cfs and 22,000 cfs



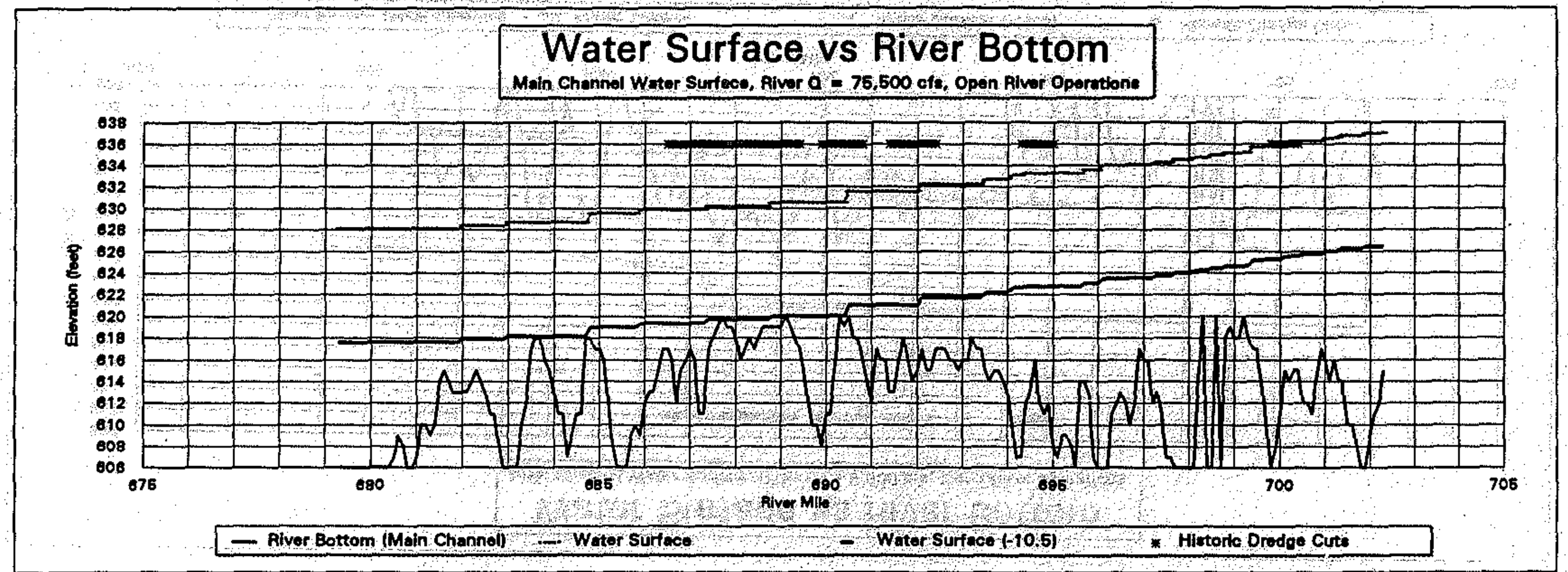


Figure 5-29. Water Surface vs. River Bottom - Open River Conditions
Q = 40,600 cfs and 75,500 cfs

Summary

The preceding analysis is based on main channel water depths as they existed in 1989. Main channel water depths change from year to year, though the general areas of shoaling tend to remain relatively constant. The 1989 water depths appear to correlate well with past dredging experience. Therefore, they provide a reasonable basis for this analysis.

It appears that the navigation channel could be maintained for a 1-foot drawdown with minor additional maintenance dredging. With a 3-foot drawdown, it appears that substantial maintenance dredging would be required to maintain the navigation channel. Further analysis of drawdown options between 1 foot and 3 feet could reveal a practical breakpoint between potential habitat benefits versus additional dredging requirements.

Going to open river conditions to facilitate a significant drawdown would close the navigation channel for most flows, especially the lower flows that potentially would provide the greatest habitat benefits. In addition, it appears that at the lowest flow evaluated (9,900 cfs), the clearance at the lower sill at Lock and Dam 7 would be reduced to the point where tow traffic would be stopped (see "Transportation Infrastructure" below).

This study only evaluated the effects of drawdown alternatives on channel maintenance requirements for channel conditions as they existed when the last channel surveys were conducted. Drawdown may result in mobilization of sediments from tributaries or off-channel areas. Sediment may also be mobilized because of increased tractive force or because of tow groundings due to lowered water levels. Increased or decreased dredging could occur at historic dredge cuts depending on whether aggradation or degradation of the river bottom occurred due to mobilization of sediments. The effects of sediment mobilization on channel maintenance requirements is unknown and would require further evaluation if drawdowns are considered for implementation.

Commercial Navigation

Over the last 10 years, Lock and Dam 8 has averaged more than 4,700 lockages per season. This figure is similar to the average of the other locks in the St. Paul District (excluding Lock 1 and the locks at St. Anthony Falls, which have lower traffic). Annual totals for commercial, recreational, and miscellaneous lockages at Lock and Dam 8 are shown in table 5-12.

Table 5-12
Lockages at Lock and Dam 8

Year	Commercial	Recreational	Other	Total
1985	2,322	2,100	101	4,523
1986	2,165	2,171	56	4,392
1987	2,257	2,451	94	4,802
1988	2,485	2,622	87	5,194
1989	2,468	2,767	138	5,373
1990	2,911	2,367	99	5,377
1991	2,569	2,290	103	4,962
1992	2,850	2,199	62	5,111
1993	1,667	1,451	38	3,156
1994	1,963	2,582	194	4,739
1995	2,359	2,278	125	4,762
average	2,365	2,298	100	4,763

The navigation season in the St. Paul District typically opens by mid-March and continues through late November. Lockages at Lock and Dam 8 are fairly evenly split between commercial tows and recreational craft, although some variation between years is evident. The total number of lockages is also fairly stable, except in 1993 when flooding closed the system for much of the summer. The number of commercial lockages is higher than the number of commercial tows because about 75 percent of commercial tows require 2 lockages to pass through the lock.

Transporting bulk commodities by barge is generally less expensive than using other forms of transportation, such as train or truck. Commodities typically transported through Lock and Dam 8, reported as a percentage of total tonnage from 1991, are grain (69 percent), agricultural chemicals (9 percent), coal (8 percent), petroleum products (4 percent) and other commodities (10 percent). Figures from 1991 are used since they comprise the base year data for the UMRS-IWW Navigation Study.

Savings from using barges, on average, amount to about $11 per ton of cargo. The total amount of material transported through the St. Paul District typically ranges from 15 to 20 million tons annually, resulting in savings of $165 to $220 million annually. The value of the commodities exceeds $3 billion annually. These figures are based on commercial lockage data collected by the St. Paul District, and market analysis of transportation costs prepared for the UMRS-IWW Navigation Study.

Costs of Disruption to Commercial Navigation

As with any transportation system, disruptions to the normal flow of traffic add to the overall costs of shipping. Channel shoaling, accidents, maintenance of structures, or "loss of pool" can all cause temporary shutdowns of the navigation system. Congestion at the locks can also cause delays that add to cost. Planned shutdowns can result in fewer losses due to advance notification.

Disruption costs can be divided into two categories: delay costs and diversion costs. Delay costs accrue in circumstances when it is cheaper to wait for the waterway to reopen than it is to switch to another mode of transport. Delay costs typically amount to $5,500 per tow per day. Diversion costs accrue when it is cheaper to switch to other modes of transport, rather than to accept delays on the waterway. Costs for switching to other modes of transportation range from $50,000 to $190,000 per tow depending on commodity.

Disruption costs associated with a number of drawdown alternatives have been generated using a spreadsheet model (DELAYSIM) which incorporates 1991 data on monthly traffic counts, commodity types and quantities, average lock times, and applicable costs for land and waterborne transport. The 1991 data set is being used as the base for the Upper Mississippi River System-Illinois Waterway Navigation Study.

The key relationship in the model is the relationship between delay costs, diversion costs, and expected length of delay. Combining the traffic, commodity, and cost information in the model with the timing of the expected downtime determines whether a shipper will choose to ship on the waterway (and absorb delay cost) or switch to another mode of transport (resulting in diversion cost). The model tallies the additional costs for each affected tow through the designated period, resulting in the expected costs for each alternative. (Note that for planned shutdowns the decision to switch is made before commodities are loaded; switching after barges are loaded would result in extra handling costs and larger losses.) These costs are contained in table 5-13.

Table 5-13
Commercial Navigation Shutdown Costs

Drawdown Dates	Delay Costs	Diversion Costs	Total Costs
Jun 15 to Jun 30	$ 4,303,564	$ 1,108,512	$ 5,412,076
Jul 01 to Aug 15	$14,550,307	$ 18,166,124	$ 32,716,431
Jun 15 to Sep 30	$ 9,323,832	$ 66,457,928	$ 75,781,760
Jun 15 to year 2	0	$115,434,655	$115,434,655
Early Close: Nov 15	0	$ 6,653,294	$ 6,653,294

Assumptions Used to Compute Shutdown Losses

A number of assumptions in the DELAYSIM model must be considered when interpreting the losses calculated using the model. These assumptions are discussed in the sections below, grouped by those that concern conditions within the navigation system, and those that concern conditions outside the navigation system.

These sets of assumptions would tend to affect loss computations in opposite directions. The assumptions about system capacity would tend to overstate losses, although they are increasingly representative for larger actions. In contrast, the assumptions about external market considerations would tend to understate losses, but are more representative for smaller actions. This implies that smaller actions would tend to result in losses at or below the estimated figures, while larger actions could result in losses higher than those estimated.

Further refinement of these issues would lead to an analysis using a system-wide model, and would be considerably more complicated and expensive than the current analysis. For this reason, it was not pursued at this stage of study.

System Flexibility Assumptions - One set of assumptions is that shipping schedules are fixed, and that the UMRS system is at (or near) full capacity at certain locks. These assumptions portray an inflexible system to simplify the modeling process. To the extent that potential flexibility is overlooked, these assumptions would lead to added transportation costs that may be higher than what would actually be sustained.

Since Lock and Dam 8 generally operates well below capacity, there is certainly good reason to explore the potential for altering shipping schedules to reduce shutdown losses. This could conceivably be accomplished by concentrating shipping in the periods before and after the planned shutdown to keep the commodities moving.

Flexibility in this regard is limited by a number of constraints beyond the capacity at Lock and Dam 8, however. Downstream lock capacity may be the largest constraining factor, since important links in the system are operating near capacity, and many of the pool 8 tows travel through these stretches. System-wide adjustments would be needed to avoid creating backups elsewhere in the system; otherwise, gains in pool 8 would be offset by delays at these "bottlenecks." Since traffic projections suggest continued system-wide growth into the foreseeable future, the capacity situation will be worse by the time a drawdown of pool 8 could be implemented.

Other potentially limiting factors relate to getting the commodities to the loading docks. These factors include market conditions affecting the availability of the commodities, equipment availability, and loading facility capacity. Even if the system were flexible enough to handle unlimited shifts in scheduling, it is uncertain that the commercial infrastructure necessary to accomplish this would be available.

Alternate Modes of Transport Assumptions - Another set of assumptions is that alternate modes of shipping are available in unlimited quantities, and at current prices. These assumptions ignore the relative equilibrium in the transportation sector, and lead to loss figures that may be lower than what would actually be sustained. Rail prices could be significantly higher in the absence of water-based competition.

Diverting large quantities of material could exceed the available capacity of truck or rail carriers. Railcar or truck shortages could add delay costs, or lead to higher prices due to the surge in demand for the services.

Light Loading as an Alternative

Under certain circumstances, tows can successfully navigate channels with less depth if the barges are loaded with less cargo, since they will float higher in the water. This concept is commonly known as "light loading." For the UMRS, "light loading" would work only to a minimum depth of 8 feet, due to the typical draft requirements of towboats. This technique has been used during periods of low water in the past.

The feasibility of "light loading" can be assessed by comparing its associated losses to the costs of additional dredging to maintain the 9-foot channel depth during the period of drawdown. Factors that would influence the costs of "light loading" include whether the barges would be loaded "light" for their entire trip, or whether they would be "topped off" downstream; or whether the remaining amounts would be diverted to other modes of transport.

"Topping off" would require additional waiting and handling time at a loading facility, and could be complicated by facility capacity restrictions, location of "topping off" facilities, and issues of commodity ownership, quality, or grade. Given the uncertainty of success in using "topping off" as a large-scale alternative, it was not investigated further at this stage of study.

If barges were loaded "light" for their entire trip, 13 percent more barges would be needed to move the same volume of commodities (or the commodities could be diverted to other modes of transport*). While it is conceivable that more barges could be added per tow, the average tow is already near the limit of barges, so it is unlikely that this would be possible regularly.

If this were enacted for an entire navigation season, the additional barges would require the creation of 13 percent more tows, which amounts to 200 more than the existing average of 1,500. Since most of the barges travel through the entire system, and parts of the system are already near capacity, this is an unlikely situation.

Given the obstacles to the system absorbing the extra barges necessary to accomplish "light loading," the most likely alternative is to divert this traffic to other modes of transportation. Costs of the additional volume can be estimated by multiplying 200 tows times an intermediate diversion cost of $125,000 per tow for a total of $25 million (for an entire navigation season). This cost compares closely with a 13-percent reduction in annual savings, which would range between $21.5 and $28.5 million for the St. Paul District.

* An empty barge requires approximately 1.5 feet of draft; a full barge (1,500 tons) requires 9 feet. Using these figures, each foot of reduced draft would require a 200-ton reduction in cargo per barge, which is a 13-percent reduction.

Commercial Docks in the La Crosse Area

Ten docks in the La Crosse area handle commercial barge traffic. In an average year, about 800,000 tons is processed through these terminals. This accounts for about 5 percent of total pool 8 traffic. While all these facilities have 9 feet or more of water, some problems with depth are experienced at six of the ten facilities.

The barge fleeting area on the lower end of Isle La Plume is also known to have problems with depth at low water. An excursion boat landing at the Holiday Inn and a proposed barge fleeting area near the mouth of Target Lake have no known problems with water depths.

Table 5-14 lists commercial facilities in the La Crosse area, their average annual tonnage, and whether problems with depth are experienced during low water. Under conditions of a navigation channel shutdown, losses at these facilities would be included in the commercial navigation figures discussed in the previous section. Losses could also occur in circumstances where the navigation channel remains open, but where water depths in the La Crosse area drop enough to impede this traffic. Losses associated with the 400,000+ tons handled at facilities with some depth problems could be as high as $2.5 million, based on an average savings of $8.50 per ton, depending on the drawdown alternatives and shipping assumptions being considered.

Table 5-14
Commercial Facilities in the La Crosse Area

Facility	River Mile	Annual Tonnage	Some Water Depth Problems
Barge Fleeting Area/ Isle La Plume	696.0	n/a	Yes
Fleeting Area (proposed) mouth/Target Lake	696.5	n/a	No
Isle La Plume Dock	696.5	n/a	No
La Crosse Bulk Transfer	696.7	80,000	No
Division St. Dock	697.4	18,000	Yes
Holnam Cement	697.5	200,000	Yes
Agra-Marketing (Cargill)	697.6	300,000	No
La Crosse Queen (excursion)	698.5	n/a	Yes
Holiday Inn (excursion)	698.0	n/a	Yes
Northside Dock	1.8 Black R.	22,500	Yes
Hydrite Chemical	1.6 Black R.	18,000	Yes
Midwest Industrial Fuels	1.2 and 1.3 Black R.	150,000	Yes
Northern States Power	0.7 Black R.	n/a	Yes
Mobil Oil Corp	0.5 Black R.	n/a	No

Transportation Infrastructure

The downstream sill at Lock and Dam 7 is at elevation 619.0, which provides 12 feet of clearance at the project pool elevation of 631.0. A 3-foot drawdown at 9,900 cfs would lower water surface elevations at the Lock and Dam 7 tailwaters to about 629.0. This would provide 10 feet of clearance which may not stop tow traffic, but would require extra precautions to insure safe passage. At flows of 22,000 cfs, the approximate tailwater elevation at Lock and Dam 7 with a 3-foot drawdown would be 630.0, providing 11 feet of clearance.

Under open river conditions, the clearance at the lower sill at Lock and Dam 7 at 22,000 cfs would be between 10.5 and 11 feet. At 9,900 cfs, the clearance would be reduced to about 8 feet which would stop tow traffic.

None of the drawdown alternatives would be expected to have any effect on the highway and railroad bridges in pool 8. These bridges are all located in the upper end of the pool above river mile 697 where the maximum drawdown under any scenario would be 4 feet or less below normal pool elevation.

Railroads run adjacent to pool 8 on both sides of the river. A potential stability concern with a drawdown (especially a large drawdown) would be if large areas of water were trapped landward of the railroad embankment. This trapped water would apply lateral forces to the embankment that could lead to failure. A review indicates there are no large areas of water lying landward of the railroad embankments, especially in the lower portion of the pool where the largest drawdowns would occur with some of the open river alternatives.

One concern with large drawdowns in the lower reaches of the pool is that the railroad embankments are located adjacent to large open water reaches. It is not known how far down the railroad embankments bank protection extends. A large drawdown such as would occur with some of the open river alternatives could lower water levels below the bank protection, exposing unprotected portions of the railroad embankments to wave erosion. A more detailed evaluation would be required to determine the validity of this concern.

Water Appropriations

Summer growing season drawdowns should have no adverse effect on water supply at the French Island generating station. Even if the pool were fully drawn down, Black River flows passing the Lake Onalaska spillway would still be in the 500 to 1,500 cfs range, which would more than suffice for the station's needs. The generating station's intake pipes would still be submerged by more than 6 feet even under low flow conditions.

Real Estate

The Government would 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, to name a few. These would have to be evaluated on a case-by-case basis.

Conversely, improved habitat quality could increase property values for riparian owners.

Recreation

Drawdowns during the summer would have noticeable effects on recreation, primarily associated with reduced launch ramp or dock access; reduced backwater access; and potential safety concerns due to lower water. The extent of the impact would be related to the size of the drawdown (1 foot, 3 feet, or open river) 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 channel would be less sensitive to drawdown alternatives than commercial craft, since most draft at 3.5 feet or less. Drawdown impacts at marinas would likely be more serious than those at ramps, since trailered boats can 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, however.

There is some uncertainty about the extent of the expected effects at individual recreational boat access sites due to the modest level of precision of the data collected. Adverse effects (table 5-15) have been identified as "likely" when access channel water depths drop below 1.0 to 1.5 feet or when the end of the ramp is exposed. Adverse effects have been identified as "potential" when water depths at the end of the ramp drop below about 1.5 feet. This evaluation is subjective because site-specific conditions at ramps vary, as do the types of recreational craft using the ramp. However, the evaluation should serve to show the relative effects of different depths of drawdown under different discharge conditions.

Table 5-15

Potential Drawdown Effects on Boat Ramps and Marinas in Pool 8

Site Name	River Mile	Owner	Estimated Low Elev. of Ramp	Control Depth for Access	Pool @ 9,900 cfs Normal	Pool @ 9,900 cfs 1-ft Draw.	Pool @ 9,900 cfs 3-ft Draw.	Pool @ 9,900 cfs Open River	Pool @ 22,000 cfs Normal	Pool @ 22,000 cfs 1-ft Draw.	Pool @ 22,000 cfs 3-ft Draw.	Pool @ 22,000 cfs Open River
Sias Isles Boat Livery	702.4L	Private	no landing		631.1	* 630.4	** 628.9	** 627.3	631.6	* 631.0	* 630.2	** 629.8
Upper I-90 Ramp	702.1R	Mn DOT	628.4		631.1	630.4	* 628.9	** 627.3	631.6	631.0	* 630.2	* 629.8
Lower I-90 Ramp	701.8R	USFWS	628.4		631.1	630.3	* 628.8	** 627.2	631.6	631.0	* 630.2	* 629.7
Lower Spillway Landing	701.7L	La Crosse Co.	631.9	627.9	631.1	* 630.3	** 628.8	** 627.2	631.6	631.0	* 630.2	** 629.7
B. River French Is. Landing	701.5L	La Crosse City	631.8	629.8	631.1	** 630.3	** 628.8	** 627.2	631.6	631.0	* 630.1	** 629.7
Black's Cove Marina	700.2L	Private	631.4	630.4	631.1	** 630.2	** 628.7	** 627.1	631.4	* 630.8	** 629.9	** 629.4
R & R Marine	700.1L	Private	630.2	628.4	631.1	* 630.2	** 628.7	** 627.1	631.4	* 630.8	* 629.9	* 629.4
Richmond Bay Landing	700.1L	Town of Campbell	629.4	629.4	631.1	** 630.2	** 628.7	** 627.1	631.4	* 630.8	* 629.8	* 629.4
Al's Marina	699.8L	Private	no landing		631.1	* 630.2	* 628.7	* 627.1	631.3	630.8	* 629.8	* 629.3
Logan St. Landing	699.5L	La Crosse City	630.6	627.1	631.1	* 630.2	* 628.7	** 627.1	631.3	* 630.7	* 629.8	* 629.2
Clinton St. Landing	699.4L	La Crosse City	630.6	627.1	631.1	* 630.2	* 628.7	** 627.1	631.3	* 630.7	* 629.8	* 629.2
Clinton St. Landing West	699.4L	La Crosse City	630.1	630.1	631.1	** 630.2	** 628.7	** 627.1	631.3	* 630.7	** 629.8	** 629.2
Bob's Bait Shop Marina	699.4L	Private	no landing		631.1	* 630.2	* 628.7	* 627.1	631.3	* 630.7	* 629.8	** 629.2
French Is. Yacht Club	699.4L	Private	629.1	627.1	631.1	* 630.2	** 628.7	** 627.1	631.3	630.7	* 629.8	* 629.2
Beacon Bay Marina	699.4L	Private	628.1	628.1	631.1	* 630.2	** 628.7	** 627.1	631.3	630.7	629.8	* 629.2
Panke's Boat Livery	699.3L	Private	no landing		631.1	* 630.2	* 628.7	* 627.1	631.3	630.7	* 629.8	* 629.2
Hill's Boat Livery	699.2R	Private	no landing		631.1	* 630.2	* 628.7	* 627.1	631.3	630.6	* 629.8	* 629.2
Sportsman's Landing	698.5R	Mn DOT	627.2		631.1	630.2	* 628.7	* 627.0	631.1	630.5	629.5	629.0
Bikini Yacht Club	698.1R	Private	614.2		631.0	630.2	628.7	627.0	631.1	630.4	629.4	628.8
Pettibone Yacht Club	697.3R	Private	627.7		631.0	* 630.2	** 628.6	** 627.0	631.0	630.3	* 629.3	* 628.8
La Crosse Municipal Harbor	696.7L	Leased	628.6		631.0	* 630.2	** 628.6	** 627.0	631.0	* 630.3	* 629.3	* 628.6
Green Island Ramp	695.8L	La Crosse City	627.9		631.0	* 630.1	* 628.6	** 626.9	630.9	630.2	* 629.1	* 628.5
Chut's Landing	695.3L	Private	626.8		631.0	630.1	* 628.6	** 626.9	630.8	630.1	629.1	* 628.4
Upper Goose Is.	692.8L	La Crosse Co.	627.8		630.9	630.0	* 628.4	** 626.5	630.7	629.9	* 628.7	* 627.9
Upper Goose Is. East	692.8L	La Crosse Co.	canoe carry-in		630.9	630.0	628.4	* 626.5	630.7	629.9	628.7	627.9
Goose Island Landing	692.0L	La Crosse Co.	626.7		630.9	630.0	* 628.4	** 626.4	630.6	629.8	628.5	* 627.7
Hunter's Point Landing	690.6L	La Crosse Co.	627.0		630.9	629.9	* 628.2	** 626.1	630.5	629.6	* 628.2	* 627.1
Lawrence Lake Marina	690.5R	Private	626.0		630.9	629.9	628.2	** 626.1	630.5	629.6	628.2	* 627.1
Shady Maple Walkdown	690.2L	Wi DOT	canoe carry-in		630.9	629.9	628.2	* 626.1	630.5	629.6	628.2	* 627.1
Wildcat Park	688.5R	Houston Co.	626.3		630.8	629.9	* 628.1	** 625.5	630.4	629.4	* 627.9	* 626.4
Wildcat Park South	688.5R	Houston Co.	627.5		630.8	629.9	* 628.1	** 625.5	630.4	629.4	* 627.9	** 626.4
Water's Edge Motel	686.5L	Private	626.8		630.8	629.8	* 627.9	** 623.7	630.3	629.4	* 627.6	** 624.8
Stoddard Park Landing	685.7L	Stoddard	627.7		630.8	629.8	** 627.9	** 622.5	630.3	629.5	** 627.5	** 624.0
Reno Walkdown	681.5R	MDNR	canoe carry-in		630.8	629.8	* 627.8	* 621.0	630.2	629.3	* 627.2	* 622.3
Engh's Boat Livery	679.8L	Private	628.8		630.8	* 629.8	** 627.8	** 620.9	630.2	** 629.2	** 627.2	** 622.3
Genoa Harbor	679.3L	Genoa	625.5		630.8	629.8	* 627.8	** 620.9	630.2	629.2	* 627.2	** 622.3

** Adverse impact likely.

* Potential for adverse effect, more information concerning the site would have to be collected.

(light shading) Should be no adverse effect because effects on water levels appear minor in comparison to existing water depths.

(dark shading) No adverse effect because water levels with drawdown would be higher than water levels under normal operation at 22,000 cfs.

Table 5–15 cont'd
Potential Drawdown Effects on Boat Ramps and Marinas in Pool 8

Site Name	River Mile	Owner	Estimated Low Elev. of Ramp	Control Depth for Access	Pool @ 22,000 cfs Normal	Pool @ 40,600 cfs 1-ft Draw.	Pool @ 40,600 cfs 3-ft Draw.	Pool @ 40,600 cfs Open River	Pool @ 22,000 cfs Normal	Pool @ 75,500 cfs 1-ft Draw.	Pool @ 75,500 cfs 3-ft Draw.	Pool @ 75,500 cfs Open River
Sias Isles Boat Livery	702.4L	Private			631.6	633.4	633.2	633.1	631.6	637.0	637.0	637.0
Upper I-90 Ramp	702.1R	Mn DOT	628.4		631.6	633.3	633.2	633.1	631.6	637.0	637.0	637.0
Lower I-90 Ramp	701.8R	USFWS	628.4		631.6	633.3	633.0	633.0	631.6	636.8	636.8	636.8
Lower Spillway Landing	701.7L	La Crosse Co.	631.9	627.9	631.6	633.3	633.0	632.9	631.6	636.8	636.8	636.8
B. River French Is. Landing	701.5L	La Crosse City	631.8	629.8	631.6	633.3	633.0	632.9	631.6	636.8	636.8	636.8
Black's Cove Marina	700.2L	Private	631.4	630.4	631.4	632.9	632.6	632.5	631.4	636.1	636.1	636.1
R & R Marine	700.1L	Private	630.2	628.4	631.4	632.9	632.6	632.5	631.4	636.1	636.1	636.1
Richmond Bay Landing	700.1L	Town of Campbell	629.4	629.4	631.4	632.9	632.6	632.5	631.4	636.1	636.1	636.1
Al's Marina	699.8L	Private	no landing		631.3	632.7	632.4	632.3	631.3	635.8	635.8	635.8
Logan St. Landing	699.5L	La Crosse City	630.6	627.1	631.3	632.7	632.4	632.2	631.3	635.7	635.7	635.7
Clinton St. Landing	699.4L	La Crosse City	630.6	627.1	631.3	632.7	632.4	632.2	631.3	635.7	635.7	635.7
Clinton St. Landing West	699.4L	La Crosse City	630.1	630.1	631.3	632.7	632.4	632.2	631.3	635.7	635.7	635.7
Bob's Bait Shop Marina	699.4L	Private	no landing		631.3	632.7	632.4	632.2	631.3	635.7	635.7	635.7
French Is. Yacht Club	699.4L	Private	629.1	627.1	631.3	632.7	632.4	632.2	631.3	635.7	635.7	635.7
Beacon Bay Marina	699.4L	Private	628.1	628.1	631.3	632.7	632.4	632.2	631.3	635.7	635.7	635.7
Panke's Boat Livery	699.3L	Private	no landing		631.3	632.7	632.4	632.2	631.3	635.7	635.7	635.7
Hill's Boat Livery	699.2R	Private	no landing		631.3	632.7	632.4	632.2	631.3	635.7	635.7	635.7
Sportsman's Landing	698.5R	Mn DOT	627.2		631.1	632.2	631.9	631.9	631.1	635.0	635.0	635.0
Bikini Yacht Club	698.1R	Private	614.2		631.1	632.1	631.8	631.8	631.1	634.8	634.7	634.7
Pettibone Yacht Club	697.3R	Private	627.7		631.0	631.9	631.6	631.4	631.0	634.3	634.3	634.3
La Crosse Municipal Harbor	696.7L	Leased	628.6		631.0	631.8	631.5	631.3	631.0	634.2	634.1	634.1
Green Island Ramp	695.8L	La Crosse City	627.9		630.9	631.6	631.2	631.3	630.9	633.7	633.6	633.6
Chut's Landing	695.3L	Private	626.8		630.8	631.4	631.0	631.0	630.8	633.3	633.3	633.3
Upper Goose Is.	692.8L	La Crosse Co.	627.8		630.7	630.8	630.3	630.0	630.7	632.5	632.4	632.4
Upper Goose Is. East	692.8L	La Crosse Co.	canoe carry-in		630.7	630.8	630.3	630.0	630.7	632.5	632.4	632.4
Goose Island Landing	692.0L	La Crosse Co.	626.7		630.6	630.7	630.1	629.8	630.6	632.4	632.2	632.2
Hunter's Point Landing	690.6L	La Crosse Co.	627.0		630.5	630.2	629.4	629.1	630.5	631.7	631.6	631.6
Lawrence Lake Marina	690.5R	Private	626.0		630.5	630.2	629.4	629.1	630.5	631.7	631.6	631.6
Shady Maple Walkdown	690.2L	Wi DOT	canoe carry-in		630.5	630.1	629.4	629.1	630.5	631.6	631.6	631.6
Wildcat Park	688.5R	Houston Co.	626.3		630.4	629.8	628.6	* 628.1	630.4	630.8	630.5	630.5
Wildcat Park South	688.5R	Houston Co.	627.5		630.4	629.8	* 628.6	* 628.1	630.4	630.8	630.5	630.5
Water's Edge Motel	686.5L	Private	626.8		630.3	629.5	* 628.2	* 627.3	630.3	630.4	630.0	630.0
Stoddard Park Landing	685.7L	Stoddard	627.7		630.3	* 629.5	* 628.0	** 626.9	630.3	630.3	629.9	629.9
Reno Walkdown	681.5R	MDNR	canoe carry-in		630.2	629.1	627.1	* 624.6	630.2	629.3	628.4	628.4
Engh's Boat Livery	679.8L	Private	628.8		630.2	** 629.0	** 627.0	** 624.5	630.2	* 629.0	** 628.1	** 628.1
Genoa Harbor	679.3L	Genoa	625.5		630.2	629.0	* 627.0	** 624.5	630.2	629.0	* 628.1	* 628.1

** Adverse impact likely.

* Potential for adverse effect, more information concerning the site would have to be collected.

Should be no adverse effect because effects on water levels appear minor in comparison to existing water depths.

No adverse effect because water levels with drawdown would be higher than water levels under normal operation at 22,000 cfs.

Under conditions of extremely low flow (9,900 cfs), nearly half of the 36 boating access sites in pool 8 potentially could be negatively affected by a 1-foot drawdown (four sites with likely negative impacts). Nearly all have the potential for adverse effects from larger drawdowns (13 sites with likely negative impacts for the 3-foot drawdown, and 27 sites with likely negative impacts for the open river drawdown).

Under more typical low flow conditions (22,000 cfs), 10 of the sites have the potential for negative effects with a 1-foot drawdown (one site with likely negative impacts); most sites have the potential for negative impacts with larger drawdowns (four sites with likely negative impacts for the 3-foot drawdown, and 11 sites with likely negative impacts for the open river drawdown).

All of the drawdown alternatives will result in reduced boating access to backwater areas during the periods of drawdown. The extent of the effect will be greater with the larger drawdown alternatives. These effects have not been quantified due to data limitations.

Lower water levels could also increase safety hazards if underwater objects (such as stumps or wing dams) were closer to the surface or exposed during the project period. These hazards exist to some degree under present conditions, but drawdown would increase the potential hazard. The extent of this potential problem has not been determined at this stage of study, but should be pursued further in subsequent stages of study. Ways to reduce public exposure to potential hazards would need to be explored.

Long-term benefits to recreationists would be expected, to the extent that improvements to fish and wildlife are realized. Recreation on the Upper Mississippi River provides substantial economic benefits and is dependent on a healthy ecosystem to provide the resources for public use. While it has not been documented that water level management in the form of drawdown is necessary to sustain recreational use, any measure that promotes a healthy ecosystem will contribute to the economic benefits related to recreation. These effects are not defined well enough to be quantified.

<u>Aesthetics</u>

Drawing down the pool would have visual effects that probably would be viewed negatively by most of the general public. Exposed river bottom, decaying vegetation, and in some locations, dead fish and mussels would not be considered by most to be visually pleasing, though it would satisfy the curiosity of those who wonder what the river bottom looks like.

Odor from the exposed sediments, decaying vegetation, and decaying fish and mussels could be locally offensive, with the effects varying greatly with temperature and wind conditions.

Those alternatives that result in the greatest drawdown and exposure of the largest area of river bottom have the potential for greatest impact. None of the alternatives would expose large areas of river bottom in the La Crosse/La Crescent area. The 3-foot drawdown and open river alternatives would expose large areas of river bottom in the lower one-third of the pool. Brownsville and Stoddard are the two developed areas where the effects would be most visible. In addition, the exposed river bottom would be highly visible to travelers on Wisconsin State Highway 35 and Minnesota State Highway 26, both of which run adjacent to the river in lower pool 8.

Over the long-term, aesthetics may become improved if emergent vegetation response results in a more diverse and lush landscape.

Cultural Resources

The National Reservoir Inundation Study (NRIS), in a 5-year program, concluded that "the effects of freshwater inundation on archaeological resources are overwhelmingly detrimental...." (Dunn: 15.) In a subsequent work, J.A. Ware identified three impact zones in and surrounding a reservoir. Zone 1, or the Conservation Pool, he defined as that portion of the reservoir below the average annual drawdown. He defined Zone 2 or the Fluctuation or Drawdown Zone as the zone exposed to periodic, usually annual, shoreline fluctuation. Finally, he defined Zone 3 or the Backshore Zone as the upper, noninundated reaches of the reservoir watershed. (Dunn: 16.)

Dunn identifies three types of impacts to cultural resources lying in and along reservoirs: mechanical, biochemical and human. Mechanical impacts include a "variety of physical erosion and deposition processes, including wave and water motion, reservoir siltation from backshore runoff and stream inflow, and saturation and slumping of shoreline and submerged geological strata." According to Dunn, "The NRIS report determined that wave action in shallow water is the most important mechanical impact to cultural resources in reservoirs." (1996:16) Dunn reports that biochemical effects are accelerated in the drawdown zone because of greater light, dissolved oxygen and ambient temperatures. After only a few exposures, he notes, alternate cycles of wetting and drying lead "to rapid deterioration of common organic materials ...." (1996: 18) Human impacts include vandalism, recreation, construction, and changes in land use. All three impacts are magnified in the Drawdown zone. (Dunn: 17-18.)

Given this background, fluctuating pool 8 and/or specific areas within the pool could adversely affect cultural resources. In areas where drawdown would lower pool 8 below the normal, seasonal low-water levels, the potential for increasing all three types of impacts would increase. As the drawdown plans examined in this report would potentially exacerbate archeological site destruction in pool 8, any plan for the drawdown would have to provide for a monitoring plan and a mitigation plan, where sites may be exposed to mechanical, biochemical and/or human destruction.

Pool-wide drawdowns would affect a much wider area than the small-scale and mid-scale drawdowns. Consequently, the potential to affect cultural resources would be much greater. In general, the greater the drawdown, the greater the chance of exposing archeological sites. For any of these drawdowns, and especially for the larger scale drawdowns, the monitoring and mitigation efforts and plans would need to be well-defined and executed. The larger scale drawdowns most likely would expose the wreck of the War Eagle and other wrecks. Special provisions would need to be made for the protection and preservation of any shipwrecks.

As Dunn points out in his study of the impacts to historic properties in drawdown zones, lowering the reservoir can change che shoreline profile. Under low water conditions, the channel can become more defined and create steeper banks. These banks are subject to greater wave and water flow erosion once the river begins to rise again. (1996:17) In addition, exposing the shoreline can make archeological sites accessible to looters. Special provisions would also have to be made for the protection and preservation of any archeological sites exposed during the drawdowns.

For any additional dredging required to maintain the navigation channel during a drawdown, the District would evaluate new dredge cuts for potential submerged resources. In addition, all placement sites would be evaluated.

Significant lowering of the water level--to the point where the wing dams and closing dams begin to function as they did before impoundment--would provide a great opportunity to study the river. If this were to occur, provisions should be made for a detailed study of the river under these conditions.

Implementation Procedure

Implementation of any drawdown plan would require a feasibility study and approval through Corps of Engineers channels. A change in the regulation plan for pool 8 that does not affect the Congressionally-authorized project purpose could be accomplished with approval from the Corps of Engineers Division level, according to Corps internal regulations (Engineering Manual 1110-2-3600) governing the Corps system of water control management. A drawdown of pool 8 during the navigation season would have the potential to significantly affect a Congressionally-authorized project purpose (navigation), and approval from Corps Headquarters would be needed. Congressional action would likely be required for any drawdown plan for which it was determined that there would be significant effects on navigation.

SECTION SIX - COMPARISON OF ALTERNATIVES

This section provides a comparison of the water level management ernatives for pool 8. Table 6-1 summarizes the effects of all the ernatives except for the pool-wide summer growing season drawdown ernatives which are summarized in table 6-2.

Table 6-3 compares the potential costs and area benefited for the non-ing season drawdown alternatives. Because most of these alternatives were uated only in a qualitative manner, acres benefited and/or costs could not eveloped for these measures.

The habitat benefits of discontinuing the 0.25-foot winter drawdown, lating on the "high" or "low" side of the operating band, and modifying distribution through the dam gates were not quantified as part of this r. Even with further study, it would be difficult to quantify the :its of these alternatives. However, the cost of implementing these natives is probably negligible. Thus, the cost per unit of habitat :it would be low.

The habitat benefits and costs of increasing the frequency of gate tments and spring pool raises were not quantified. The potential exists ubstantial costs being associated with implementation of these natives. Thus, the cost per unit of habitat benefit could also be antial.

The habitat benefits of a winter drawdown would be highly variable ling on the range of acres benefited. The costs would be relatively as they are associated with the shortening of the navigation season to ent a winter drawdown, regardless of how large a drawdown is ented.

he estimated cost per acre benefited with changing the pool control is relatively low, especially considering the worst case assumptions o estimate the number of acres to be Federally acquired with this ative.

Table 6–1
Summary of Effects of Non–Pool Wide Growing Season Drawdown Alternatives

			Large Scale Measures within Present System				Large Scale Changes to Present System		
	Small Scale Measures	Mid–Scale Measures	Discontinue 0.25-foot Winter Drawdown	Regulate on High or Low Side of Band	Increase Frequency of Gate Adjustments	Modify Flow Through Dam Gates	Winter Drawdowns	Spring Pool Raises	Change Control Point
Water Quality	Site specific effects; no significant effects	Site specific effects; no significant effects	Minor beneficial effects	Minor effects depending on location	No Effect	No Effect	Dissolved oxygen depletion in backwaters; significance of effects highly dependent on the depth of drawdown	No significant effects	No significant effects
Ecological	262 acres managed with average annual costs ranging from $140 to $3,900 per acre	429 acres managed at an average annual cost of about $93 per acre	Positive effects; difficult to quantify; can be achieved at no cost	Probable minor beneficial effects; can be achieved at no cost	Probable beneficial effects on aquatic plants and survival of YOY fish	Probable beneficial effects on tailwater habitat	Potential for substantial short term adverse effects; beneficial effects could be substantial by allowing winter habitat project construction work	Potential beneficial effects on fish spawning and recruitment	Permanent change in water levels would affect zonation of vegetation in lower pool; positive effects on shallow aquatic habitat
Operations	No Effect	No Effect	No Effect	No Effect	May not be implement-able with current man-power; cost of automation may be significant	Some additional efforts likely required by lock and dam personnel	Some additional efforts required by lock and dam personnel	Engineering constraints would limit extent; additional efforts would be required at lock and dam to implement	No effect
Channel Maintenance	No Effect	No Effect	No Effect	Minor beneficial or adverse depending on the situation	No Effect	No Effect	No Effect	May alter short term dredging requirements; no long term effects foreseen	May alter short term dredging requirements; no long term effects foreseen
Commercial Navigation	No Effect	No Effect	No Effect	Minor beneficial or adverse depending on the situation	No Effect	No Effect	No Effect	No Effect	No Effect
Transportation Infrastructure	No Effect	No Effect	No Effect	No Effect	No Effect	No Effect	No Effect	No Effect	No Effect
Water Supply	No Effect	No Effect	No Effect	No Effect	No Effect	No Effect	No Effect	No Effect	No Effect
Real Estate	Real estate interest or other type of agreement would be required for non–Federal sites	No Effect	No Effect	No Effect	No Effect	No Effect	No Effect	No Effect	Land acquisition or flowage easements required; maximum 1,700 acres
Recreation	Localized effects which would tend to be minor in most instances	Localized effects which would tend to be minor in most instances	No direct effects; Beneficial secondary effects from improved habitat conditions	No direct effects; Beneficial secondary effects from improved habitat conditions	No direct effects; Beneficial secondary effects from improved habitat conditions	No direct effects; Beneficial secondary effects from improved habitat conditions	Adverse effects on ice fishing; Beneficial secondary effects from better habitat conditions	No direct effects; Beneficial secondary effects from improved habitat conditions	No direct effects; Beneficial secondary effects from improved habitat conditions
Aesthetics	No Appreciable Effect	No Appreciable Effect	No Effect	No Effect	No Effect	No Effect	Potential for adverse effect depending on the situation	No Effect	No Effect
Cultural Resources	Moderate potential for effects on a site specific basis	Moderate potential for effects	Low potential for effects	Low potential for effects	Low potential for effects	Low potential for effects	Moderate potential for effects on a site specific basis	Moderate potential for effects	Moderate potential for effects
Implementation	Federal and/or State resource management agencies	U.S. Fish and Wildlife Service would have lead responsibility	St. Paul District has authority to implement	St. Paul District has authority to implement	St. Paul District has authority to implement	St. Paul District has authority to implement	Approval required by Corps of Engineers Headquarters and Congress	Approval required by Corps of Engineers Headquarters and possibly by Congress	Approval required by Corps of Engineers Headquarters and possibly by Congress

Table 6–2
Summary of Effects of Pool Wide Growing Season Drawdown Alternatives

	One-Foot Drawdown 9,900 cfs	One-Foot Drawdown 22,000 cfs	One-Foot Drawdown 40,600 cfs	One-Foot Drawdown 75,500 cfs	Three-Foot Drawdown 9,900 cfs	Three-Foot Drawdown 22,000 cfs	Three-Foot Drawdown 40,600 cfs	Three-Foot Drawdown 75,500 cfs	Open River Drawdown 9,900 cfs	Open River Drawdown 22,000 cfs	Open River Drawdown 40,600 cfs	Open River Drawdown 75,500 cfs
Water Quality	No significant effects	No significant effects	No significant effects	No significant effects	Some dissolved oxygen depletion in backwaters	Some dissolved oxygen depletion in backwaters	Some dissolved oxygen depletion in backwaters	No significant effects	Some dissolved oxygen depletion in backwaters; extensive dewatering	Some dissolved oxygen depletion in backwaters; extensive dewatering	Some dissolved oxygen depletion in backwaters; extensive dewatering	No significant effects
Ecological	4,300 acres exposed; 1,100 unvegetated acres exposed; 3,200 vegetated acres exposed	4,600 acres exposed; 1,300 unvegetated acres exposed; 3,300 vegetated acres exposed	2,400 acres exposed; 700 unvegetated acres exposed; 1,700 vegetated acres exposed	500 acres exposed; 200 unvegetated acres exposed; 300 vegetated acres exposed	8,600 acres exposed; 4,100 unvegetated acres exposed; 4,500 vegetated acres exposed	9,300 acres exposed; 4,800 unvegetated acres exposed; 4,500 vegetated acres exposed	5,600 acres exposed; 2,800 unvegetated acres exposed; 2,800 vegetated acres exposed	700 acres exposed; 300 unvegetated acres exposed; 400 vegetated acres exposed	16,600 acres exposed; 11,800 unvegetated acres exposed; 4,800 vegetated acres exposed	15,000 acres exposed; 10,400 unvegetated acres exposed; 4,600 vegetated acres exposed	9,400 acres exposed; 6,200 unvegetated acres exposed; 3,200 vegetated acres exposed	700 acres exposed; 300 unvegetated acres exposed; 400 vegetated acres exposed
Operations	Minor additional effort required to implement	Minor additional effort required to implement	Minor additional effort required to implement	Minor additional effort required to implement	Minor additional effort required to implement	Minor additional effort required to implement	Minor additional effort required to implement	Minor additional effort required to implement	Minor additional effort required to implement	Minor additional effort required to implement	Minor additional effort required to implement	Minor additional effort required to implement
Channel Maintenance	Minor additional dredging required to maintain navigation channel; additional cost likely less than $100,000	Minor additional dredging required to maintain navigation channel; additional cost likely less than $100,000	Minor additional dredging required to maintain navigation channel; additional cost likely less than $100,000	Minor additional dredging required to maintain navigation channel; additional cost likely less than $100,000	Substantial additional dredging required to maintain navigation channel; additional estimated at approx. $1,200,000	Substantial additional dredging required to maintain navigation channel; additional estimated at approx. $1,200,000	Substantial additional dredging required to maintain navigation channel; additional estimated at approx. $1,200,000	Substantial additional dredging required to maintain navigation channel; additional estimated at approx. $1,200,000	Navigation channel could not be maintained	Navigation channel could not be maintained	Navigation channel could not be maintained	No additional dredging likely required to maintain the navigation channel
Commercial Navigation	9-foot channel would be maintained; no adverse effects	9-foot channel would be maintained; no adverse effects	9-foot channel would be maintained; no adverse effects	9-foot channel would be maintained; no adverse effects	9-foot channel would be maintained; potential delays with dredging needed to maintain channel	9-foot channel would be maintained; potential delays with dredging needed to maintain channel	9-foot channel would be maintained; potential delays with dredging needed to maintain channel	9-foot channel would be maintained; potential delays with dredging needed to maintain channel	Navigation channel closed; $33 million to $115 million in losses depending on draw-down duration	Navigation channel closed; $33 million to $115 million in losses depending on draw-down duration	Navigation channel closed; $33 million to $115 million in losses depending on draw-down duration	9-foot channel would be maintained; no adverse effects
Transportation Infrastructure	No Effect	No Effect	No Effect	No Effect	No Effect	No Effect	No Effect	No Effect	Potential for exposing unprotected railroad embankments	Potential for exposing unprotected railroad embankments	Potential for exposing unprotected railroad embankments	No Effect
Water Supply	No Effect	No Effect	No Effect	No Effect	No Effect	No Effect	No Effect	No Effect	No Effect	No Effect	No Effect	No Effect
Real Estate	No appreciable effects	No appreciable effects	No appreciable effects	No appreciable effects	No appreciable effects	No appreciable effects	No appreciable effects	No appreciable effects	No appreciable effects	No appreciable effects	No appreciable effects	No appreciable effects
Recreation	4 boat ramps affected; potential effects on 15 boat ramps; beneficial effects from improved habitat conditions	1 boat ramp affected; potential effects on 9 boat ramps; beneficial effects from improved habitat conditions	1 boat ramp affected; potential effects on 1 boat ramp; beneficial effects from improved habitat conditions	Potential effect on 1 boat ramp; beneficial effects from improved habitat conditions	13 boat ramps affected; potential effects on 19 boat ramps; beneficial effects from improved habitat conditions	4 boat ramps affected; potential effects on 24 boat ramps; beneficial effects from improved habitat conditions	1 boat ramp affected; potential effects on 4 boat ramps; beneficial effects from improved habitat conditions	1 boat ramp affected; potential effects on 1 boat ramp; beneficial effects from improved habitat conditions	27 boat ramps affected; potential effects on 8 boat ramps; beneficial effects from improved habitat conditions	11 boat ramps affected; potential effects on 22 boat ramps; beneficial effects from improved habitat conditions	3 boat ramps affected; potential effects on 4 boat ramps; beneficial effects from improved habitat conditions	1 boat ramp affected; potential effects on 1 boat ramp; beneficial effects from improved habitat conditions
Aesthetics	Minor visual and odor effects	Minor visual and odor effects	Minor visual and odor effects	No appreciable effect	Minor visual and odor effects	Minor visual and odor effects	Minor visual and odor effects	No appreciable effect	Moderate visual and odor effects	Moderate visual and odor effects	Minor visual and odor effects	No appreciable effect
Cultural Resources	Moderate potential for effects based on area exposed	Moderate potential for effects based on area exposed	Moderate potential for effects based on area exposed	Low potential for effects based on area exposed	Moderate potential for effects based on area exposed	Moderate potential for effects based on area exposed	Moderate potential for effects based on area exposed	Low potential for effects based on area exposed	Substantial potential for effects based on area exposed	Substantial potential for effects based on area exposed	Moderate potential for effects based on area exposed	Low potential for effects based on area exposed
Implementation	Approval required by Corps of Engineers Headquarters	Approval required by Corps of Engineers Headquarters	Approval required by Corps of Engineers Headquarters	Approval required by Corps of Engineers Headquarters	Approval required by Corps of Engineers Headquarters	Approval required by Corps of Engineers Headquarters	Approval required by Corps of Engineers Headquarters	Approval required by Corps of Engineers Headquarters	Approval required by Corps of Engineers Headquarters and Congress	Approval required by Corps of Engineers Headquarters and Congress	Approval required by Corps of Engineers Headquarters and Congress	Approval required by Corps of Engineers Headquarters and Congress

Table 6–3
Costs/Acres Benefited of Non–Growing Season Drawdown Alternatives

Alternative	Range of Acres* Benefited	Range of Costs	Range of Costs/Acre Benefited	Comments
Discontinue Winter Drawdown	max. 17,000	$0	$0	Acres benefited is not a significant factor because the benefits can be obtained at no cost.
Regulate on the "High" or "Low" Side of Band	max. 17,000	likely to be minor	likely to be minor	Acres benefited is not a significant factor because the benefits can likely be obtained at a minor cost.
Increase Frequency of Gate Adjustments	max. 17,000	could be substantial	could be substantial	May not be implementable with current lock and dam staffing. Cost of automating gate operations could be substantial.
Modify Flow through Dam Gates	unknown	likely to be minor	likely to be minor	Acres benefited is not a significant factor because the benefits can likely be obtained at a minor cost.
Winter Drawdown	min. 1,000 max. 15,000	up to $6,650,000	min. $450 max. $6,650	Cost per acre benefited would be highly variable depending upon the extent of the drawdown.
Spring Pool Raise	max. 17,000	could be substantial	could be substantial	Constraints at the lock and dam would limit the extent to which this alternative could be implemented.
Change Pool Control Point	max. 17,000	$1,500,000	$88	Cost per acre assumes worst case real estate costs and maximum acres benefited.

* contiguous backwater habitat

Table 6-4 provides estimated costs per acre of habitat benefited for the summer growing season drawdown alternatives. Note that the costs per acre benefited are only approximate.

Isolation and management of small waterbodies will have highly variable costs because of the unique circumstances associated with each waterbody. The range of costs developed for the 30 sites in pool 8 should provide a good indicator of costs that may be encountered using this management technique. Only one larger waterbody (Lawrence Lake) was evaluated as part of this study. The results show a cost per acre benefited lower than that for the small waterbodies. This was not unexpected because the cost per unit area of isolating and pumping a larger area should be lower than for smaller sites due to economies of scale.

It is readily apparent for the pool drawdown alternatives that the cost per acre benefited would be significantly lower if the navigation channel was not closed to traffic. The cost per acre benefited associated with a 3-foot drawdown with dredging would be approximately 4 to 6 times that associated with a 1-foot drawdown with dredging. However, the unit costs of both are relatively small when compared to the small- and mid-scale measures and the pool drawdown alternatives involving channel closure.

The costs per acre benefited of two large habitat restoration projects in lower pool 8 are included in table 6-4. While the habitat benefits of the two habitat restoration projects are not directly comparable to the habitat benefits of a growing season drawdown, they do provide an indication of the relative costs resource management agencies consider justified to improve habitat conditions on the Upper Mississippi River. The cost per acre benefited of the two habitat projects are generally higher than the estimated costs for the drawdown alternatives where the navigation channel is maintained with additional dredging; and lower than the estimated costs associated with drawdown alternatives that result in closure of the navigation channel.

Table 6-4
Costs/Acres Benefited of Growing Season Drawdown Alternatives

	Range of Acres Benefited	Estimated Ave Annual Costs (1)	Range of Ave Annual Costs/Acre Benefited
Small-Scale Measures	2–61	$1,900–$14,200	$140–$3,800
Mid-Scale Measures	429	$40,000	$93
1-Foot Drawdown (w/dredging)			
Partial Growing Season	2,400–4,600	$17,000	$4–$7
Full Growing Season	2,400–4,600	$17,000	$4–$7
Two Growing Seasons	2,400–4,600	$33,000	$7–$14
3-Foot Drawdown (w/dredging)			
Partial Growing Season	5,600–9,300	$224,000	$24–39
Full Growing Season	5,600–9,300	$224,000	$24–39
Two Growing Seasons (2)	5,600–9,300	$275,000	$30–$48
3-Foot Drawdown (w/ch. closure)			
Partial Growing Season	5,600–9,300	$6,250,000	$670–$1,100
Full Growing Season	5,600–9,300	$14,380,000	$1,550–$2,500
Two Growing Seasons (3)	5,600–9,300	$14,431,000	$1,550–$2,500
Open River (w/ch. closure)			
Full Growing Season	9,400–15,200	$14,380,000	$950–$1,530
Two Growing Seasons (3)	9,400–15,200	$14,431,000	$950–$1,530
Two Growing Seasons (4)	9,400–15,200	$14,604,000	$960–$1,550
Pool 8 Islands Phase I HREP	1,000	$160,000	$160
Pool 8 Islands Phase II HREP	500	$297,000	$594

(1) On a 7-year cycle annualized over 25 years.
(2) Second growing season drawdown only 1.5 feet.
(3) Second growing season drawdown only 1.5 feet, channel maintained by additional dredging.
(4) Second growing season drawdown only 3 feet, channel maintained by additional dredging.
(5) HREP project costs annualized over 50-project life

A rough incremental analysis was performed for single growing season pool drawdowns. The assumption was made that the per acre benefits of a given duration drawdown would be somewhat similar whether the drawdown is 1 foot, 3 feet, or something greater. An incremental analysis cannot be performed at this stage of study comparing partial growing season vs. full growing season vs. two growing season drawdowns because the quality and the duration of habitat benefits are likely to be significantly different for those different durations of drawdown.

The results of the incremental analysis of single growing season pool drawdown alternatives are shown in tables 6-5 through 6-7. For each option, an average of the range of acres affected was used. If a partial growing season drawdown were implemented (table 6-5), the cost per acre affected of the 4,000 additional acres exposed with a 3-foot drawdown would be about 10 times greater on a per acre basis than the first 3,500 acres exposed with the 1-foot drawdown. However, even at $52 per acre benefited, this incremental cost is relatively low. A more detailed analysis applying a quality factor to the acres exposed with a 1-foot versus 3-foot drawdown would probably narrow the difference between the incremental costs of these two options. The reason is that there probably would be greater and longer lasting benefits with a 3-foot drawdown due to greater sediment consolidation and drying.

For the full growing season drawdown (table 6-6), the same general relationship exists between the 1-foot and 3-foot drawdown options, as no additional costs are projected with a full growing season drawdown. The navigation channel would have to be dredged to provide adequate depths whether the drawdown lasted 45 days (partial growing season) or 105 days (full growing season). (In an actual drawdown situation, there may be additional costs associated with keeping the channel open for an additional 60 days, but this study did not identify those costs.)

Going to an open river drawdown would result in a significant increase in the incremental cost per acre benefited. The cost of exposing the additional 4,800 acres would be over 50 times greater than the previous increment. As noted earlier for the partial growing season options, further analysis could close this gap somewhat due to the additional sediment consolidation benefits of greater depth drawdown. Conversely, some of the area exposed by open river drawdown would be reinundated by water 4 to 10 feet deep, making it unlikely that any new aquatic vegetation growth in these areas would be sustainable. Regardless, it is likely that the incremental cost of the open river drawdown option would still be significantly higher than the incremental costs of the 1-foot and 3-foot drawdown options.

Table 6-5
Incremental Analysis of Partial Growing Season Pool Drawdown Options

Option	Acres Benefited	Average Annual Cost	Incremental Acres Benefited	Incremental Ave. Annual Cost	Incremental Cost/Acre Benefited
1-ft draw. w/dredging	3,500	$17,000	3,500	$17,000	$5
3-ft draw. w/dredging	7,500	$224,000	4,000	$207,000	$52

Table 6-6
Incremental Analysis of Full Growing Season Pool Drawdown Options

Option	Acres Benefited	Average Annual Cost	Incremental Acres Benefited	Incremental Ave. Annual Cost	Incremental Cost/Acre Benefited
1-ft draw. w/dredging	3,500	$17,000	3,500	$17,000	$5
3-ft draw. w/dredging	7,500	$224,000	4,000	$207,000	$52
Open river w/closure	12,300	$14,380,000	4,800	$14,156,000	$2,950

Table 6-7
Incremental Analysis of Two Growing Season Pool Drawdown Options

Option	Acres Benefited	Average Annual Cost	Incremental Acres Benefited	Incremental Ave. Annual Cost	Incremental Cost/Acre Benefited
1-ft draw. w/dredging	3,500	$33,000	3,500	$33,000	$9
3-ft draw. w/dredging	7,500	$275,000	4,000	$242,000	$61
Open river w/closure	12,300	$14,431,000	4,800	$14,156,000	$2,950

The results for the two growing season drawdown options (table 6-7) are similar to those for the full growing season option; i.e., the incremental costs of exposing the additional acres with an open river drawdown would be significantly greater than those for the 1-foot and 3-foot drawdown options. Although slightly higher in unit area costs than single season drawdown alternatives, two growing season drawdowns would have qualitatively much greater benefits, through the establishment of larger areas of emergent aquatic vegetation. This benefit would continue into years following the drawdown.

SECTION 7 - APPLICABILITY TO OTHER ST. PAUL DISTRICT POOLS

This section discusses water level management for the other navigation pools within the St. Paul District based on the results of the pool 8 evaluations. The potential for implementation of alternative water level management measures is discussed along with the potential effects where possible.

SMALL-SCALE MEASURES

Isolation and independent management of small backwater areas could be implemented in any of the St. Paul District navigation pools where there are backwaters. Because of size and land/water area differences, some of the pools would provide more opportunity for this type of management than others. Table 7-1 contains a qualitative assessment of this opportunity for each pool, using pool 8 as the standard of comparison.

Table 7-1
Opportunities for Isolation and Management
of Small Waterbodies in Comparison to Pool 8

Pool	Opportunity	Comments
USAF	no opportunity	pool contains no backwaters
LSAF	no opportunity	pool contains no backwaters
1	no opportunity	pool contains no backwaters
2	much less than pool 8	small isolated backwaters limited
3	much less than pool 8	aquatic area 35% of pool 8 aquatic area
4	much less than pool 8	aquatic area 55% of pool 8 aquatic area
5	somewhat less than pool 8	aquatic area 90% of pool 8 aquatic area
5A	much less than pool 8	aquatic area 35% of pool 8 aquatic area
6	much less than pool 8	aquatic area 50% of pool 8 aquatic area; most managed as part of Trempealeau NWR
7	somewhat less than pool 8	aquatic area 65% of pool 8 aquatic area
9	more than pool 8	aquatic area 145% of pool 8 aquatic area
10	more than pool 8	aquatic area comparable; less large, deep open water area than in pool 8

The range of costs per acre benefited associated with isolating and managing small backwaters in the other pools should be comparable with those identified for pool 8. In addition, the potential effects on other resources and public use of those resources would be similar as discussed for pool 8.

MID-SCALE MEASURES

A brief review of the other navigation pools was conducted to identify large (100 acres or greater) backwaters that could be isolated from the river without a significant investment in diking systems. The sites are listed in table 7-2. Sites with private residential developments and known high recreational use for boating and fishing were not included because of the potential for conflicts with these existing uses.

Table 7-2
Large (>100 acres) Backwater Lakes Suited to
Independent Water Level Management

Lake	Pool	Approx. Acres	Linear Feet of Dike
Pigs Eye Lake	2	700	500
River Lake	2	200	500
Mooers Lake	2	100	500
Gantenbein Lake	4	100	500
Mud Lake	4	300	500
Dead Slough Lake	4	400	1,000
Goose Lake	4	100	500
Duck Lake	9	100	1,000
McGregor Lake	10	200	500

A majority of the sites listed in table 7-2 are located in pool 2 and in pool 4 above Lake Pepin. Table 7-3 lists other locations where large backwater areas could be isolated from the river with substantial investments in diking systems and/or where there could be substantial conflicts with existing public uses. Table 7-4 shows the percent of non-channel aquatic area affected in each pool if all the backwaters listed in tables 7-2 and 7-3 were isolated and managed (pool 8 is included for comparison purposes). This tabulation indicates that the greatest potential for affecting an appreciable portion of Mississippi River non-channel aquatic habitat with this management technique is in pools 2 through 4.

Table 7-3

ge (>100 acres) Backwater Lakes That Would Require Substantial Diking and/or Could Involve Conflicts With Existing Uses

Lake	Pool	Approx. Acres	Linear Feet of Dike
3aldwin Lake	2	500	4,000
3pring Lake	2	1,800	12,000
Jorth Lake	3	1,200	4,000
3turgeon Lake	3	800	5,000
obinson Lake	4	800	7,000
eterson Lake	4	500	8,000
remore Lake	10	300	1,000
ussey Lake	10	200	1,500

Table 7-4

pproximate Percent of Pool Non-Channel Aquatic Areas That Could Be Isolated and Managed Independently

ol	Approx. Acres* Non-Channel Aquatic Habitat	Acres Manageable	Percent Manageable
2	7,000	3,300	47
3	7,000	2,000	29
4	9,000**	2,200	24
5	10,000	0	0
A	5,000	0	0
5	3,000***	0	0
7	12,000	0	0
3	18,000	500	3
)	28,000	100	<1
)	10,000	700	7
(rounded)	110,000	9,000	9

on and Meyer (1976)

e Pepin excluded

mpealeau National Wildlife Refuge excluded

LARGE-SCALE MEASURES WITHIN THE PRESENT SYSTEM OF RIVER REGULATION

DISCONTINUE 0.25-FOOT WINTER DRAWDOWN

Discontinuing the 0.25-foot winter drawdown is being implemented for all the navigation pools in the St. Paul District. Because elimination of the historically practiced winter drawdowns provides benefits to shallow contiguous backwaters, those pools with the greatest areas of shallow contiguous backwaters (pools 5, 7, 8, 9, and 10) are likely to benefit the most. Because pool 10 was formerly regulated with a winter drawdown of up to 1 foot (vs. 0.25 foot in the other pools), the positive effects of discontinuing winter drawdowns are probably greatest in pool 10.

REGULATION ON THE "HIGH" OR "LOW" SIDE OF THE REGULATING BAND

Regulation on the high or low side of the regulating band could be implemented for any of the navigation pools in the St. Paul District. As with elimination of winter drawdowns, pools with the greatest areas of contiguous shallow backwater areas are likely to benefit the most from regulation on the high or low side of the regulating band.

INCREASE THE FREQUENCY OF GATE ADJUSTMENTS

Increasing the frequency of gate adjustments could be implemented at any of the navigation dams in the St. Paul District. Because reducing the frequency and amplitude of regulation-induced water level fluctuations would affect primarily shallow littoral areas, those pools with the greatest areas of contiguous shallow backwaters would probably benefit the most from this change in river regulation.

MODIFY DISTRIBUTION OF FLOW THROUGH THE DAM GATES

Modifying the distribution of flow through the dam gates could be implemented at any of the navigation dams in the St. Paul District. No information has been developed to indicate whether the benefits would be greater or less at any particular dam(s).

-SCALE CHANGES TO THE PRESENT SYSTEM OF RIVER REGULATION

WINTER DRAWDOWN

Winter drawdown could be implemented for any of the navigation pools in t. Paul District. The depth of drawdown would determine the benefits and se effects of any particular drawdown event. A winter drawdown for those with large tributary inflows could be more difficult to maintain. Those be pool 2 (Minnesota River), pool 3 (St. Croix River), lower pool 4 ppewa River), and pool 10 (Wisconsin River).

A winter drawdown in the Upper St. Anthony Falls (USAF) pool, pool 1, or pool 2 would have the potential for having adverse effects on ercial navigation because of the local navigation traffic in these pools ng the winter months. A winter drawdown to open river conditions could ably not be done in pool 3 without adverse effects on the water intakes discharge at the Prairie Island Nuclear Generating Plant in pool 3.

SPRING POOL RAISES

Spring pool raises could be implemented for any of the navigation pools the St. Paul District. As with winter drawdowns, the specifics of a spring l raise would determine the level of benefits and adverse effects. Similar Lock and Dam 8, there would be practical physical constraints on how much ing pool levels could be artificially increased. Spring pool raises could accomplished with fewer structural modifications at the dams without fixed-st spillways.

CHANGE PRIMARY CONTROL POINT FROM MID-POOL TO THE DAM

In addition to pool 8, changing the primary control point from mid-pool the dam could be implemented in pools 2 through 6 and pool 9. Pool 7 is ways in secondary control at the dam. The USAF pool and pool 1 are ntrolled at the dam. Primary and secondary control for pool 10 is located the dam (except for a small flow range that is inconsequential to this scussion).

The effects of changing the primary control point to the dam in the other ools would be similar to those described for pool 8. Water levels would enerally be maintained at a higher level. Changing the primary control point n any pool would require the acquisition of additional real estate in the orm of fee title or flowage easements. The extent of required real estate cquisitions has not been quantified.

SUMMER GROWING SEASON DRAWDOWNS

Hydrology/Hydraulics

Pool drawdowns could be implemented for any of the pools in the St. Paul District. The basic hydrologic/hydraulic effects discussed for pool 8 can be expected to occur in most of the other pools as well, although each pool would have its own unique characteristics such as the location of the water surface slope breakpoint within the pool and the rate at which the drawdown would be attenuated proceeding upriver within the pool.

Pool 4 would present a unique situation with Lake Pepin located within the pool. Due to the length of Lake Pepin, drawdowns at Lock and Dam 4 would probably be greatly attenuated in upper pool 4. Drawdowns at Locks and Dams 2 and 3 would have some effects on the Minnesota River and St. Croix River, respectively.

Water Quality

The effects on water quality in most pools would be expected to be similar in nature to those described earlier for drawdowns in pool 8. Any proposed drawdown of the pools in the Twin Cities metropolitan area would have to take into account the pollutant loading from the storm sewers and the metropolitan waste treatment facility.

Effects on the thermal discharge from the Prairie Island Nuclear Generating Plant would have to be considered in planning drawdown of pool 3.

Ecological

The ecological effects of pool drawdown in any pool would be similar to those described earlier in this report for pool 8. The primary difference between pools would be the number of acres potentially affected; i.e., a greater amount of habitat would likely be benefited in those pools with larger areas of non-channel aquatic habitat. Table 7-4 (page 7-3) shows the approximate acres of non-channel aquatic habitat for the St. Paul District navigation pools, other than the USAF pool and pool 1 which have very limited non-channel habitat.

Pool 9 has by far the largest amount of non-channel aquatic habitat and thus would be the pool where drawdown would have the potential to provide the greatest benefits. After pool 8, pools 5, 7, and 10 all have relatively the same potential in terms of acres of non-channel aquatic habitat.

Pool 4 is next in terms of total non-channel aquatic habitat acres. However, this total is for upper and lower pool 4 collectively. It may be difficult to accomplish any appreciable drawdown in upper pool 4 without a significant drawdown of Lake Pepin in lower pool 4. Thus, the potential for achieving benefits in pool 4 with drawdown is probably lower than the acreage total would indicate.

Pools 2 and 3 have approximately 7,000 acres of non-channel aquatic habitat and pool 5A has about 5,000 acres. Pool 6 has the lowest amount of non-channel aquatic habitat that could potentially be benefited by drawdown. Much of the non-channel portion of pool 6 is managed independently as part of the Trempealeau National Wildlife Refuge. A drawdown in pool 6 could provide additional management flexibility in the Trempealeau National Wildlife Refuge, allowing additional drawdown of the pools beyond what is currently possible. This would increase the potential area benefited by a pool 6 drawdown by approximately 5,000 acres.

Operations

The amount of additional effort required of water control and lock and dam personnel would be similar regardless of the pool(s) selected for drawdown.

Channel Maintenance

A review was conducted on the navigation pools in the St. Paul District (other than pool 8) to evaluate the potential effects of drawdown on channel maintenance requirements. The Upper St. Anthony Falls pool and pool 1 were not included as it is very unlikely that a drawdown in these pools would be considered because they contain little non-channel aquatic habitat.

The review focused on the potential for maintaining a 9-foot navigation channel with additional dredging for 1-foot and 3-foot drawdowns at the dams. This review was qualitative in nature and was based on historic dredging requirements. The hydraulic modeling results for pool 8 for the 1-foot and 3-foot drawdown alternatives were used as indicators of potential water surface levels in other pools under drawdown conditions. It is not possible to quantify additional dredging requirements associated with either drawdown alternative. This review assumes "normal" flow conditions during the navigation season.

Pool 2

Pool 2 is approximately 32.2 miles long and contains seven active dredge cuts. Four of the seven dredge cuts have a relatively high frequency of maintenance (annual frequencies ranging from 30 to 46 percent). The average annual dredging volume for the pool is about 128,000 cubic yards. Dredging in pool 2 is done both mechanically and hydraulically.

It is expected that, with a 1-foot drawdown, a 9-foot navigation channel could be maintained in pool 2 with additional dredging. The worst maintenance problem in pool 2 is at the St. Paul Barge Terminal dredge cut. However, this cut is in the upper one-third of the pool where the effects of a 1-foot drawdown at the dam would probably be less than one-half foot. Existing placement site capacity in pool 2 should be sufficient to handle the additional dredged material on a one-time or infrequent basis. If 1-foot drawdowns became a regular or normal practice, additional placement site capacity in pool 2 could be required.

It may be possible to maintain a 9-foot navigation channel in pool 2 with a 3-foot drawdown. However, the additional dredged material generated could exceed the capacity of currently designated placement sites. At the St. Paul Barge Terminal dredge cut, existing designated placement sites could probably handle the additional dredged material, but the useful life of the sites would be decreased. Three dredge cuts (Pine Bend, Boulanger Bend, and Boulanger Bend Lower Light) are located in the lower one-third of the pool where the effects of a 3-foot drawdown would be most pronounced. Dredging these cuts to provide for a 3-foot drawdown could require substantial additional dredging that would shorten the life expectancy of existing placement sites, requiring more frequent transfers to permanent placement sites.

Pool 3

Pool 3 is approximately 18.8 miles long and contains eight active dredge cuts. Six of the eight dredge cuts have annual dredging frequencies greater than 25 percent, with three of the six having annual dredging frequencies greater than 40 percent. The average annual dredging volume for the pool is about 31,000 cubic yards. Channel maintenance in pool 3 can be characterized as chronic; i.e., required relatively frequently although the dredging quantities are not particularly large. Dredging in pool 3 is done both mechanically and hydraulically.

It is expected that, with a 1-foot drawdown, a 9-foot navigation channel could be maintained in pool 3 with additional dredging. Existing placement capacity is probably sufficient to handle the additional dredged material one-time or infrequent basis. If 1-foot drawdowns became a regular or al practice, additional placement site capacity in pool 3 could be ired. Pool 3 is already a problem area in terms of finding acceptable ement sites, and this would aggravate the problem.

Some of the channel maintenance problem areas in pool 3 are located in Lower one-third of the pool, while the others are located in the middle third. It is unlikely that additional dredging could maintain a 9-foot gation channel in pool 3 with a 3-foot drawdown because of the locations hese cuts within the pool.

Upper Pool 4

Upper pool 4 from the head of Lake Pepin to Lock and Dam 3 is ximately 12 miles long. This area contains five active dredge cuts, none ich would be considered high frequency cuts or problem areas. The ge annual dredging volume for this reach is approximately 19,000 cubic . Dredging in upper pool 4 is done both mechanically and hydraulically.

It is expected that, with a 1-foot drawdown, a 9-foot navigation channel be maintained in upper pool 4 with little additional dredging. A 1-foot own at Lock and Dam 4 probably would have less than a one-half foot t in upper pool 4. Existing placement site capacity is probably cient to handle any additional dredged material.

With a 3-foot drawdown at Lock and Dam 4, it should be possible to ain a 9-foot navigation channel in upper pool 4 with additional dredging. , because of the distance from the lock and dam, the drawdown in upper 4 probably would be 1 foot or less. Because upper pool 4 is not a em area from a channel maintenance perspective, the additional dredging may be required should be manageable.

Lower Pool 4

Lower pool 4 from the foot of Lake Pepin to Lock and Dam 4 is ximately 11 miles long. This area contains five active dredge cuts, all ich have a relatively high frequency of maintenance (annual frequencies ng from 27 to 73 percent). The average annual dredging volume for this is approximately 164,000 cubic yards. Lower pool 4 constitutes the st channel maintenance problem area in the St. Paul District. Dredging wer pool 4 is done both mechanically and hydraulically. However, the ty of the dredging is done hydraulically, with the material placed in riverine containment sites. When these riverine containment sites reach capacity, the material is generally transferred to a permanent site.

It may be possible to maintain a 9-foot navigation channel in lower pool 4 with a 1-foot drawdown. This could require substantial additional dredging that would shorten the life expectancy of existing placement sites, requiring more frequent transfers to permanent placement sites.

Maintaining a 9-foot navigation channel in lower pool 4 with a 3-foot drawdown is not considered feasible because of the amount of additional dredging that would likely be required.

Pool 5

Pool 5 is approximately 14.4 miles long and contains seven active dredge cuts. Six of the seven dredge cuts would be considered high frequency dredge cuts (annual frequencies ranging from 23 to 69 percent). The average annual dredging volume for pool 5 is about 90,000 cubic yards. After lower pool 4, pool 5 is the next largest channel maintenance problem area in the St. Paul District. Dredging in pool 5 is done both mechanically and hydraulically. However, the majority of the dredging is done hydraulically with the material placed in riverine containment sites.

It may be possible to maintain a 9-foot navigation channel in pool 5 with a 1-foot drawdown. This could likely require a substantial amount of additional dredging that would shorten the life expectancy of existing placement sites, requiring more frequent transfers to permanent placement sites.

Maintaining a 9-foot navigation channel in pool 5 with a 3-foot drawdown is not considered feasible because of the amount of additional dredging that would likely be required.

Pool 5A

Pool 5A is approximately 9.8 miles long and contains four active dredge cuts. Three of the four dredge cuts would be considered high frequency dredge cuts (annual frequencies ranging from 31 to 77 percent). The average annual dredging volume for pool 5 is about 47,000 cubic yards. Dredging in pool 5A is done both mechanically and hydraulically.

It may be possible to maintain a 9-foot navigation channel in pool 5A with a 1-foot drawdown. This could likely require a substantial amount of additional dredging that would shorten the life expectancy of existing placement sites.

Maintaining a 9-foot navigation channel in pool 5A with a 3-foot drawdown is not considered feasible because of the amount of additional dredging that would likely be required.

Pool 6

Pool 6 is approximately 14.2 miles long and contains four active dredge cuts. Only one of the four dredge cuts would be considered a relatively high frequency dredge cut with an annual frequency of 23 percent. The average annual dredging volume for pool 6 is about 15,000 cubic yards. In relative terms, pool 6 would be considered the pool with the least channel maintenance problems in the St. Paul District. Dredging in pool 6 is done both mechanically and hydraulically. However, the majority of the dredging is done mechanically.

It should be possible to maintain a 9-foot navigation channel in pool 6 with a 1-foot drawdown. The existing dredge cuts are all located in the middle one-third of the pool where the actual drawdown would be less than 1 foot. The amount of additional dredging required may not be significant, and would not be expected to shorten the life expectancy of existing placement sites because, for the most part, they are beneficial use removal sites.

Maintaining a 9-foot navigation channel in pool 6 with a 3-foot drawdown may be possible, although the amount of additional dredging required could be substantial. Even though most placement sites are beneficial use removal sites, their capacity in the short term could be taxed.

Pool 7

Pool 7 is approximately 11.6 miles long and contains seven active dredge cuts. Four of the seven dredge cuts would be considered high frequency dredge cuts (annual frequencies ranging from 23 to 58 percent). The average annual dredging volume for pool 7 is about 53,000 cubic yards. Dredging in pool 7 is done both mechanically and hydraulically.

It may be possible to maintain a 9-foot navigation channel in pool 7 with a 1-foot drawdown. However, this could require a substantial amount of additional dredging because most of the channel maintenance problem areas in pool 7 are in the lower one-half of the pool where there would be little attenuation of the drawdown. Any additional dredging would shorten the life expectancy of existing placement sites.

Maintaining a 9-foot navigation channel in pool 7 with a 3-foot drawdown is not considered feasible because of the amount of additional dredging that would likely be required.

Pool 9

Pool 9 is approximately 31.3 miles long and contains six active dredge cuts. Only two of the six dredge cuts would be considered high frequency dredge cuts (both with an annual frequency of 58 percent). The average annual dredging volume for pool 9 is about 54,000 cubic yards. Dredging in pool 9 is done both mechanically and hydraulically. Pool 9 is similar to pool 8 in that most channel maintenance problems are located in one reach in the middle one-third of the pool. The problem area in pool 9 is a 2-mile reach extending upstream from Lansing, Iowa.

It should be possible to maintain a 9-foot navigation channel in pool 9 with a 1-foot drawdown with minor additional dredging in the Lansing area. It is expected that a 1-foot drawdown at Lock and Dam 9 would result in a drawdown of 0.6 to 0.8 foot at Lansing. The drawdown in the upper reaches of the pool where the other active dredge cuts are located would likely be less than 0.5 foot.

Maintaining a 9-foot navigation channel in pool 9 with a 3-foot drawdown may be possible with additional dredging in the Lansing area that could be substantial. Additional minor dredging could also be required at the upper dredge cuts. Most permanent placement sites in pool 9 are beneficial use removal sites. A substantial amount of dredging at any one time could tax their capacity.

Pool 10

Pool 10 is approximately 32.7 miles long and contains five active dredge cuts. Only the McMillan Island dredge cut in lower pool 10 would be considered a relatively high frequency cut (annual frequency of 39 percent). The average annual dredging volume for pool 10 is about 34,000 cubic yards. Dredging in pool 10 is done both mechanically and hydraulically.

It may be possible to maintain a 9-foot navigation channel in pool 10 with a 1-foot drawdown with additional dredging in the McMillan Island area. Because the McMillan Island dredge cut is located only 3 to 4 miles above Lock and Dam 10, a 1-foot drawdown at the dam would likely result in a 1-foot drawdown in this area. The remaining dredge cuts in pool 10 are in the middle to upper reaches of the pool where the actual amount of drawdown would likely be 0.5 foot or less.

Maintaining a 9-foot navigation channel in pool 10 with a 3-foot drawdown would be questionable. Because the McMillan Island area is so close to the dam, a significant amount of dredging would likely be required in this location to maintain adequate water depths. The upper cuts in the pool could also require additional dredging to maintain the channel under a 3-foot drawdown.

Summary

Table 7-5 summarizes the results of the qualitative assessment of the potential for maintaining a 9-foot navigation channel under 1-foot and 3-foot drawdown scenarios. Pool 8 is included for comparison purposes. Further study would be required to determine what level of drawdown may be feasible in each pool while still maintaining navigation with additional dredging. It is expected that the break point in most pools would fall somewhere between a 1-foot and a 3-foot drawdown.

Table 7-5

Summary of Potential for Maintaining a 9-Foot Navigation Channel with Additional Dredging

Pool	1-Foot Drawdown	3-Foot Drawdown
2	Possibly	Possibly
3	Possibly	Unlikely
Upper 4	Likely	Possibly
Lower 4	Possibly	Unlikely
5	Possibly	Unlikely
5A	Possibly	Unlikely
6	Likely	Possibly
7	Possibly	Unlikely
8	Likely	Possibly
9	Likely	Possibly
10	Possibly	Unlikely

Likely = likely that the channel could be maintained with minimal additional dredging

Possibly = the channel could be maintained but the additional dredging required could be substantial

Unlikely = unlikely that the channel could be maintained because additional dredging requirements would probably be significant ercial Navigation

The potential effects to commercial navigation from drawdowns in other s would be of a magnitude similar to those discussed for pool 8. The most rtant factor is that, if navigation is closed in any one pool, the tional effects of closing other pools would be relatively small. Since barge traffic goes through the entire district, a disruption in one k" automatically disrupts all the "links" in the system. Therefore, if pool is drawn down enough to halt commercial navigation, it would make e to draw down as many pools as possible to gain substantial additional fits for relatively little additional cost. (The effects to other ificant resources would need to be taken into account separately.)

sportation Infrastructure

Bridges

USAF pool and pool 1 have eight and seven bridge crossings, respectively, ributed throughout the pools. Any proposal for a significant drawdown of e pools would have to evaluate the potential effects on these structures. largest concern would be whether the changed conditions would induce scour nd bridge piers and abutments. Pool 2 has 10 bridge crossings, all ted in the upper one-half of the pool where the effects of any drawdown d be less significant. Pool 3 has two bridge crossings in the very upper of the pool where the actual amount of drawdown would be relatively small.

Upper pool 4 has one bridge at Red Wing. The effects of any drawdown at and Dam 4 would be minor at this location. There is a highway bridge at sha, Minnesota, located about 8 miles above Lock and Dam 4. A significant down at Lock and Dam 4 such as going to open river conditions would ire an evaluation of the potential effects on this bridge.

There are no bridges crossing pools 5, 5A, and 7. There are three bridge sings in pool 6, all located in the upper one-third of the pool. Thus, effects of any drawdown probably would not warrant any concerns with these ges. There are single bridges crossing pools 9 and 10, both at or above mid-point of the pool. Even with open river conditions, it is unlikely the drawdowns in these locations would be significant enough to cause any ern with these bridges.

Railroad Embankments

The only railroad embankment separating a large body of water from the Mississippi River is in pool 6 where the Trempealeau National Wildlife Refuge is separated from the Mississippi River by a railroad embankment over a distance of approximately 6 miles. If pool 6 were drawn down, the Trempealeau National Wildlife Refuge pools may have to be drawn down at the same time to eliminate lateral forces on this railroad embankment.

Water Appropriation

Information on uses of the river for water supply has not been developed for the other St. Paul District navigation pools. The only readily identifiable major users of the Mississippi River for water supply are the electric generating stations located in the USAF pool (Riverside), pool 2 (Black Dog (MN R) and High Bridge), pool 3 (King Plant (St.Croix R) and Prairie Island), pool 4 (Red Wing), pool 5 (Alma), and pool 9 (Genoa and Lansing). As these facilities are designed to be operable under the lowest flow conditions, it is likely that their intakes are set low enough that they would not be adversely affected by drawdowns of the nature being evaluated by this study. Depending on the power plant cooling systems and the permitted thermal discharges, pool drawdowns could affect thermal loading to the river and compliance with discharge permits.

Real Estate

Implementation of drawdowns in the other navigation pools would be expected to have effects similar to those discussed for pool 8. The potential for claims of adverse impact on property values or other real estate values would be greatest in the Twin Cities area simply because of higher levels of development present in those pools.

Recreation

Recreational boating on the Mississippi River is a popular activity throughout the St. Paul District. The 1993 Economic Impacts of Recreation on the UMRS study estimated there were 3.4 million daily visits by boaters to the St. Paul District during the study year. These visits accounted for 1.3 million boats during the year. Boaters can access the river from boat ramps, marinas, and private docks. Approximately 75 percent of the boat trips originated from boat ramps, 20 percent from marinas, and the remainder from private docks.

In 1995, over 120,000 recreational boats were counted passing through the
; in the St. Paul District. The total number of boaters using the locks
ıtimated to be below 5 percent; this figure is imprecise since there is
ed information about how many locks boaters typically use.

Boating patterns along the main channel have been observed through aerial
graphy since 1989 by the Minnesota-Wisconsin Boundary Area Commission
C). The 1995 Recreational Boating Study has documented that use patterns
remained fairly steady through that period. Upper and lower pools 4,
3, and pool 10 are the most heavily used. The distribution of boaters
pools for 1995, based on MWBAC data is shown in table 7-6.

Table 7-6
Distribution of Boaters Among St. Paul District Pools in 1995

Pool	Percent
U/LSAF	2.2
1	0.4
2	6.2
3*	6.0
4	16.8
5	5.7
5A	5.2
6	6.2
7	5.7
8	17.1
9	9.5
10	19.0
total	100.0

ding the St. Croix River

analysis of drawdown alternatives for pool 8 indicates that drawdown
ikely to affect boat ramps and marinas in the lower portion of the
least likely to affect boat ramps and marinas in the upper portion of
The relative location of boat ramps for the St. Paul District
n pools is shown in tables 7-7 and 7-8. Pool 8 is included for
n purposes.

Table 7-7
Location of Boat Ramps (Number)

Pool	Total Boat Ramps	Lower 1/3 of Pool	Middle 1/3 of Pool	Upper 1/3 of Pool
USAF	3	3	0	0
1	0	0	0	0
2	8	2	2	4
3	8	2	2	4
4	28	10	11	7
5	11	3	5	3
5A	7	3	1	3
6	8	2	1	5
7	15	8	2	5
8	28	4	6	18
9	17	3	5	9
10	31	8	11	12
total	164	48	46	70

Data source: Wisconsin Department of Natural Resources, 1994; Minnesota Department of Natural Resources, 1994a and 1994b

Table 7-8
Location of Boat Ramps (Percent)

Pool	Total Boat Ramps	Lower 1/3 of Pool	Middle 1/3 of Pool	Upper 1/3 of Pool
USAF	3	100	0	0
1	0	0	0	0
2	8	25	25	50
3	8	25	25	50
4	28	36	39	25
5	11	27	46	27
5A	7	43	14	43
6	8	25	13	62
7	15	54	13	33
8	28	14	21	65
9	17	18	29	53
10	31	26	35	39
total	164	29	28	43

The potential for drawdown to have an adverse impact on boat ramps in any particular pool should be related to their distribution within the pool. On the basis of the information in table 7-8, it appears that the pool where drawdown would likely have the greatest impact on boat ramps (discounting the USAF pool) is pool 7, where over 50 percent of the ramps are located in the lower one-third of the pool. Pools 4 and 5A are the next two pools with the greatest potential for impact. The pool where the potential for adverse impact is probably the lowest is pool 9.

This comparative evaluation applies only to the availability of serviceable boat ramps in a particular pool. The economic effects on privately owned facilities are not considered.

Tables 7-9 and 7-10 show the location of marina slips within the various St. Paul District navigation pools. Marina slips are considered a better indicator of potential impact on marina users than are the number of marinas, because the number of slips per marina can vary greatly. Based solely on percent of slips in the lower one-third of the pool, it appears that the greatest potential for adverse impact would be in pool 7. However, because of a much larger number of slips, pools 4 and 10 appear to have the greatest potential for adverse impacts on marina users from a drawdown. There is no potential impact in pool 1 and the USAF pool, while the potential for adverse effect would appear to be relatively low in pools 3, 5, and 6.

Aesthetics

The potential aesthetic effects of drawdowns in the other pools would likely be similar to those discussed for pool 8. Drawdowns in more developed pools such as those in the Twin Cities area would be expected to have greater aesthetic impact simply because they would be visible to and experienced by larger populations.

Cultural Resources

The potential effects on cultural resources of drawdowns in the other pools would likely be similar to those discussed for pool 8.

Implementation Procedure

The implementation requirements for a drawdown in any of the navigation pools would be the same as those discussed for pool 8.

Table 7-9
Location of Marina Slips (Number)

Pool	Total Marina Slips	Lower 1/3 of Pool	Middle 1/3 of Pool	Upper 1/3 of Pool
USAF	0	0	0	0
1	0	0	0	0
2	697	0	423	274
3	621	0	0	621
4	2,046	443	815	788
5	12	0	0	12
5A	114	0	70	44
6	57	0	0	57
7	89	80	5	4
8	1,139	30	70	1,039
9	223	20	185	18
10	853	435	180	238
total	5,851	1,008	1,748	3,095

Data source: U.S. Army Corps of Engineers, 1989

Table 7-10
Location of Marina Slips (Percent)

Pool	Total Marina Slips	Lower 1/3 of Pool	Middle 1/3 of Pool	Upper 1/3 of Pool
USAF	0	0	0	0
1	0	0	0	0
2	697	0	61	39
3	621	0	0	100
4	2,046	22	40	38
5	12	0	0	100
5A	114	0	61	39
6	57	0	0	100
7	89	90	5	5
8	1,139	3	7	90
9	223	9	82	9
10	853	51	21	28
total	5,851	17	30	53

SECTION 8 - CONCLUSIONS

A number of water level management alternatives were evaluated in this study, ranging from site-specific isolation and management of small backwaters to pool-wide drawdowns. The alternatives can be classified as three basic types based upon the scope of potential effects. They are:

1) alternatives that would have site-specific effects

   a) isolation and management of small waterbodies
   b) isolation and management of large waterbodies
   c) modifying the distribution of flow across the dam gates

2) alternatives that would have minor pool-wide effects

   a) discontinue 0.25-foot winter drawdown
   b) regulate on the "high" or "low" side of the regulation band
   c) increase the frequency of gate adjustments

3) alternatives that could have significant pool-wide effects

   a) winter drawdowns
   b) spring pool raises
   c) change pool control point
   d) summer growing season drawdowns

ALTERNATIVES WITH LOCALIZED SITE-SPECIFIC EFFECTS

ISOLATION AND MANAGEMENT OF SMALL AND LARGE WATERBODIES

Isolating and managing water levels in small or large backwaters will have benefits largely restricted to the areas being managed. Federal and State resource management agencies have the authority to implement these management measures in pool 8, and elsewhere on the river. The decision whether to implement these management measures at any particular site should be based on agency resource management objectives, costs, expected benefits, and secondary effects.

Isolating and managing small and large backwaters will not provide a systemic solution to declining habitat values on the Upper Mississippi River. It is probably not physically and/or financially possible to affect a large enough area in this manner to have a significant effect on systemic or even pool-wide habitat quality. Drawdown of shallow aquatic areas, however, is a proven technique for consolidating sediment and encouraging vegetation growth. Dramatic effects can be achieved in managed waterbodies through controlled drawdowns. This management measure would be more cost-effective to apply with larger areas. Restoring connectivity of managed areas following drawdown would be important in simulating a naturally occurring low water event and allowing free access by fish and exchange of materials. Permanently isolating and managing backwaters could be considered inappropriate from a systemic perspective, because isolating the river from its off-channel areas is contrary to the goal of restoring natural river processes. Many floodplain waterbodies were isolated from the flowing parts of the river except during flood events prior to dam construction, however.

The conclusion arising from this study is that the isolation and management of backwaters, large or small, can be ecologically effective and cost-effective on a site-specific basis. Because most of the backwater areas that can be managed through temporary isolation and drawdown are on U.S. Fish and Wildlife Refuge or private property, implementation of these drawdown efforts should be left to the discretion of the U.S. Fish and Wildlife Service and the State natural resource management agencies. The St. Paul District can assist with small- and mid-scale drawdown projects through partnership arrangements.

MODIFYING THE DISTRIBUTION OF FLOWS ACROSS DAM GATES

Modifying the distribution of flows across the dam gates has the potential for improving habitat conditions in tailwaters at Lock and Dam 8 and at other locks and dams within the St. Paul District. 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.

This management alternative was given low priority during this study, and as such, was evaluated only in a qualitative manner. Based on this evaluation, it is apparent that a decision to implement this action at Lock and Dam 8 (or at any other lock and dam) would be based on operational costs vs. tailwater habitat benefits. Modifying the distribution of flows across the dam gates would not be expected to have any adverse effects on other river resources or uses of those resources by the public.

The conclusion of this study is that the potential benefits of this management measure warrant a more detailed evaluation at one or more lock and dam sites. Because implementation of this measure would be within the current river regulation authority of the St. Paul District and the effects would be site-specific, further evaluation need not be part of a pool-wide or systemic water level management planning effort. Further evaluation of this management measure should proceed on its own track.

ALTERNATIVES - MINOR POOL-WIDE EFFECTS

DISCONTINUE 0.25-FOOT WINTER DRAWDOWN

The St. Paul District implemented this management measure beginning in the winter of 1995-96. This study evaluated this alternative in a qualitative manner. The conclusion of this evaluation is that discontinuing the 0.25-foot winter drawdown probably has an overall beneficial effect for backwater habitats, but it will be difficult to measure and document these benefits. Anecdotal reports on conditions in backwater areas during the first winter without drawdowns were positive. Implementation of this measure has no cost, and no adverse effects on river resources or uses of those resources by the public have been identified. Continued implementation of this measure appears warranted, along with further research on winter aquatic habitat conditions and the effects of winter water levels.

REGULATE ON THE "HIGH" OR "LOW" SIDE OF THE REGULATING BAND

This study evaluated this alternative in a qualitative manner. The conclusion of this evaluation is that regulating on the "high" or "low" side of the regulating band could have beneficial habitat effects, but that it would be difficult to measure and document these benefits. Implementation of this measure may have a cost if it requires more frequent gate adjustments to achieve. No appreciable adverse effects on river resources or uses of those resources by the public have been identified for this management alternative.

The conclusion of this study is that the potential benefits of this management measure warrant additional consideration. This measure is within the authority of the St. Paul District and could be implemented before other, more significant water level management alternatives. Thus, further evaluation of this alternative should proceed on its own track so as not to be delayed unnecessarily by being tied to a larger water level management planning effort.

Widening the regulation band could be evaluated as part of this further study. If this were pursued, review and approval by Corps higher authority would be required.

INCREASE THE FREQUENCY OF GATE ADJUSTMENTS

This study evaluated this alternative in a qualitative manner. It ars that there is potential for environmental benefits, with the only tifiable adverse effect being the potential for increased costs, in the of either additional manpower or gate automation. The ongoing gate mation study for Lock and Dam 7 may answer some of the questions erning potential costs. Therefore, further evaluation of this alternative ld be delayed pending completion of the Lock and Dam 7 study.

ALTERNATIVES - SIGNIFICANT POOL-WIDE OR SYSTEMIC EFFECTS

WINTER DRAWDOWNS

This management alternative was given low priority during this study and, as such, was evaluated only in a qualitative manner. This alternative was evaluated from the perspective of using winter drawdown as an independent management technique. Winter drawdown as part of a long-term drawdown to improve conditions for vegetation growth was evaluated in conjunction with the open water season drawdown alternative.

Winter drawdown could be employed to consolidate backwater sediments or to construct habitat improvement projects "in the dry." This management alternative, depending on its magnitude, has the potential to have significant adverse impacts on fish and furbearers. Winter drawdown would require Congressional action because it currently would not be allowed under the Anti-Drawdown Law.

Given the potential for significant adverse impacts and the requirement for Congressional action, the conclusion of this study is that this management measure does not warrant further study at this time as an independent or "stand-alone" management measure. Over-winter drawdowns logically would be included in multiple-year drawdown plans to allow a number of other habitat management measures to be conducted in conjunction with drawdown. Winter drawdowns should continue to be evaluated in conjunction with summer growing season drawdown alternatives.

SPRING POOL RAISES

This management alternative was given low priority during this study and, as such, was evaluated only in a qualitative manner. Artificially raising pool levels during the spring by more than 2 to 3 feet does not appear to be engineeringly feasible without substantial modifications to Lock and Dam 8 and the two overflow spillways in the dike.

Maintaining or creating higher water conditions in the spring would provide direct benefits to targeted species or groups of fish and wildlife, such as by improving spawning conditions for northern pike. Spring pool raises would not be expected to result in any appreciable changes to vegetation or habitat types in pool 8 or in any other pool.

The conclusion of this study is that, although the benefits of spring pool raises may justify the costs, other alternatives, most notably drawdown, have the potential to provide much greater benefits. Therefore, further evaluation of spring pool raises should be considered a lower priority relative to pursuit of these other alternatives.

CHANGING THE PRIMARY CONTROL POINT FROM MID-POOL TO THE DAM SITE

Changing the primary control point in pool 8 from mid-pool to Lock and Dam 8 would have the basic hydrologic effect of raising pool 8 water levels for regulated flows. In a "typical" growing season, the levels would be increased by 0.3 to 1.0 foot depending on the location within the pool. Changing control point to control at the dam would eliminate the artificial relationship between stage and discharge that presently occurs between the control point and the dam during low to moderate levels of discharge.

One effect of this alternative would be to increase the amount of aquatic habitat in pool 8, possibly by a few thousand acres. This is considered neither a positive nor a negative effect from the perspective of this study. The change in primary control point would reduce some pool level fluctuations in the lower portion of the pool, and may provide some increased management flexibility, although this would be slight since the pool is already controlled at the dam about 70 percent of the time during the open water season.

Although the evaluation was only qualitative, one conclusion of this study is that changing the pool control point in pool 8 is unlikely to provide significant ecological benefits. The net effect would be a slightly more aquatic area at the expense of floodplain terrestrial area, but the basic water level management system affecting the quality of habitat within the pool would remain relatively unchanged. Changing control point to the dam would disrupt the zonation of vegetation in the lower part of the pool. This further disturbance to aquatic and floodplain vegetation would take many years to stabilize.

Changing the pool control point would require the Federal Government to acquire additional real estate rights in pool 8, either fee title or flowage easement. A worst case analysis indicates the costs could be $1 to $2 million, although they are likely to be considerably less. Regardless of the costs or the amount of additional property rights required, this alternative could require Congressional approval.

The conclusion of this study is that, although the benefits of changing the pool control point may justify the costs, other alternatives, most notably summer growing season drawdowns, have the potential to provide much greater benefits. Therefore, changing the pool control point should be considered a lower priority relative to pursuit of these other alternatives.

SUMMER GROWING SEASON DRAWDOWNS

Summer growing season drawdowns have the potential to provide significant ecological benefits. Depending upon the flow conditions and the depth of drawdown, over 70 percent of the aquatic area of pool 8 could be directly affected. Conversely, summer growing season drawdowns have the potential for significant adverse economic effects if commercial navigation is interrupted. The potential benefits and adverse effects of drawdown alternatives have been discussed and quantified in previous sections of this report. The basic conclusions of this study relative to summer growing season drawdowns are as follows:

a. Any pool drawdown that interrupts commercial navigation will require Congressional approval. Drawdowns that maintain commercial navigation may still require Congressional approval.

b. Commercial navigation cannot be maintained in pool 8 with a drawdown to open river conditions.

c. It is highly likely that commercial navigation can be maintained in pool 8 with a 1-foot drawdown with minor additional dredging.

d. Commercial navigation could probably be maintained in pool 8 with a 3-foot drawdown, although substantial additional dredging would be required. It appears that the depth of drawdown in pool 8 that would still allow for the maintenance of commercial navigation with a reasonable amount of additional dredging is somewhere between 1 and 3 feet.

e. The ecological benefits in the form of sediment consolidation and vegetation response will increase with the duration of the drawdown.

f. A full growing season (approximately June 15 to September 30) should be the minimum duration drawdown that should be considered.

g. One growing season drawdowns would provide benefits in the fall, winter, and following spring associated with flooded annual plants. A one-time, single growing season drawdown would provide limited benefits, compared to multiple growing season drawdowns. Some consolidation of sediment and improvement of conditions for submersed aquatic vegetation can be expected from a single growing season drawdown.

h. Two successive growing season drawdowns (the first to the greatest drawdown depth practicably attainable, the second to 1.5 feet or less) would be needed to gain the benefits associated with reestablishment of perennial emergent aquatic plants. To be effective, drawdowns would need to be implemented on a periodic basis to restore perennial emergent aquatic vegetation and to consolidate sediment.

i. The effects of drawdowns on other resources and resource users in pool 8 appear to be manageable with drawdowns of 3 feet or less. With drawdowns of 3 feet or less, individual resource users or enterprises may be adversely affected, but collectively, the potential effects do not appear to be significant. Facilities with water intakes and permitted discharges would not be affected. Some restrictions to use of marinas, private boat docks, boat launching ramps, and navigable areas would affect recreational boating activity and associated businesses. The benefits of substantially increased acreage of emergent aquatic vegetation and consolidated sediments to fish, wildlife, and aesthetic appearance of the pool could be considerable, benefiting a wide spectrum of resource users following pool drawdown.

One stated purpose of this study was to identify water level management alternatives that may be implementable. The purpose of this study was not to determine if an alternative should be implemented. From a practical standpoint, the following basic criteria would apply in making a determination on whether a drawdown alternative may be implementable and thus warrant further consideration.

- commercial navigation should be maintained

- the foreseeable ecological benefits should exceed or be commensurate with the foreseeable costs

- there should not be significant adverse effects to other resources or resource users

Based on the evaluation conducted as part of this study, there are drawdown alternatives that appear to meet all of these criteria and, thus, warrant further consideration.

SUMMARY

This study evaluated 10 basic water level management alternatives and variations thereof. All the alternatives have the potential to provide ecological benefits to the Upper Mississippi River, though most would require further study to determine if the potential benefits justify the potential costs and/or negative effects. However, of all the alternatives evaluated, only one appears to have the potential to provide significant ecological benefits. That is the alternative of summer growing season drawdowns. This study identified that limited drawdowns in pool 8 (and possibly in other pools) should be feasible without interruption of commercial navigation. This is a significant point, as navigation is the authorized purpose of the 9-Foot Navigation Channel Project, and interruption of navigation for other purposes would require Congressional approval. This study also identified that for pool 8, at least, limited drawdowns could probably be implemented without significant adverse effects to other resources or to the public's ability to use those resources.

As indicated earlier, one purpose of this study was to identify water level management alternatives that may be feasible to implement, not to determine if any alternative(s) should be implemented. However, a logical outcome of this study will be the question: "What is the next step?" Two alternative approaches have been developed for further consideration by the Corps of Engineers, river resource management agencies, and the public. For purposes of this discussion, they have been labeled the "Traditional" and "Empirical" approaches. A number of variations or combinations of these two approaches could undoubtedly be developed. However, the intent here is to provide a framework for future discussions concerning water level management on the Upper Mississippi River.

TRADITIONAL APPROACH

Under this approach, the St. Paul District would request funds to conduct a feasibility study for alternative water level management for the 9-Foot Navigation Channel project. All the pools within the District would be studied, though scoping could eliminate certain pools from consideration for certain alternatives; e.g., drawdowns in pool 1 or the USAF pool. The result would be a recommended water level management plan for all the navigation pools in the St. Paul District.

The advantage of this approach is that it would provide a systemic evaluation of the entire navigation system within the St. Paul District and would include a comprehensive evaluation of all water level management alternatives.

The primary disadvantages of this approach are time and money. A study of this type would have a significant cost. A St. Paul District study comparable in scope was the GREAT I study which cost approximately $1.7 million in 1970's dollars. In 1996 dollars, this would be $3.5 to $4.0 million. A feasibility study of this scope would probably take a minimum of 3 to 4 years, and perhaps more, to accomplish, especially if study funds were not readily available.

EMPIRICAL APPROACH

Under the empirical approach, the St. Paul District would seek permission to institute a summer growing season drawdown in one pool; in effect, to conduct a large pilot study. The drawdown would have to be limited to a depth at which the 9-foot channel can still be maintained with a practicable amount of additional dredging. The drawdown would need to be monitored extensively to determine the ecological response. Based on the monitoring results, this practice could then be further pursued, both geographically and in frequency.

The advantage of the empirical approach is that the money spent on a feasibility study could be applied to the monitoring of an actual pool-wide drawdown. Decisions concerning future use of this water level management measure could then be based on practical experience and empirical data. Another advantage is that implementation of this management measure, at least on a single pool basis, may occur at an earlier date than under the "Traditional" approach.

The disadvantage of this approach is that it focuses on a single management measure being implemented over a limited geographical area. The holistic or systemic perspective of water level management of the Upper Mississippi River could be lost, or at least given only secondary consideration by management agencies. In addition, other water level management alternatives which could provide net benefits may not be pursued in a timely manner.

PUBLIC INVOLVEMENT

Regardless of the direction in which future water level management may be pursued, a prerequisite will be extensive coordination with and involvement by the public in the decision making process. Changes in water level management on the Upper Mississippi River has the potential to affect a broad spectrum of river users, and implementation of any modification to existing practices will require the support of all interests.

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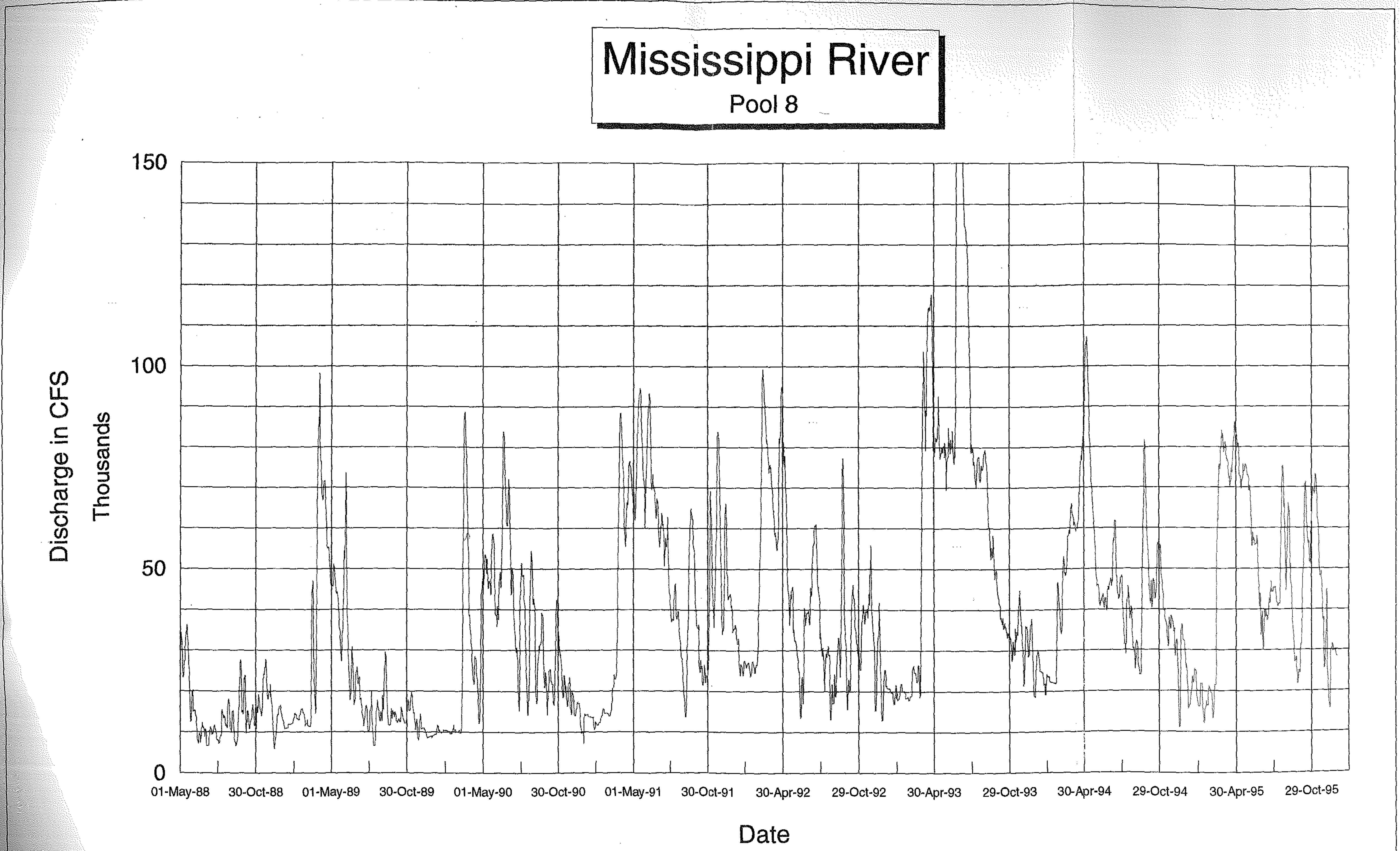
PARTICIPANTS

This study was conducted under the auspices of the Water Level Management Task Force of the River Resources Forum. The River Resources Forum was established to serve as an advisory body to the St. Paul District, Corps of Engineers for implementation of GREAT study recommendations and to coordinate river related issues. The Water Level Management Task Force is a technical advisory group established by the River Resources Forum. The Water Level Management Task Force consists of technical representatives from Forum member agencies and also includes representatives of river user groups such as the navigation industry and recreational interests.

This study was funded and managed by the St. Paul District, Corps of Engineers. The Water Level Management Task Force provided direction during study scoping and served in a review capacity during various stages of report preparation. Task Force members assisted in the study by collecting and/or providing data and other information necessary for the study. Those providing this assistance included the Upper Mississippi River National Wildlife and Fish Refuge, the Environmental Management Technical Center, and the Wisconsin and Minnesota Departments of Natural Resources.

The participants in the study from the St. Paul District included Gary Palesh, study management; Dan Wilcox, water quality and ecology; Scott Jutila, hydrology and hydraulics; Bruce Carlson, economics and recreation; Terry Birkenstock, GIS analyses; Dan Krumholz, channel maintenance; and John Anfinson, cultural resources. Other St. Paul District personnel provided assistance in consultive and/or review capacities.

PLATES


Mississippi River
Pool 8
150
100
50
0
Discharge in CFS
Thousands
01-May-88
30-Oct-88
01-May-89
30-Oct-89
01-May-90
30-Oct-90
01-May-91
30-Oct-91
30-Apr-92
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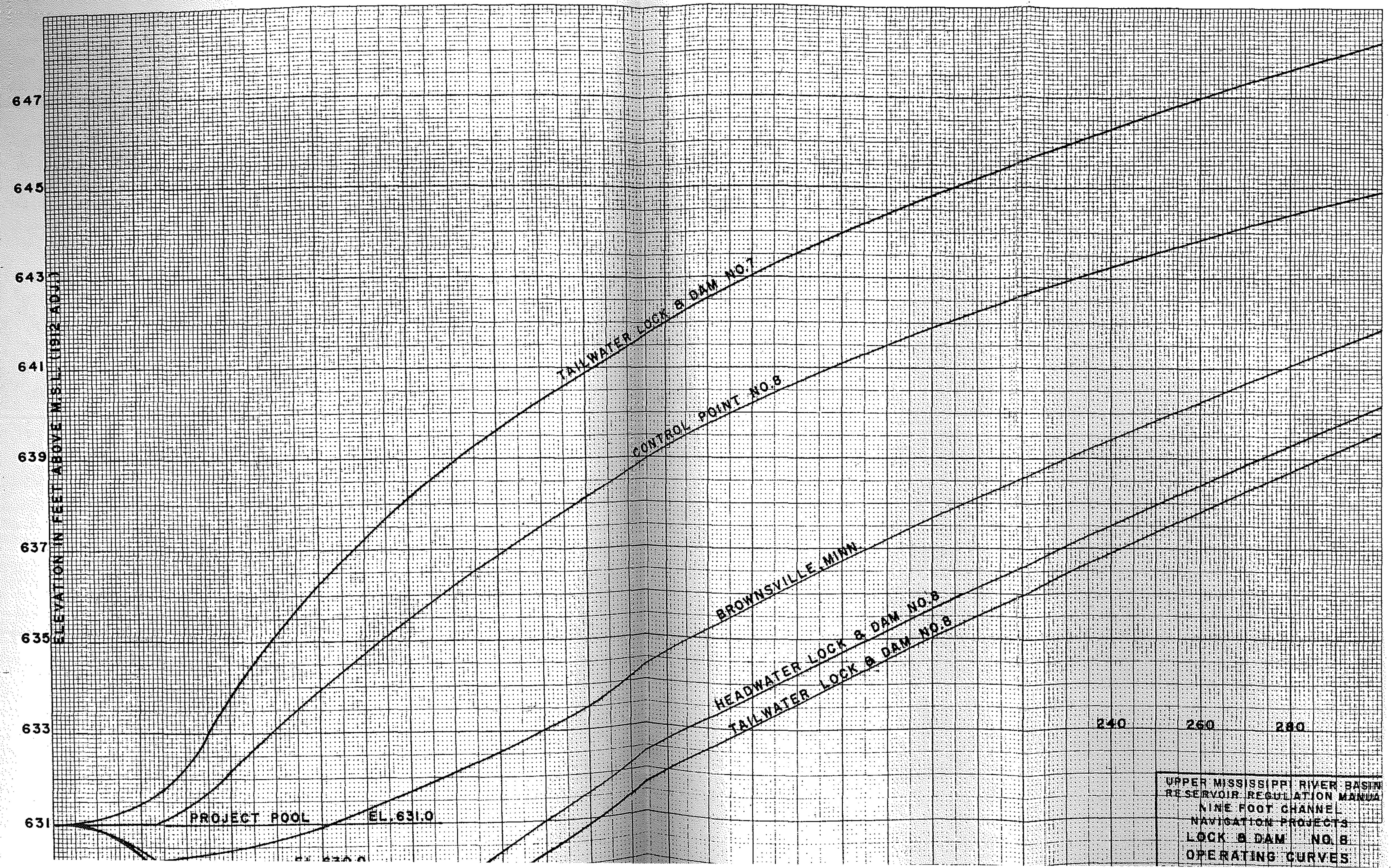
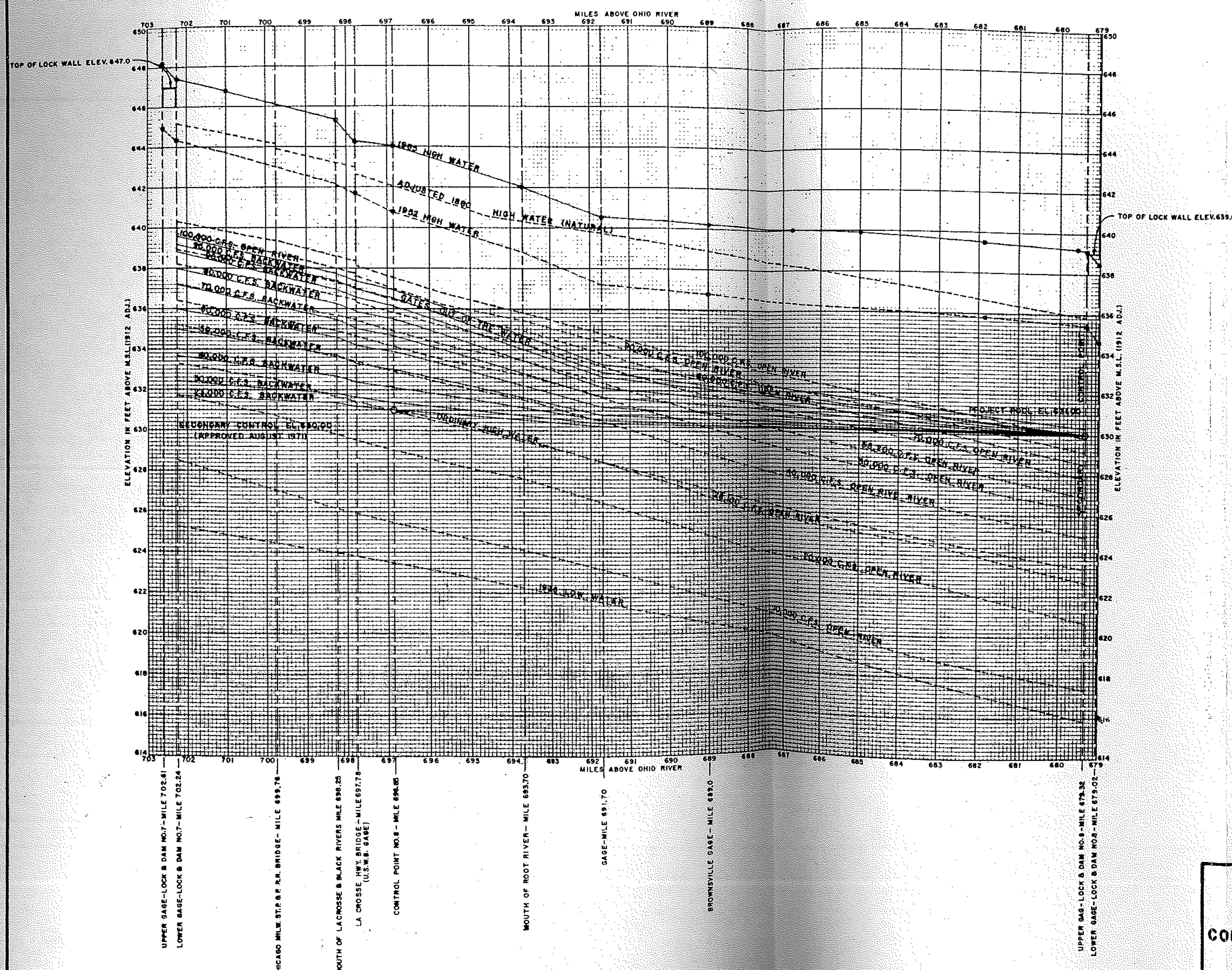
29-Oct-95
Date

PLATE 1



ELEVATION IN FEET ABOVE M.S.L. (1912 ADJ.)
647
645
643
641
639
637
635
633
631
TAILWATER LOCK & DAM NO.7
CONTROL POINT NO.8
BROWNSVILLE, MINN.
HEADWATER LOCK & DAM NO.8
TAILWATER LOCK & DAM NO.8
PROJECT POOL EL. 631.0
240
260
280
UPPER MISSISSIPPI RIVER BASIN
RESERVOIR REGULATION MANUAL
NINE FOOT CHANNEL
NAVIGATION PROJECTS
LOCK & DAM NO. 8
OPERATING CURVES



NOTE:

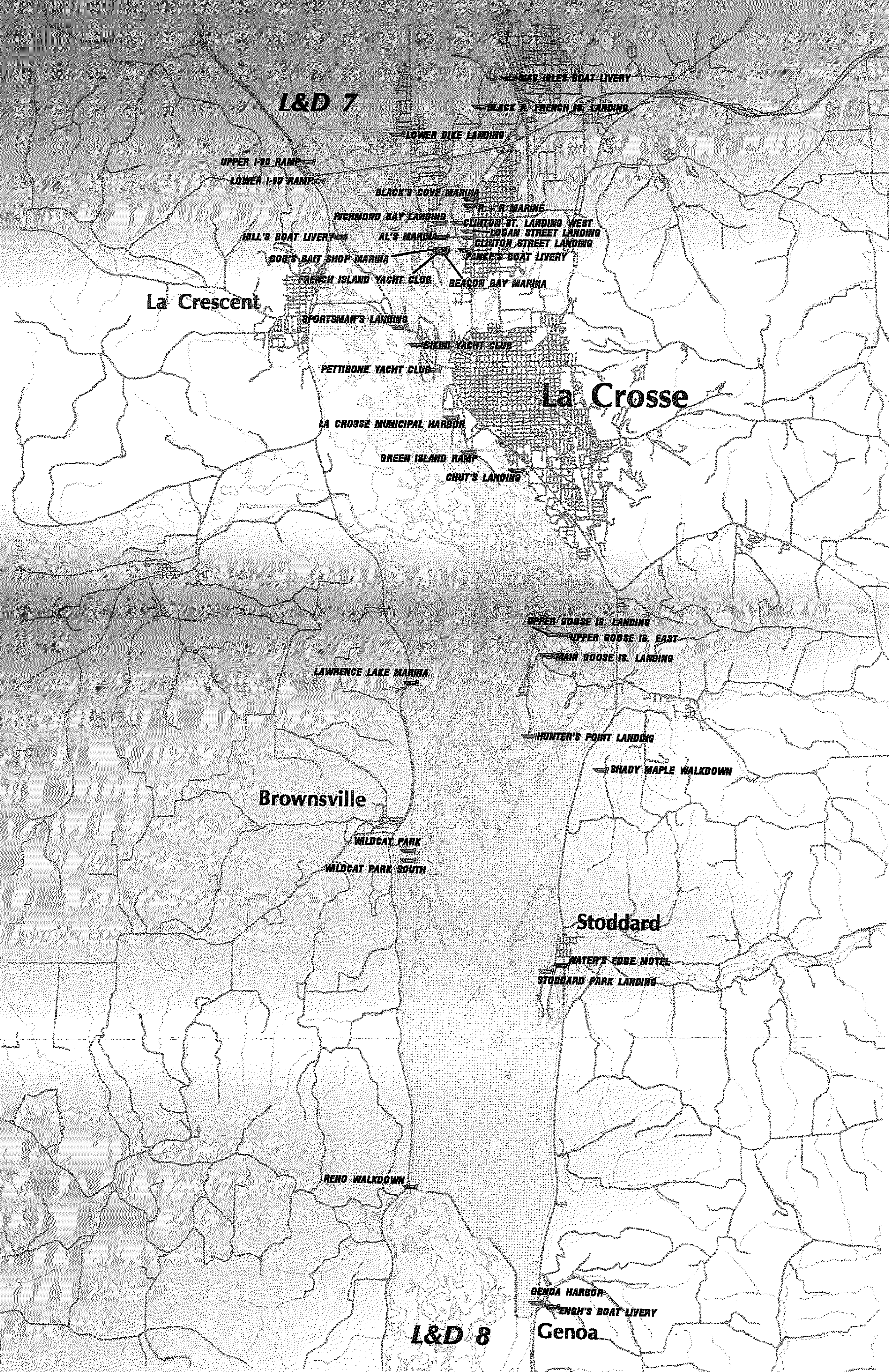
THE COMPUTED BACKWATER CURVES ARE BASED ON 1970 DATA, AND THE OPEN WATER PROFILES ARE DERIVED FROM PRE-CANALIZATION RECORDS.

LEGEND

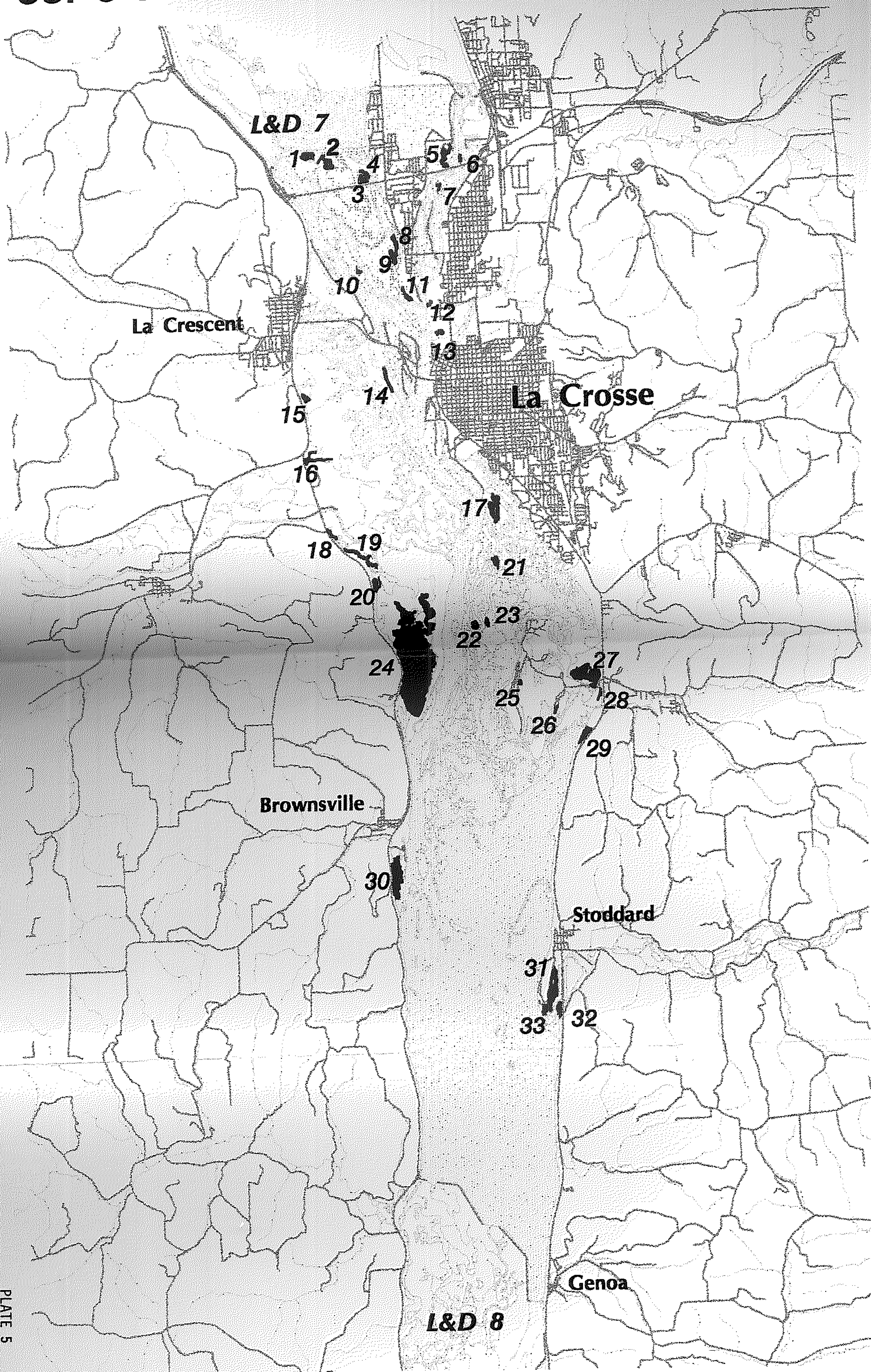
● HIGH WATER READING

UPPER MISSISSIPPI RIVER BASIN
RESERVOIR REGULATION MANUAL
NAVIGATION PROJECTS
LOCK & DAM NO. 8
COMPUTED BACKWATER CURVES
AND
OPEN WATER PROFILES
CORPS OF ENGINEERS, U.S. ARMY
ST. PAUL ENGINEERING DISTRICT

Pool 8 Boat Access Points



Pool 8 Potential Drawdown Sites (May 1996)



APPENDIX A

BIOLOGICAL BENEFITS OF WATER LEVEL MANAGEMENT
WATER LEVEL MANAGEMENT TASK FORCE
RIVER RESOURCES FORUM

Biological Benefits of Water Level Management
Water Level Management Task Force
River Resources Forum, 1/17/96

Overview

The natural processes (flows, water levels) of the Mississippi River have been altered for more than a century through the construction of wing dams, side channel closures, and locks and dams. These actions have turned the Mississippi into a series of lakes rather than a free-flowing river. Biologists believe there is sufficient evidence to suggest these physical changes are threatening the ecological health of the river.

In an effort to investigate restoring some riverine processes, the River Resources Forum established a task force to evaluate water level management options. The purpose of this document is to describe the potential biological benefits associated with these options.

The Naturally Flowing Upper Mississippi River (pre-1800's)

To describe biological benefits from water level management, ne must first recognize natural riverine processes. Recent ctivities such as the Large Rivers Conference (La Crosse, WI 994), articles in Bioscience magazine (March 1995), and cosystem planning efforts by a number of agencies have mphasized the importance of natural river processes to the long-erm health of large floodplain rivers.

Prior to European settlement, water levels on the ississippi River often fluctuated on an annual basis with a pring flood pulse followed by low summer flows, and relatively table winter flows. During low flow periods, the distribution nd abundance of vegetation expanded as bottom substrates dried, onsolidated, and stimulated seed germination. Newly vegetated areas would then flood during wet cycles and provide tremendous habitat for the many plant, insect, and animal species dependant upon this flood pulse cycle.

During this same period, flows were not constricted and the river channel migrated freely throughout it's floodplain. Over time this migration caused tremendous variability in depths by scouring some areas and filling others, especially during large flood events. Islands, backwater lakes, and side channels were continually created or lost over long periods of time. These conditions combined with natural water level fluctuation allowed for tremendous biological diversity and sustainability of the Mississippi River ecosystem.

River Flows Today

The natural processes of the river have been changed as a result of the construction of wing dams, closing structures, and locks and dams. The river is now a series of reservoirs, which have continually declined in biological diversity (Upper Mississippi River Conservation Committee 1993). With water levels controlled to maintain channel depths, low water levels no longer occur, and for 60 plus years substrates have not been allowed to consolidate creating unfavorable conditions for aquatic plant growth. In general, the abundance, diversity, and distribution of vegetation has declined since impoundment and along with it the ability to sustain it's former diversity of fish and wildlife (see attached figure).

The Environmental Management Program has attempted to sustain or improve some areas through Habitat Rehabilitation and Enhancement Projects (HREP's). Islands have been constructed to reduce wind fetch, side channels have been closed to reduce sedimentation in backwaters, culverts have been installed to provide flow into backwater areas that are important wintering habitat for fish, and dredging has been utilized to increase backwater depths. While many of these projects have met their objectives, they are small in scale and may not be enough to reverse negative river-wide trends due to altered flows and water levels (Theiling 1995).

Water Level Management

Water level management holds considerable promise as a tool or restoring some of the river's natural processes. Biologists ave long recognized the value of water level management, specially drawdowns. Drawdowns (summer or winter) have been sed to consolidate substrates, improve water quality, and ncrease or control aquatic and terrestrial vegetation for the enefit of fish and wildlife. Other options for water level anagement on the Mississippi River include raising pool levels bove the existing 9' navigation channel, modifying dam control oints (in pools with mid-point control), or working within urrent USCOE operating ranges at each dam.

Biological Benefits of Drawdowns

Considerable research has been completed to evaluate the pacts of water level management in lakes, reservoirs, ponds and olated wetlands. Dunst et. al. (1974) reported drawdowns ccessfully compacted sediments in a number of water bodies, cluding an 11% increase in lake depth in Beaver Lake, sconsin. Birch (1960) and Kadlec (1960) reported drawdowns crease nutrient availability. Studies of small marshes and rge reservoirs have demonstrated that lowering water levels to pose sediments increases seedbank germination and improves the sity and diversity of aquatic and terrestrial vegetation ourt 1978; Blindow et. al. 1993; Burgess 1969; Gaudet 1977; rris and Marshall 1963; Hartman 1949; Heerdt and Drost 1994; ld and Taub 1973; Kadlec 1960; Weller and Fredrickson 1973; onald 1955; McGragor 1948).

Drawdowns have been an important tool of wildlife managers for many years, and often are the most practical way to maintain the productivity of wetlands for waterfowl and furbearers (Neal 1977). Improvements in marsh vegetation following drawdowns have enhanced waterfowl habitat and use (Fredrickson and Reid 1986; Fredrickson and Taylor 1982; Johnson and Montubano 1989; Korschgen 1989; Merendino and Smith 1991; Uhler 1956).

Fisheries also benefit from water level management. Arner et. al. (1971) and Heman (1965) reported drawdowns increase the availability of prey fish to predatory fish, thereby improving the growth of predatory fish. Many authors have reported improved fish production following drawdowns and subsequent re-flooding (Fourt 1978; Groen and Schroeder 1978; Keith 1974; Wegener and Williams 1974; Lantz 1974). In older reservoirs, raising water levels during spring to improve spawning conditions, and lowering water levels during summer to encourage plant growth and increase prey availability is a common fisheries management technique (Bensen 1976; Culver et. al. 1980). Drawdowns have also been used during spring or winter to negatively impact undesirable fish or aquatic plant species (Hartman 1949; Jeppson 1957; Shields 1955). Improved fish populations result in increased recreational opportunities. Wegener and Williams (1974) reported the value of a fishery in a 22,700 acre Florida reservoir increased 37% following a drawdown.

Specific benefits depend upon the rate and extent of drawdown, type of substrates exposed, and timing and duration of exposure. Benson (1976) concluded high water levels from April - June, followed by a summer drawdown beginning in July was most beneficial to fish production in Missouri River reservoirs. Meeks (1969) reported early drawdowns (beginning in mid-May) were more effective at establishing emergents than later drawdowns on an 80 acre marsh in Ohio, while Merendino and Smith (1991) found early drawdowns (beginning in May) maximized shoot, cover, and seed production of desirable aquatic vegetation for waterfowl in Delta Marsh, Manitoba, Canada. Martin et. al. (1981) recommended a summer drawdown one year out of every three to nhance fish spawning and growth in a Missouri reservoir. Uhler 1956) reported biennial drawdowns were preferred over annual rawdowns to reduce undesirable plant growth in small mpoundments managed for waterfowl.

Limited information is available concerning drawdowns on arge floodplain rivers, like the Mississippi River. Small-scale rawdowns in some Mississippi River pools have shown biological enefits similar to those reported for lakes and reservoirs. neiling et. al. (1992) reported positive changes in water uality, vegetation and fish species following water level hanges in Mississippi River Pool 26. Mississippi River Pools 4 and 25 were drawn down 1.5 ft during 1994. Areas exposed uring the drawdown quickly colonized with vegetation; however, he impact of the drawdown was only evaluated qualitatively. nother drawdown was implemented in 1995 with more specific onitoring, and should help further quantify benefits related to rawdowns specific to Mississippi River pools.

Biological Benefits of Raising Water Levels

Raising water levels would increase the amount of wetland abitats available for fish and wildlife similar to what occurred hen the Upper Mississippi River was initially impounded. Like ll new reservoirs, productivity would increase initially but ecline over time. A navigation channel greater than 9' would rovide more flexibility in drawdowns while not impeding avigation. Changing the dam control point from mid-pool to the ock and dam would allow for greater manipulation of water evels, either high or low, within individual pools. Also, olding water levels on the high end of the USCOE operating range uring winter would provide slightly more depth for backwater ish and furbearers.

Conclusions

Physical processes on the Mississippi River have been altered due to the construction of the lock and dam system. The Illinois River faced similar conditions and experienced a biological "crash" in the 1950's (Mills et. al. 1966). Without restoring physical processes, productivity in the Mississippi River is expected to continue to decline, and some organizations have warned of potential collapse of the ecosystem (Upper Mississippi River Conservation Committee 1993).

Water level management offers a chance to improve biological conditions on the Mississippi River. Large-scale restoration of the natural hydrograph may reverse or halt negative biological trends. Such efforts have improved habitat in small wetlands and large reservoirs managed by drawdowns, and may benefit the Mississippi River as well.

From past research, the timing and duration of drawdown will determine biological impacts. The broad range of options (i.e. from a 0.1 ft drawdown to natural low flows) for the Mississippi River make predicting specific biological benefits difficult. Experimentation and planning to develop biological objectives is needed to determine appropriate drawdown options for the Upper Mississippi River. With many users benefitting from the impounded system, it is critical that all interested parties become involved with future decisions regarding water level management on the Mississippi River.

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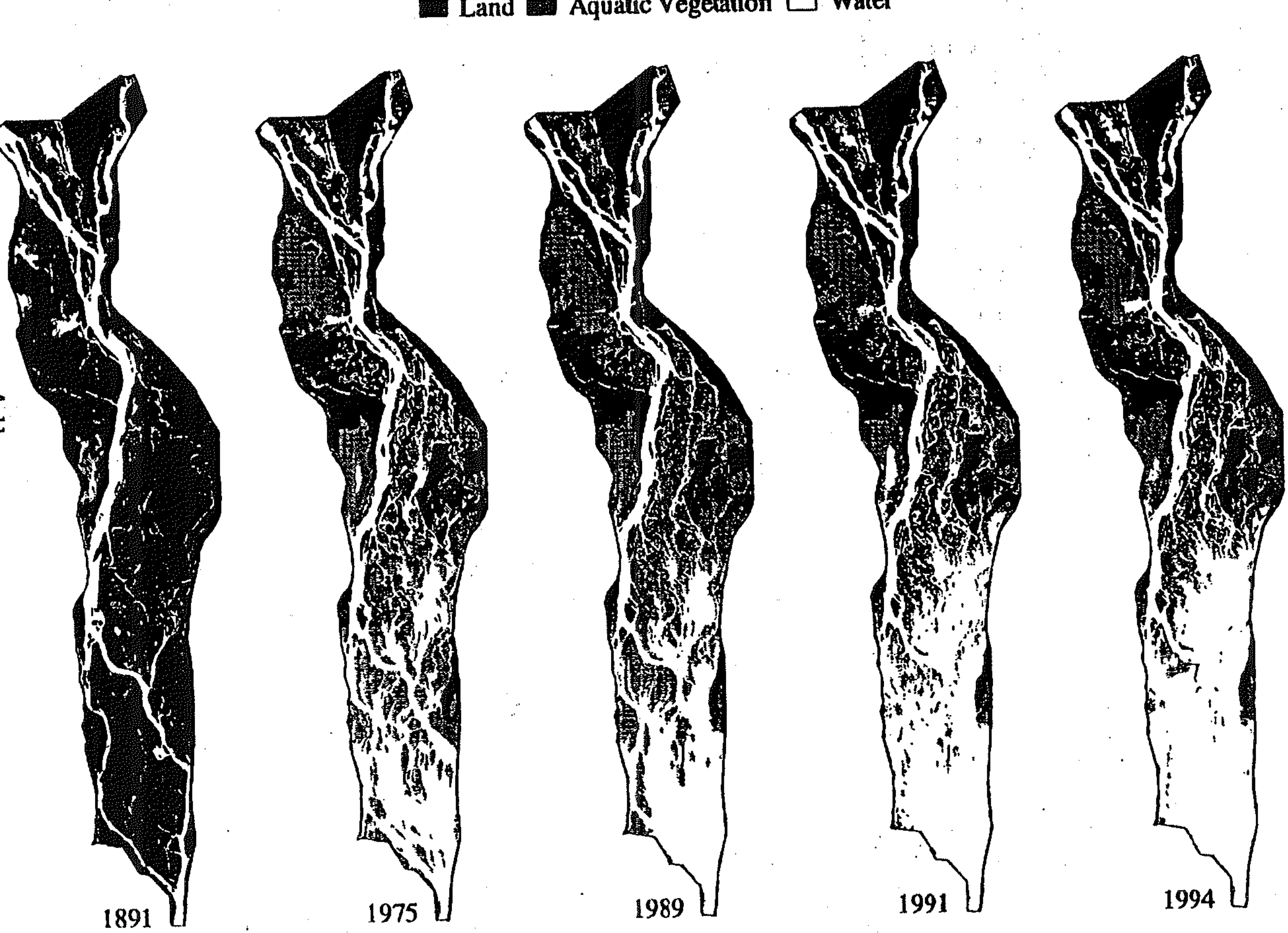
Land
Aquatic Vegetation
Water
1891
1975
1989
1991
1994

APPENDIX B

EXISTING WATER LEVEL REGULATION
POOL 8, UPPER MISSISSIPPI RIVER

APPENDIX B

EXISTING WATER LEVEL REGULATION
FOR POOL 8 - UPPER MISSISSIPPI RIVER

1.0 PROJECT FEATURES

Lock and Dam 8 is located at Genoa, Wisconsin. Lock and Dam 8 is supported on timber piling, driven into sand and gravel, with steel sheet piling cutoff walls. The 110-feet wide by 600-feet long main lock is located on the left side of the lock and dam. A 110-feet wide auxiliary lock chamber equipped with an upper miter gate is located riverward of the main lock chamber. The moveable dam section is 934.5 feet wide and consists of five 80-feet wide roller gates and ten 35-feet wide tainter gates. A service bridge spans the length of the moveable dam and storage yard, providing a track for operation of a locomotive crane. The crane can be used to install bulkheads, to facilitate gate dewatering and repair, and to remove debris.

1.1 GATES

The roller gates are cylindrical gates that can be both raised above the dam sill during normal operation and submersed to 3 feet below normal pool elevation, to allow passage of ice. Roller gates are raised and lowered by lifting chains that cause the gates to rise along geared tracks embedded in the concrete piers. The roller gates are 20 feet in diameter, and extend to elevation 631.0 ft from the roller gate sills when in the closed position. Roller gates can be raised entirely out of the water during periods of high river discharge.

The tainter gates are radial gates 15 feet high. The tainter gates are raised and lowered by lifting chains that cause the radial gates to turn around trunnions, or pivot points embedded in the concrete piers. The tainter gates on lock and dam 8 extend to elevation 631.0 ft from the tainter gate sills when in a closed position. Tainter gates can be raised entirely out of the water during periods of high river discharge.

Vertical slots in the gate piers allow placent of bulkheads on the upstream side of the gates to allow dewatering for maintenance and repairs. The bulkheads are placed and removed using the locomotive crane on the bridge deck.

Both roller and tainter gates at lock and dam 8 are actuated by electric motors. Controls for gate movements are located on the dam at each gate. The minimum practical increment of gate movement is 0.5 feet. The frequency of gate movements is limited by staff availability. Normally, only two people are on duty at the lock and dam. On weekdays during the navigation season, four people are on duty. Gate changes are routinely made once a day if needed. When additional gate changes are needed, it is often necessary to operate gates during shift changes, or pay an operator overtime. Winter gate changes are kept to a minimum because of difficulties imposed by ice.

The rate of release through the gate openings is controlled by the head at the dam (difference between pool and tailwater elevation), and the area of gate opening. Position of individual gates in the dam with respect to the upstream channel geometry also has an influence on rate of release. The schedule of gate operation is approximate, based on a partial rating of lock and dam 8 made in 1971.

The gates are opened evenly across the face of the dam to attain the combined opening for each type of gate required to release the desired rate of flow. There is normally less than 0.5 ft difference in opening between gates of each type across the face of the dam. This even distribution of flow release across the dam is made to minimize downstream velocity and prevent scour. Even distribution of flow across the dam also limits currents which could affect navigation in the lock approaches.

Maximum allowable openings for individual gates are imposed to prevent scour damage on the downstream side of the dam, based on a maximum allowable velocity of 4.5 feet per second over the derrick stone below the dam. In the case of an emergency, the discharge velocity can be increased to 6.0 feet per second.

1.2 EARTHEN DIKE

The earth dike at Lock and Dam 8 is 15,720 feet long with a top elevation of about 640.0. This dike extends in a northwesterly direction to the Minnesota mainland. Two submersible dams (fixed crest spillways) with crest elevations of 631.0 are present in the dike. The left submersible dam is 1,337.5 feet long, while the right submersible dam is 937.5 feet long. These submersible dams contain arched, flat bottomed culverts to provide flows to downstream areas for water quality purposes. The culvert in the left submersible dam permits a flow of 50 cfs at project pool elevation 631.0, while the culvert in the right submersible dam permits a flow of 70 cfs.

2.0 BASIC PLAN OF OPERATION

2.1 GENERAL

If Mississippi River discharge fell to near zero, the water surface throughout the navigation pools could be maintained at the project pool elevations. The water surface profile of each pool during extreme low flow conditions would be flat. With increasing river discharge, a slope develops in the water surface of the pool. The upstream end of the pool rises as releases from the upstream dam increase, and the downstream end of the pool falls as discharge through the downstream dam increases, resulting in a drawdown at the dam. The water surface of the pool tends to pivot around a point in mid-pool. The pivot point is called the "primary control point," and its location is at or near the point of intersection of the project pool elevation and the ordinary high water profile".

Court decisions have defined ordinary high water as "where the banks of a body of water are relatively steep, ordinary high water mark is coordinate with the limit of the bed of the water; and that only, is to be considered the bed which the water occupies sufficiently long and continuously to wrest it from vegetation and destroy its value for agricultural purposes. When the banks are low and flat, ordinary high water mark is to be considered the point up to which the presence and action of the water is so continuous as to destroy the value of the land for agricultural purposes by preventing the growth of vegetation, constituting what may be termed any ordinary agricultural crop."

The primary purpose of the dams in the St. Paul District is to maintain a minimum channel depth of 9 feet for navigation. To allow navigation, project pool elevations must be maintained at or above project pool elevation at the primary control points. Operation of the dams is required at low and moderate flows, but the dams are not needed during high flows, and dam gates must be raised from the water well before flood stages are reached. Except for water that goes into valley storage as the inflows increase, all inflow must be discharged.

Prior to construction of the dams, field surveys established the ordinary high water profile. The location of the primary control point for pool 8 was determined to be at La Crosse, Wisconsin, at river mile 696.85. Project pool elevation of 631.0 is maintained at the primary control point, and the pool elevation at the dam is allowed to fall as the discharge increases. Drawdown at the dam is limited to one foot so that conditions for navigation and fish and wildlife are not damaged by extremely low water.

On navigable lakes and rivers, the federal Government can use the riparian lands up to the ordinary high water mark for navigation, through the right of navigational servitude. By use of the mid-pool control point method of operation, the only area above the ordinary (pre-project) high water mark overflowed by operation of the dam, is between the control point and the dam. This method of regulation greatly limited the area above the ordinary high water mark affected by dam operation and limited the cost to the Government of acquiring real estate flowage rights.

2.2 POOL 8 REGULATION

Pool 8 is regulated to attain target pool elevations at the control point and at the dam illustrated in the operating curves shown in plate 5 of the main report. The target band for pool elevation is +/- 0.2 feet from the elevations shown in the operating curves when the dam is in control of the pool (below 95,000 cfs).

As river discharge increases above extreme low flow, pool elevation at the dam is drawn down to a maximum of one foot at 23,000 cfs in order to maintain project pool elevation at the control point. Above 23,000 cfs, control of the pool is shifted to secondary control at the dam.

As discharge increases above 23,000 cfs, the pool level at the dam is held at elevation 630.0, and the stage at all other points in the pool is allowed to rise. As discharge increases, head at the dam decreases (difference between pool and tailwater elevation).

When discharge reaches 95,000 cfs, head at the dam is less than one foot, and all the gates in the dam are then raised clear of the water. As the flow increases above 95,000 cfs, open river conditions are in effect, and the dam is out of control. Head at the dam (difference between pool and tailwater elevation) when gates are out of the water is approximately 0.5 feet.

As flow recedes, gates are returned to the water when pool elevation at the dam drops to 630.0, the secondary control elevation. This elevation is reached when flow recedes to 95,000 cfs, and secondary control elevation is maintained at the dam until water level at the primary control point drops to project pool elevation of 631.0, at a flow of 23,000 cfs. Then control of the pool is returned to the primary control point, and as the discharge decreases, the water surface at the dam rises above the full drawdown level of 630.0.

The lock miter gates are never used for regulating river discharge. When pool elevation exceeds 634.0, lock operating motors must be removed, and the upper miter gates are kept in a closed position while the lock is out of operation.

2.3 ROUTINE RIVER REGULATION - DECISION MAKING AND PROCEDURES

The St. Paul District Water Control center has three hydraulic engineers and three engineering technicians. Water Control directs the operation of the Mississippi River navigation dams, the Mississippi River Headwaters reservoirs, and nine other flood control reservoirs in the St. Paul District. The unit is a part of the Hydraulics and Hydrology Branch of the Engineering Division. Decisions on river regulation and orders to lockmasters for dam operation are routinely made by the regulator in Water Control in St. Paul.

Under emergency conditions, the Chief of Water Control makes the river regulation decisions for St. Paul District. Additional engineers assist, and if the situation warrants, Water Control is staffed 24 hours each day. Engineers from the District Office provide flood damage prevention assistance to local authorities and report on field conditions to Water Control. Higher Corps of Engineers authorities are kept continuously informed of conditions during flood situations by telephone and computer network.

Each lock and dam is staffed by a Lockmaster, a Lock and Dam Equipment Repairman, five head lock and dam operators and four lock and dam operators. During the navigation season, there are at least two persons per shift at all times. During the non-navigation season, there is at least one person per shift at the lock and dam.

All of the locks and dams have short wave radio equipment. The District Electronic Service Center is located at Lock and Dam 2 near Hastings, Minnesota. Each day Water Control contacts all lockmasters from lock and dam through lock and dam 10 by radio.

The St. Paul District maintains a computer network connecting each lock and dam with the District office via telephone lines. Lockmasters enter information on pool elevation, tailwater elevation, primary control point elevation, discharge through the dams, gate openings, weather conditions, and the most recent dam operating orders into the Water Control computer system once every four hours. Lockmasters obtain information on control point elevations either from telemark gages located at the control points or by telephone contact with gage readers. At some locations, data collection platform gaging stations (DCP's) are located at pool control points, and water surface elevation data is transmitted to the District Water Control by satellite and downlink.

Starting at 6:30 each morning, Water Control staff in St. Paul review the system operating conditions, weather, and river discharge information from the gaging network via the water control computer system. Inflow to pool 8 is estimated using outflow from Lock and Dam 7, La Crosse River flow at West Salem, Root River flow at Houston, and estimates of local inflow and change in storage of pool 8. Along with inflow to pool 8, the stage at the control point, primary or secondary as the case may be, must be considered by the regulating engineer. When inflow is steady, all inflow is discharged if the stage at the control point is within +/- 0.2 feet of the target stage. If the stage at the control point is not within this range, the regulating engineer increases or decreases the storage as necessary to bring the stage at the control point to the correct level. The gate operating schedule is used to determine gate openings needed to pass the required flow.

If the inflow is increasing, the discharge must be increased to prevent the stage at the primary control point from rising above elevation 631.2 if the pool is in primary control, or elevation 630.2 at the dam if the pool is in secondary control. However, the outflow cannot be increased the full amount of the increase in inflow, for the storage in the pool must be increased as the discharge increases. Therefore, the outflow from lock and dam 8 must equal the inflow minus the required change in storage for increasing discharge. The flow-storage curves are consulted.

If the inflow is decreasing, the discharge must be reduced to prevent the stage at the primary control point from falling below elevation 630.8 if the pool is in primary control, or elevation 629.8 if the pool is in secondary control. The discharge cannot be decreased the amount of the decrease in inflow, because the storage in the pool must be reduced as the discharge decreases. Therefore, the outflow must equal the inflow plus the required change in storage for decreasing discharges.

Orders for dam operation are radioed from Water Control to the lockmaster at Lock and Dam 8 each morning before 9:00. Orders consist of directions for gate adjustments, given in feet of opening for roller and tainter gates, the range of pool elevation to hold in feet, and discharge in cfs. Telephone communication with the lock and dam is also available. During periods of rapidly changing river discharge, this process is repeated as necessary up to several times a day.

The lockmaster at Lock and Dam 8 recieves the orders and determines the gate changes needed to attain the total gate opening required. Gate changes are made to attain the total gate opening to pass the required flow and to maintain an even distribution of flow across the dam gates. An operator then goes out on the dam to make the gate changes. Adjacent to the control switch for each gate is a gage that indicates the gate position. Under normal, ice-free conditions, it usually takes one person about half an hour to make the gate changes. Gate changes take longer the larger the change in opening to be made, and raising all 15 gates from the water takes about three hours.

In addition to the daily gate settings, lockmasters are instructed to maintain the pools within specified bands of water surface elevation. Lockmasters may make interim gate adjustments to increase or reduce releases by up to 10 percent in 24 hours on their own initiative in order to maintain the pool elevation within the operating band. Interim gate adjustments at lock and dam 10 are limited to a maximum of 5,000 cubic feet per second change in 24 hours to avoid complications with river regulation downstream in the Rock Island District.

2.4 WINTER OPERATION

Ice formation removes water from active flow, causing a rapid decrease in river discharge. Flow through the dam must be decreased in to maintain water levels during ice formation. As this process continues, the ice formation-related decrease in flow translates downstream through locks and dams in the system. Dams must be operated in order to compensate for both the decrease in flow due to ice formation in the pool and the decrease in flow recieved from upstream.

Flow during the winter months is normally low and steady. Gate changes are difficult to make because of ice. From a river regulation perspective, it would be desirable to allow the pools to fall within a wide range of draw down to minimize gate changes, the Anti-Drawdown Law limits winter drawdown of pool 8 to 0.25 feet below winter target pool elevation at the primary control point. For pool 8, winter target pool elevation is 630.75 at the primary control point at La Crosse, with a maximum drawdown at the dam of one foot, to 630.0, just as during the open water season. A slightly wider regulating band is allowed during winter, owing to the difficulties of winter dam operation. The target operating band at the control point during winter is +/- 0.3 feet, rather than the +/- 0.2 feet during the open water season.

Before freeze-up begins, Water Control estimates the probable base flow for the winter period, based on fall discharge conditions and winter discharge during the previous several years. This estimate is made so that the tainter gate openings can be set and the tainter gates allowed to freeze in place. Orders for winter setting of tainter gates are issued before icing conditions makes their operation too difficult.

The roller gates are lowered to the submerged position, and the remainder of the winter flow not discharged through the tainter gates is dishcarged over the submerged roller gates. These gates can be submerged as much as 3 feet below project pool elevation. In the submerged position, most gate operation difficulties caused by ice are eliminated. If possible, the flow in the roller gate section is distributed equally over the 5 gates, and all changes in the outflow during winter are made in the roller gate section of the dam.

Because the range of discharge capacity of roller gates in the submerged position is limited, winter thaws or rains can cause an increase in river flow that requires one or more of the roller gates to be raised into the normal position (with flow under, rather than over the gate). Large magnitude winter thaws or rains can result in the need to de-ice some tainter gates to make additional outflow capacity available.

The roller gates are equipped with electric drum and side seal heaters, and the tainter gates have seal heaters. Water control informs the lockmaster well in advance of an anticipated gate change, and the heaters are turned on. The heaters alone seldom free the gates completely of ice so that they can be moved. Dam operators must manually chop and steam ice off the gates before they can be moved in winter, a labor-intensive and hazardous job.

Throughout the winter, the tainter valves in the lock-filling conduits within the lock walls are kept open about a foot so that the discharge through the lock prevents the formation of solid sheet ice and also to reduce sedimentation within the lock chamber. Winter flow through the lock is estimated to equal 1/10 of the flow through a roller gate with the same gate opening.

Ice cover affects stage:flow rating curves for the gaging stations in the basin, and the backwater effect induced by ice must be taken into account in computing inflows from tributaries. This correction is obtained from stream measurements made periodically throughout the winter by the U.S. Geological Survey. The discharges through the dam are computed from gate openings and unit discharges based on head, so no correction for ice effect is required.

Ice jams occur occasionally and can cause uncontrolled increase in pool level and considerable damage. In order to maintain the pool below an ice jam, it may be necessary to close dam gates until the ice jam breaks up. It has been found that manipulating flow at the dam has no noticeable effect on ice jams.

2.5 EMERGENCY OPERATION

;.1 Damaged Gates

Failure of a dam gate requires emergency action to restore the water ıtrol function of the dam. In the event of a gate failure, it is necessary install bulkheads on the upstream side of the gate to close off the gate r and to allow repair work to proceed.

Bulkheads cannot be installed in an uncontrolled gate bay if the head at dam (difference between pool and tailwater elevation) is greater than out 1.3 feet, otherwise water pressure on the bulkhead during installation ıld cause the bulkheads to jam in their slots or cause difficulties with traveling crane. Therefore, the head at the dam must be reduced, and ning of an impending drawdown of pool 8 must be given to Locks and Dams 7, 10, 11, 12, Rock Island District Water Control, navigation interests, and other concerned interests.

The most severe condition for bulkhead installation in uncontrolled gate rs at lock and dam 8 occurs at low flow of about 10,000 cfs, since the head l required drawdown would be near maximum. Drawdown of the pool would be uired to allow emergency installation of bulkheads. The head at the dam be reduced to 1.3 feet, all gates removed from the water, and bulkheads start to be placed 2 hours after starting drawdown from full pool. The imum theoretical discharge during an emergency drawdown would be 60,900 . In order to prevent a large wave of increased river discharge from nslating too far downstream, pools 9, 10, 11, and 12 would be used to store water from a drawdown of pool 8, then the excess storage would be dually released over a period of time.

The stage increase in downstream pools resulting from an emergency wdown at lock and dam 8 would depend on the prevailing river discharge and volume that would need to be discharged from pool 8. The downstream dams ıld be regulated to minimize stage increases by distributing the flow pulse ween the four large downstream pools.

On January 16, 1982, a trunnion bearing on a tainter gate at Lower St. hony dam in Minneapolis failed. The St. Anthony Falls pool was drawn down l bulkheads were installed. Following the gate failure at about 3 P.M., the kheads were installed and the pool was restored by about 2 A.M. the lowing morning. There have been no gate failures that have required pool wdown at any of the downstream dams in the St. Paul District, although ficulties in moving gates have resulted in several close calls.

.2 Spills

The St. Paul District has prepared a plan for emergency response to a ll of petroleum or other substances into the river. The District Emergency agement office and Water Control will work cooperatively with the erally-designated On-Scene Coordinator and State spill response teams to tain, clean up, and minimize adverse effects of spills. Measures by Water ıtrol in response to a spill will be made at the request of the Federal On-

Scene Coordinator, and could include temporarily closing dam gates to allow placement of spill containment equipment, diversion of flow, or discharge under roller gates to limit the downstream movement of floating substances.

2.5.3 Navigation Emergencies

Changes from routine operation are rarely made to assist grounded vessels, usually only if the grounded vessel is blocking the channel and presents a hazard to navigation. In the St. Paul District portion of the 9-Foot Channel Project, this type of navigation emergency has required temporary changes from routine river regulation about once every two or three years. A temporary increase in pool elevation of less than 0.5 ft is usually all that is necessary to free grounded vessels. When severe channel shoaling exists, the pool is regulated toward the high side of the operating band (+ 0.2 feet, or 631.2 at the control point) to minimize the potential for grounding before the shoal area is removed by maintenance dredging. These minor changes in routine pool regulation have very minor effects on river discharge and water surface elevation in the downstream navigation pools.

2.5.4 Floods

Lock and Dam 8 goes out of control at 95,000 cfs, when the gates are raised clear of the water. Lock and dam 8 has no significant effect on pool elevations at higher levels of river discharge. When the river level at the dam reaches 634.0, corresponding to a river discharge of about 165,000 cfs, the motors that operate the lock machinery must be removed, and lock and dam 8 is closed to navigation.

Pool 8 cannot be used, and is not used for flood control storage. Even if the pool were completely drawn down, river flow during a flood would fill the pool in a matter of hours, and would not produce any significant reduction in downstream flood levels.

When the river is receeding from flood levels, dam gates are returned to the water when river discharge falls to 95,000 cfs and routine operation, as described above, is resumed.

3.0 CONSTRAINTS

3.1 FACTORS AFFECTING THE ABILITY TO ATTAIN TARGET POOL ELEVATIONS

Lock and Dam 8 is operated to maintain water surface elevations in pool 8 within +/- 0.2 ft of the target levels shown in the operating curves (+/-0.3 ft in the non-navigation season). Several factors make regulating within this operating band problemmatic.

3.1.1 Control Point Regulation

Regulation using mid-pool control points (discussed above) imposes difficulties in maintaining target pool elevations during periods of falling river discharge. When river discharge is declining in the 30,000 cfs to about 18,000 cfs range, operation at most of the St. Paul District dams shifts from secondary control with drawdown at the dam to primary control with less drawdown at the dam. As river discharge falls below about 30,000 cfs, considerable river discharge goes into storage in the pools as drawdown at the dams is decreased. Releases must be cut back to accomodate this change in storage plus the decline in river discharge. The effect of this system of regulation is that river discharge falls off rapidly below about 30,000 cfs. During this time of rapidly falling river discharge, regulation of the dams to maintain target pool elevations becomes more difficult to accomplish, and more frequent adjustments to dam gates are required.

3.1.2 Estimation of Change in Storage

The stage:storage curves for the pools are approximate, not based on detailed surveys of river bed elevation . Below about 30,000 cfs, changes in river discharge result in relatively little change in storage. Regulation requires estimation of change in storage with changing stage and river discharge. Over the years, Water Control regulators have refined the stage:storage relationship for the pools empirically. Also, time considerations for daily regulation decision-making require Water Control regulators to estimate change in storage rather than conduct detailed calculations in the course of daily regulation.

3.1.3 Gate Ratings

The schedule of gate operation is based on ratings of gate opening to discharge. Empirical experience of the regulators allows close estimation of releases, but impoved gate rating would eliminate some inaccuracies from the schedule of gate operation.

3.1.4 Inflow Estimates

The river gaging network provides accurate and timely information on inflows from major tributaries. Prediction of inflows from tributaries is needed, particularly during periods of lower Mississippi River discharge when changes in tributary inflow can have proportionally larger effect on river flow. Water Control regulators make regulating decisions based on estimates of not only the flow rate, but also the total volume and timing of inflows to pools in the system. Inflows from the Chippewa River in particular, impose problems in regulating Mississippi River dams because of the cyclical releases associated with hydropower operation to meet peak elecrical demands. Accurate prediction of the volume and timing of pulsed releases from the Chippewa river has not been made available.

3.1.5 Flow Routing

River regulating decisions based on the volume and timing of inflows must incorporate estimates of travel time through the system under different discharge conditions. Empirical experience of the regulators allows good estimation of flow routing through the system. These estimates of flow routing are made without the assistance a computerized flow routing model. Development of a computerized flow routing model for the system with sufficiently accurate simulation of flows is a major undertaking currently underway which will require a number of years to complete. Products of a system flow routing model will provide regulators with improved estimates of the timing and volume of inflows, allowing closer regulation.

3.1.6 Wind Set-Up

The target range of pool elevation can be exceeded due to water surface changes induced by strong and sustained northerly or southerly winds. Wind set-up as much half a foot at the dam is not uncommon at Lock and Dam 8 because of the large expanse of open water in the lower end of the pool.

3.2 POOL LEVEL REQUIREMENTS FOR NAVIGATION

A major constraint on river regulation is the need to maintain the authorized 9-foot channel depth. The primary purpose of Lock and Dam 8 is to maintain project pool elevation of 631.0 during periods of low river discharge so that the navigation channel with a minimum depth of 9 feet can be maintained. Even with operation of Lock and Dam 8, dredging is required to maintain the minimum channel depth of 9 feet.

3.2.1 Historic Dredge Cuts

Ten channel reaches have historically required dredging in pool. Sounding surveys of the historic dredge cuts are routinely made by the St. Paul District Navigation Section to assess condition of the channel. Maintenance dredging is normally initiated when water depth in the navigation channel becomes less than 10 feet, when corrected to low control pool elevation (631.0). Channel areas are routinely surveyed to track conditions and are scheduled for maintenance dredging as necessary.

Better sounding equipment and changes in channel maintenance procedures have reduced the amount of dredging in pool 8 necessary to maintain the channel from historic practices. A review of dredging records for the period 1970-93 indicate there are only four dredge cuts that require dredging on a regular basis. They are the La Crosse R.R. Bridge (RM 699.8-700.4), Above Brownsville (RM 689.9-690.8), Brownsville (RM 688.7-689.4), and Head of Raft Channel (RM 687.5-688.7) dredge cuts.

3.3 REAL ESTATE

The Federal government acquired virtually all the land in pool 8 for establishment of the Upper Mississippi Wildlife and Fish Refuge and for construction of the Mississippi River 9-Foot Channel Navigation Project. Land and water areas were acquired in fee title, and flowage easement was obtained on land around the periphery of the lower half of the pool. The Corps of Engineers and the FWS administer the Federally-owned land in pool 8. Plate *** shows the extent of Federal real estate holdings in pool 8.

3.3.1 Fee Title Property in Pool 8

The Corps of Engineers aquired 9,496 acres of land and obtained special rights on 14,588 acres of land and water area in pool 8 administered by the U.S. Fish and Wildlife Service (FWS) prior to initial project operation. All of the Corps-administered land except for recreation areas at Goose Island Park, Wildcat Park, Stoddard Park, and at the lock and dam have been placed under cooperative agreement for management by the FWS as part of the refuge system.

Federal land in pool 8 was aquired in fee title primarily in the areas below project pool elevation and on islands within the pool. Federal government rights of use on the Federal fee title land in pool 8 are complete. There are no legal restrictions against overflowing of water on the fee title land.

3.3.2 Flowage Easement Property

In areas that would be intermittently flooded by intentional regulation of lock and dam 8 and that were above the ordinary high water mark, flowage easement rights of use were acquired by the Federal government prior to inital operation. These areas extend along the periphery of pool 8 from the primary control point at La Crosse downstream to lock and dam 8. Flowage easement rights of use were acquired for properties along the pool shoreline between the control point and the dam that were not acquired in fee title.

Flowage easement properties were aquired along the pool shoreline in order to encompass the land lying above the ordinary high water mark that would be overflowed by operation of the dam. The ordinary high water mark was a legally-defined line along navigable rivers where recurring water levels prevented use of the land for agricultural or other purposes. In practice, the ordinary high water mark was identified by changes in vegatation cover and stranded debris. The flowage easements were acquired tract by tract, not up to any particular elevation, in order to encompass the pool downstream of the control point at Lansing. The landward boundaries of most of the flowage easements therefore do not follow a particular elevation contour, but are assumed to be at least a few feet above the water surface elevation profile of the pool when the dam goes out of control at 95,000 cfs.

The flowage easement boundaries are described in the taking documents by metes and bounds. Flowage easement boundaries around pool 8 have not been monumented. Much of the flowage easement properties are narrow bands along the shore. Flowage easements were acquired along the railroad embankments that follow much of pool 8 shoreline, for example, and are very narrow in width.

The relationship between elevation and the landward boundaries of flowage easement properties cannot be defined exactly, lacking detailed elevation surveys.

Rights of use on flowage easement are defined in the eminent domain taking orders issued for the various flowage easement properties in Federal District Courts:

"...flowage easement being the full, complete and perpetual right, power, and privelege to overflow each and all of the tracts of land described, together with the right, power and privelege to cut, remove, and dispose of all wood, timber, and other natural and artificial structures, projections, or obstructions on said land, or in the slack-water pool created or to be created by said lock and dam, or on the margins thereof, which may in any way or at any time shall interfere with navigation or the use of the lands and pool for the maintenance and operation of said lock and dam, or to render said lock and dam, or the pool created thereby, inaccessible, unsafe, or unsanitary, together with the right to enter upon said lands from time to time, as occasion may require for any of the purposes aforesaid."

This language is unequivocal on the right of the federal government to cause water to overflow the flowage easement property.

3.4 LEGAL CONSTRAINTS

Legal constraints on river regulation exist. The following sections identify the major legal constraints. The listing is not intended to be and all-inclusive legal review. There are a relatively large number of laws, executive orders, and regulations that pertain.

3.4.1 Interagency Agreements

Engineer Pamphlet 1165-2-1, 15 Feb 89, Digest of Water Resources Policies and Authorities, contains sections on Legislation Pertinent to the Water Resources Program of the Corps of Engineers in Chapter 26, and Interagency Agreements in Chapter 28. A list of Interagency Agreements is available in EP 1165-2-2.

An interagency agreement exists between the Department of Army and the Department of Interior for management of over 43,000 acres of Corps-administered Federal land along the UMRS for refuge purposes by the U.S. Fish and Wildlife Service. The 1963 Department Army - Department of Interior Cooperative Agreement on the land and water areas of the Upper Mississippi River nine-foot channel project made all privileges granted for fish and wildlife management purposes subject to navigation and flood control purposes including changing water surface elevations.

3.4.2 Legal Requirement to Maintain the 9-Foot Channel

The primary constraint on water control operations on the UMRS is the need to maintain the nine-foot channel project. The River and Harbor Act of July 3 1930, as amended, provides for a channel depth of nine feet at low water level with widths suitable for long-haul, common-carrier service.

The broad regulatory authority of the Secretary of the Army to prescribe regulations for the use, administration and navigation of navigable waters of the United States, 33 U.S.C. 1, could be exercised to impact water levels. P.L. 90-483, 33 U.S.C. 562a, authorizes the Chief of Engineers to maintain authorized river and harbor projects in excess of authorized project depths where such depths have been provided for defense purposes and will also serve essential needs of commerce. The Act of August 11, 1888, ch 860, 25 Stat. 419, 33 U.S.C. 602, directs the Secretary of the Army to prescribe rules and regulations regarding use of the reservoirs at the headwaters of the Mississippi River.

3.4.3 Corps of Engineers Water Control Regulations

Code of Federal Regulations 33 C.F.R. 222.7 (ER 1110-2-240, 8 Oct 82 Water Control Management) covers policy and procedures for water control management. That regulation references certain laws and regulations and those which seem applicable to this study are discussed below. While not directly concerned with water level fluctuation, laws appearing in vol. 33 of the United States Code regarding flood control, river and harbor improvements, and protection of waters could impact water levels through construction or improvement projects or the Corps permitting authorities. For example, under the Flood Control Act of 1944, 33 U.S.C. 709, the Secretary of the Army is to prescribe regulations for use of storage allocated for flood control or navigation in all reservoirs constructed totally or in part with Federal funds. 33 U.S.C. 540 requires that investigations and improvements of rivers, harbors, etc., include a "due regard for wildlife conservation." Because such laws do not directly involve water control, they are not further cited.

EM 1110-2-3600, 30 Nov 87 Management of Water Control Systems, implements ER 1110-2-240 Water Control Management providing guidance on management of water control projects. This manual contains information related to social and environmental considerations, describing as it does, general water management goals and objectives. As noted in para. 21, subparagraph c of this manual, even in single purpose projects operations "must be tuned to produce the benefits for environmental and social goals such as flood control, instream quality, in-lake quality, recreation, power, or any other attainable goals a project can achieve without compromising the authorized project purpose."

3.4.4 Federal Power Act

The Federal Power Act, June 10,19 20, c285, 41 Stat. 1077, 16 U.S.C. 791a, authorized development of hydropower in waters subject to Congressional control under the Commerce Clause of the Constitution. 16 U.S.C. 797 requires that plans and structures affecting navigation be approved by the Chief of Engineers and the Secretary of the Army. A developer and the Corps enter into a memorandum of agreement on operational methods.

3.4.5 Fish and Wildlife Coordination Act and Related Legislation

The Fish and Wildlife Coordination Act, 16 U.S.C. 661, et seq. provides that fish and wildlife receive equal consideration with other project purposes. As noted in EM 1110-2-3600 Management of Water Control Systems, para. 2-7,b, authorized project purposes usually contain enough flexibility to permit manipulation of water levels for fish and wildlife considerations.

3.4.6 National Environmental Policy Act and Clean Water Act

The National Environmental Policy Act, E.O. 91190, 42 U.S.C. 4321, et seq., and the Clean Water Act, P.L. 95-217, 33 U.S.C. 1251, et seq. impact water control to the extent that their procedural and substantive requirements must be considered. Executive Order 12088, Federal Compliance with Pollution Control Standards, 13 Oct 78, mandates agency compliance with applicable pollution control standards including those established under the Federal Water Pollution Control Act (Clean Water Act). As noted in EM 1110-2-3600 Management of Water Control Systems, para. 2-6, b, whether or not water quality control is an authorized purpose, water quality is an integral consideration with a goal to meet state and Federal water quality standards. ER 1130-2-334, 30 Apr 86 Reporting of Water Quality Management Activities at Corps Civil Works Projects, establishes reporting requirements and objectives for water quality programs at existing Corps civil works projects.

3.4.7 Federal Water Project Recreation Act

The Federal Water Project Recreation Act of 1965, P.L. 89-72, provides for a Federal interest in the provision of recreational opportunities at Corps projects subject to the authorized project purposes. As a consequence of this legislation, EM 1110-2-3600 Management of Water Control Systems states that regulation of project outflow should consider the effects of streamflow and water level on such activities.

3.4.8 Legal Requirements for Changes in Water Control Plans

The Digest of Water Resources Policies and Authorities, EP 1165-2-1, 15 Feb 89, notes in para. 11-7, Changes in Water Control Plans, that "Revised water control plans to add a new objective not included in the project authorization, other than 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." The Water Resources Development Act of 1988, P.L. 100-676, Sec. 5, provides for public review and comment prior to any change in reservoir operation which would significantly affect any project purpose.

3.4.9 Anti-Drawdown Law

Mississippi River pools are not drawn down to provide flood control storage. In addition to the practical reason of very limited storage capacity of the pools, the "Anti-Drawdown Law" passed by Congress on March 10, 1934 prevents drawdowns of the pool for flood control purposes. The act, entitled "An act to promote the conservation of wildlife, fish and game, and for other purposes," was amended by Public Law 732 on August 14, 1946 and by Public Law 697 on June 19, 1948 to include the following new section:

16 U.S.C. 665a applies directly to the St. Paul District in its provision that:

> **In the management of existing facilities (including locks, dams, and pools) in the Mississippi River between Rock Island, Illinois, and Minneapolis, Minnesota, administered by the United States Corps of Engineers of the Department of the Army, that Department is hereby directed to give full consideration and recognition to the needs of fish and other wildlife resources and their habitat dependent on such waters, without increasing additional liability to the Government, and, to the maximum extent possible without causing damage to levee and drainage districts, adjacent railroads and highways, farm lands, and dam structures, shall generally operate and maintain pool levels as though navigation was carried on throughout the year.**

The Anti-Drawdown Law and amendments, directs the Corps of Engineers to maintain normal pool elevations year-round, with limited (up to 0.25 ft at the control point) drawdown of pools in winter. The law also provides the mandate to regulate the river with full consideration of the needs of fish, wildife, and their habitat.

3.4.10 Legal Rights of Use - Real Estate

A major constraint on river regulation is the Government's legal right to overflow land. The real estate interests acquired by the Government in the 1930's for construction of the Mississippi River 9-Foot Channel Project allow the Government to intentionally overflow the acquired property - on both fee title and flowage easement properties. The cost of real estate acquisition for the St.Paul District portion of the Mississippi River 9-Foot Channel Project was minimized through adoption of the mid-pool control point method of river regulation by limiting the landward extent of real estate aquisition, and by acquisition of flowage easement rather than fee title purchase.

The major legal constraint imposed on pool regulation through real estate rights of use arises from the existing landward and vertical elevation limits of the real estate boundaries, and the upstream limits of flowage easement that was acquired. Intentional increases in pool elevation above low control pool elevation could overflow land for which the Government has not acquired real estate interests. Lacking a detailed topographic survey and monumented boundaries of the Government's real estate interests, acceptable upward limits for intentional increase in pool elevation cannot be identified at this time. It is likely that an intentional pool raise of less than one foot above 620.0 would exceed flowage easement and fee title property boundaries, especially just upstream of the control point where intentionally raised water level could overflow land where flowage easements were not obtained.

3.5 SYSTEM REGULATION

Routine regulation of the system of Mississippi River navigation dams in e St. Paul District follows the procedures described for lock and dam 8. ch day Water Control recieves hydrologic and weather information for the sin from the St. Paul District-maintained Basin Hydrologic Network, from the S. Geological Survey, the National Weather Service, and from Northern States wer Company. A summary of basin hydrologic information is prepared daily on e Water Control computer system for dissemination to interested agencies and rps higher authorities.

5.1 Basin Hydrologic Network

The Mississippi River Basin Hydrologic Network consists of 63 stream ıging stations within the St. Paul District. Eleven of the stations are ›rps of Engineers navigation dams on the river, 38 are data collection .atforms (DCP's), 9 are Northern States Power Company dams, and the remainder :e telemark gage stations. The U.S. Geological Survey (U.S.G.S.), Corps of ıgineers, and the National Weather Service cooperatively operate and maintian ıe DCP and telemark stations.

The data collection platforms (DCP's) record stage and water temperature. ata is transmitted by satellite to the National Weather Service downlink in aryland and then passed on by wire to the Minneapolis River Forecast Center, hich is linked by computer the St. Paul District Water Control. A telephone all is made daily to the Northern States Power Company hydropower operations ffice in Eau Claire to obtain data on reservoir stages and releases from heir dams in the basin. Lockmasters and other Corps field personnel contact he telemark gages by telephone each day and enter the stage data into the ater Control computer network.

Daily stage and discharge records from Corps-operated gages are reviewed ınd maintained by Water Control. Data from U.S.G.S. gages are retained in later Control until the U.S.G.S. annual water supply report is published. ›ata on releases from the NSP dams is maintained but is not reviewed for ıccuracy.

3.5.2 Communications With Rock Island District

In addition to the Basin Hydrologic Network and communications between Water Control and the Locks and Dams described above, Water Control also relays system hydrologic information to Rock Island District Water Control each day. Information transmitted by to Rock Island by telephone each day includes gate settings, discharge, pool and tailwater elevations and a five day discharge forecast for locks and dams 8, 9 and 10.

3.5.3 System Regulation During Rapid Increases and Decreases in River Discharge

Since intense rainfall affects the pools very quickly, all lockmasters have instructions to report to Water Control whenever 1.5 inches or more of rain falls in a 24-hour period. Also, if a total change of 4,000 cfs or 10%

or more of river flow occurs in a 24-hour period, lockmasters are required to report to Water Control.

Rapid, localized increases in inflow can cause significant fluctuations in pool elevation. Water Control regulators assess the rate and volume of inflows to the system and issue orders for dam operation designed to attenuate short-term flow pulses as they travel downstream through the system. This is accomplished by progressively gradual increases in gate openings in downstream dams, allowing successive minor changes in pool storage to attenuate the pulse of discharge without exceeding the target ranges of pool elevation. Larger increases in discharge cannot be attenuated to any significant degree, and must be passed downstream in the manner described for routine operation.

During rapid decreases in discharge, reduced inflow and the need to increase storage in the pools as drawdown at the dams is reduced results in a rapid fall of discharge throughout the system. Water Control issues orders for dam operation in the system designed to make reductions in discharge as gradual as possible while maintaining target pool elevations.

3.5.4 System Regulation During Low Flow Periods

During extended periods of low flow, an attempt is made to maintain pools elevations in the system near the upper side of the operating band. This minor amount of increased storage in the pools serves to buffer further decreases in river discharge, so that decreases in river flow can be made gradually through the system and without pools falling below project pool elevations, which could restrict navigation.

3.5.5 System Regulation During Floods

Each lock and dam in the system has a different level of river discharge at which the dam goes out of control. Generally, the downstream dams in the system have higher discharge capacity and go out of control at higher levels of river discharge than the upstream dams. As river discharge increases into the high flow range, different dams progressively go out of control, with gates raised entirely out of the water. The dams go out of control well before river discharge reaches flood stage, and during floods, the navigation dams in the sytem do not regulate flow at all. The St. Paul District Water Control Center activities during floods involve hydrologic analyses and providing hydrologic information to assist flood protection efforts. The National Weather Service has the legal responsibility for issuing weather forecasts, flood warnings and flood stage predictions to the public. During recession from floods, the dams successively go back into operation, and normal river regulation activities are resumed.

3.5.6 System Regulation During Winter

In late fall before freeze-up, Water Control evaluates hydrologic conditions in the basin and estimates the upcoming winter rate of base flow in the system. Orders are then issued for winter gate settings at each lock and dam. Winter variations in river discharge are regulated using the submerged roller gates when possible. Pools are maintained 0.25 feet lower at the ntrol points during the winter to accomodate changes in discharge in order minimize the need to make gate changes.

5.7 System Regulation During Emergencies

Emergency actions involving vessel groundings in the channel are usually calized to one pool, without causing major changes in downsteam operation. pair of damaged gates could require pool drawdown and placement of bulkheads described above. Water released from a pool drawdown would have to be gulated downstream through the system. Temporary increases in elevation of veral downstream pools would result, before the flow pulse could be tenuated.

3.6 ADMINISTRATION

Administration of Corps of Engineers water control management activities is described in detail in EM 1110-2-3600, November 30, 1987.

3.6.1 Responsibility

Responsibility for water control management throughout the Corps is assigned to the Water Control/Quality Section, Hydraulics and Hydrology Branch, Engineering and Construction Directorate, HQUSACE (CEEC-EH-W). CEEC-EH-W establishes major policy and guidance pertaining to Corps-wide water control activities. The Corps North Central Division Water Control Center (CENCD-ED-WH) has responsibility for Mississippi River water control activities within the St. Paul and Rock Island Districts. Real-time water control decisionmaking is conducted at the District Water Control centers.

3.6.2 Functions of the District Water Control Center

The principal functions of the District Water Control centers are:

- o hydrologic data collection and processing
- o inter- and intra-agency data exchange
- o water control decision-making and project regulation for authorized purposes
- o instructions to project operators
- o reporting to higher authority
- o monitoring project effectiveness and preserving project integrity
- o input to inter- and intra-agency studies affecting or affected by project regulation
- o review of plans, construction, actions by others affecting project regulation

The real-time functions stated above are generalized. They encompass many tasks, such as information exchange, hydrologic forecasting, application of computer models, briefings and release scheduling. District Water Control staff also maintain instrumentation and communications facilities in the office and in the field, develop water control plans, prepare water control manuals, establish discharge ratings for streams and structures, and prepare annual and post-flood reports, including input to any studies affecting project regulation.

3.6.3 Development of Water Regulation Manuals

Reservoir regulating manuals are required for each water control structure operated by the Corps of Engineers by Engineering Manual 1110-2-3600, Chapter 9, dated November 30, 1987.

Standing Instructions to Project Operators for Water Control are issued for each navigation dam to the lockmaster. Physical operating constraints are clearly outlined to assure that the dams are operated in a safe and efficient manner.

A Master Regulation Manual for Mississippi River 9-Foot Channel Projects was completed in September 1969 and reprinted with revisions in 1981. This manual documents pertinent aspects of system operation that had been incorporated into the design of the system and that have evolved through nearly fifty years of operating experience. The Master Manual contains information common to all the 9-Foot Channel Project navigation dams. Its purpose is to provide guidance and instructions for project personnel and to serve as a reference source for higher authority and new personnel involved with regulation of the river.

Manuals for the individual navigation dams, including lock and dam 8, were completed in 1972. These manuals contain detailed information pertinent to the operation of the specific projects and are issued as appendices to the Master Manual. Division Commanders are responsible for approving Water Control Manuals.

3.6.4 Process for Modifying Reservoir Operating Plans and Regulation Manuals

Minor modifications to operating plans of existing Corps of Engineers reservoirs that increase benefits for Congressionally-authorized project purposes (optimize operation) without significant reductions in benefits for other project purposes can be developed and implemented by Corps Districts following review and approval by the appropriate Corps Division office.

Revised water control plans to add a new objective not included in the project authorization, other than 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.

The Water Resources Development Act of 1988, P.L. 100-676, Sec. 5, provides for public review and comment prior to any change in reservoir operation which would significantly affect any project purpose.

Investigations to update and optimize reservoir operating plans are funded under standing authorities for operation and maintenance of existing projects. During this process, coordination is made with Federal, State, industry, and public interests. An Environmental Assessment may be prepared and distributed for review, following the requirements of the National Environmental Policy Act. Following a Finding of No Significant Impact by the District Engineer, and Division approval, the modified regulation plan may be implemented. A number of modifications to reservoir operating plans in the St. Paul District have been made in this manner. This kind of minor modification to existing operating plans is incorporated into the Reservoir Regulating Manuals as they are updated. The only significant change to the reservoir regulation manual for lock and dam 8 was made in 1971, when the drawdown at the dam was reduced to one foot.

APPENDIX C

COORDINATION/CORREPSONDENCE

Water Level Management Task Force
Study Coordination

Five meetings of the Water Level Management Task Force were held during e period May 7, 1996, through September 26, 1996, for the primary purposes study scoping, coordination, and review. The following is a list of rticipants.

Name	Representing	May 7	Jun 4	Jul 11	Aug 6	Sep 26
ry Palesh	Corps of Eng	x	x	x	x	x
etchen Benjamin	Wisconsin DNR	x	x		x	x
ot Johnson	Minnesota DNR	x		x	x	x
ott Jutila	Corps of Eng	x	x	x		x
nt Pehler	Brennan Marine		x	x	x	x
e Wlosinski	Nat Bio Ser	x	x		x	x
ith Beseke	USFWS			x	x	x
rry Birkenstock	Corps of Eng	x	x		x	
uce Carlson	Corps of Eng		x	x	x	
n Krumholz	Corps of Eng		x		x	x
ck Otto	Corps of Eng	x	x		x	
m Schlagenhaft	Minnesota DNR		x	x		x
n Wilcox	Corps of Eng	x	x			x
ke Griffin	Iowa DNR				x	x
e Nelson	UMR Services				x	x
n Powell	Corps of Eng				x	x
Stevens	Minnesota DNR	x			x	
vin Berg	Corps of Eng			x		
rol Damberg	USFWS	x				
ke Davis	Minnesota DNR	x				
n Dieterman	Minnesota DNR					x
len Fisher	Wisconsin DOT	x				
n Hendrickson	Corps of Eng				x	
n Lubinski	Nat Bio Ser			x		
rry Moe	Wisconsin DNR			x		
hn Murren	Coast Guard					x
ic Nelson	USFWS				x	
Passe	Private Citizen	x				
rc Schultz	UW Extension		x			
ry Wege	USFWS		x			

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Upper Mississippi River Refuge Complex
51 East 4th Street
Winona, Minnesota 55987

IN REPLY REFER TO:

September 19, 1996

Mr. Gary Palesh, Project Manager
St. Paul District, Corps of Engineers
190 Fifth Street East
St. Paul, Minnesota 55101-1638

Dear Mr. Palesh:

Enclosed are Fish and Wildlife Services (Service) comments to aid you in the development of the final Problem Appraisal Report for Water Level Management, Pool 8, Upper Mississippi River.

This study of the implication of possible drawdown scenarios reflects a philosophical change on the part of the Corps. The report points out that channel maintenance to allow safe and reliable navigation and environmental restoration of the river are not mutually exclusive. From a wetland ecology point of view, 50 years of stable water levels has harmed the river. It is time to implement a drawdown. The Corps has done a fine job in drafting this important document.

Specific comments follow:

Page 1-3, Section 1.2 (Purpose)

Under specific study purposes: the #2 statement omits any economic benefits (only mentions costs). There will be economic benefits with increased fishing, hunting, tourism, water quality, etc., if the river health is improved as a result of increased aquatic vegetation (and ultimately, lower habitat rehabilitation project costs).

Plate 5

This would be more useful if it were more legible. You may need to expand your explanation of this chart on page 2-4 to clarify what you are saying.

Plate 6

Again, this plate would be better if it were more legible.

Page 2-4, 2nd paragraph, 2nd sentence

The term "backwater" needs to be defined. Most people think of backwaters as those areas off the main channel.

Page 2-8, vegetation terrestrial

Check to see that your genus is correct. Most honeysuckle is in the genus *Lonicera* or *Diervilla* (Northern Bush-honeysuckle)

Page 2-8, vegetation aquatic

The loss of vegetation in open lake areas may also be due to lack of drawdown type events.

Page 2-11, 2.6.1 Wildlife

More emphasis should be placed on the importance of this pool relative to waterfowl use in the fall (numbers of species and waterfowl use-days). Also you might mention other types of wildlife utilizing the pool (herons, egrets, bitterns, rails, passerine birds, turtles, etc.).

Page 2-14, Section 2.6.4, Threatened or Endangered Species

The Higgin's pearly mussel is a federally listed endangered species.

Page 5-4 Hydrologic/hydraulic changes

Isolation of small water bodies of 30 - 60 acres could impact the pool 8 hydrology. Connectivity of the River would be affected. The same is true for mid size drawdowns

Page 5-5 5.1.3 Ecological

There would be a potential increase in Purple loosestrife.

Page 5-9 5.1.13 Implementation

Increased Operation & Maintenance costs to the Service would be a serious concern.

Page 5-29 Ecological

A winter drawdown beginning in mid-November may also disrupt migrating waterfowl and wading bird feeding patterns, depending on the years weather patterns. Waterfowl may be utilizing areas which are drawn down. There are potential negative and positive effects depending on the species.

Page 5-45, Drawdown Duration

The growing season start date of June 15 seems a little late. Submergents begin growing in pools before ice out. A June 1 or mid-May would probably be better.

Page 5-51, table 5-7

This table needs clarification e.g. what is meant by "Acres exposed by height of exposure"

We should consider draft restrictions with 3 foot drawdown scenario? Perhaps 8 feet would be cost effective to reduce the amount of dredging required.

Page 5-60, last paragraph, St. sentence

Citations to back up this statement about the cost ratio of barge vs other transportation and the other subsequent statements would be appropriate.

Table 6-1

This table could use some explanation. At first glance, there would appear to be an anomaly in the ecological effects portion (acres exposed at various flow rates). It makes sense, but some readers won't have the background to reason it out.

Table 6-2

It's worth stating that there are significant economic benefits for a drawdown in terms of number of acres of restored versus the cost to the COE for additional dredging. Witness what we are spending now in EMP to attempt to restore just a few acres.

Table 6-4

Cost of EMP habitat restoration in Pool 8 (i.e. Pool 8 Island, Phase I and II and East Channel Project) should be reflected in table as one row. This would give the reader the opportunity to understand this type of restoration costs (cost versus acres impacted).

What is the incremental cost of the additional dredging needed for the drawdowns? The estimated average annual costs column doesn't have much meaning without something to use as a comparison - e.g. $275,000 seems like a lot of money for a two season drawdown until it is compared to the annual budget for maintaining and operating the 9-foot channel.

Table 6-4 to 6-7

Are the additional incremental costs entirely the result of additional dredging or do they include other factors (i.e. navigation losses, inconvenience to industry, etc)? In other words, are the additional costs actual project construction costs?

Page 8 - 11

The river has two Congressional mandates, 1) navigation and 2) the establishment of the Upper Mississippi River National Wildlife & Fish Refuge for the preservation of wildlife and fish for future generations. Throughout this document, the economic value of a biologically and ecologically healthy river system has not been stressed enough. The emphasis has been on the economic costs to navigation, CoE, and private marinas. The economic benefits related to recreation, increased tourism/hunting/fishing, commercial fishing, and federal/state governments (with relation to implementing habitat management) need to be factored in.

Thank you for the opportunity to review this preliminary draft document. If you have any questions, please contact Keith Beseke or myself (507/452-4232). When this document is revised the Service will make its recommendations to the Water Level Management Task Force and the Corps of Engineers on "What is the next step?" or which combination of the two approaches outlined in the summary in Chapter B should be implemented.

Sincerely,

Jim Fisher

James R. Fisher
Complex Manager

cc: Gary Wege, TCFO
Pam Thiel, FRO
District Managers, UMRNW&FR

WISCONSIN DEPT. OF NATURAL RESOURCES

State of Wisconsin \ DEPARTMENT OF NATURAL RESOURCES

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September 23, 1996

Mr. Gary Palesh
USACE - St. Paul District
Corps of Engineers Centre
190 Fifth Street, East
St. Paul, Minnesota 55101-1638

Subject: Preliminary Draft, Problem Appraisal Report for Water Level Management
Pool 8 - Upper Mississippi River

Dear Mr. Palesh:

Thank you for providing the Preliminary Draft - Problem Appraisal Report For Water Level Management, Pool 8, Upper Mississippi River. This document represents a great step forward in the understanding of water level management in Pool 8 and for the other St. Paul District pools. Thank you for your hard work and your role in moving forward on this important issue.

Comments from the Wisconsin Department of Natural Resources, River Unit are included in the balance of this letter. For the ease of editing, the comments will be listed in sequential order by page.

The Executive Summary is a wonderful synopsis of the information and discussion contained in the document. I would suggest that once the document is finalized that you send it out to voting members on the River Resources Forum. The summary will provide an excellent background for those members who do not typically get into the nuts and bolts of a document this size. It may also be appropriate to send the summary to the UMRBA and the Rock Island District.

Page 2-1 has a small error in the text. In the third paragraph it states that a minimum discharge of 1500 cfs is maintained over the spillway. The Wisconsin Department of Natural Resources has recommended summer flows between 1200 and 1500 cfs and the winter flows around 500 cfs. It is my understanding that the crew at Lock 7 has agreed to honor those targets and will adjust the gates in the spring and the fall to achieve the correct cfs. The effects of the two flow levels recommendations will be monitored to determine if they are accomplishing the goals for the natural resources downstream of the spillway. Therefore, it would be more accurate to list the target flows on page 2-1.

Page 4-6 contains the priority for alternatives that merit further evaluation according to the Water Level Management Task Force. With the additional information provided by this document, the Wisconsin Department of Natural Resources would like to recommend a modification to the priorities. We believe that increasing the frequency of gate adjustment (pool wide) should be a medium priority. There are three reasons why we would like to this alternative evaluated in more depth than is currently suggested.

One of the main goals of water level management work is to try and examine methods to replicate natural river processes. One attribute of a natural river is the gentle transition from one water level to another, unless a significant rainfall or snow melt event occurs. Increasing the frequency of gate adjustments would help provide that gentle slope rather than the bounce that occurs with the twice daily gate adjustments. Daily fluctuations of up to 0.5 feet, as mentioned in this report, are significant to those seeds germinating at the edge of the water line. If these fluctuations could be minimized by more frequent gate adjustments, there would be a substantial increase in quantity and quality of edge plants, one of the main components we are trying to stimulate with water level management.

It appears with this document that drawdown is an option for management of Mississippi River habitats in the future. Any drawdown would be enhanced if the water levels went down slow and remained relatively stable until the fall flood pulse brought higher water levels back to the river. More frequent gate adjustments would stabilize water level throughout drawdown and raise which would effectively expand the area that germination would occur.

More frequent gate adjustment should also be investigated because the Corps' has authority to implement this strategy immediately. It is important to implement useful measures that will help maintain vital components of the ecosystem as we work toward additional solutions.

Section 5.3.2. discusses the opportunities to regulate on the "high" or "low" side of the band. Operating on the low end of the band during the summer could have some major impacts, especially if combined with more frequent gate adjustments. The combination of these techniques could be implemented next summer without changing any authorization. This technique would not have as great of an impact as a one foot or more drawdown, but would probably have a greater impact than stated in the evaluation. As suggested in the Nike commercials, "Just do it."

Section 5.3.2.4 discusses operations and the frequency of gate adjustment. A general statement suggests that there is a point where existing staff cannot keep up with gate adjustments. Do you know what point that is?

Page 5-46: Last Paragraph. The table reference is 5-6, not 5-5.

Page 5-54: The information and conclusion about drawdown and reflooding stated in this section appear to be absolutes. Because we can only speculate what will happen, it is important to write in those terms and very closely monitor any actual work that is done so we can document what the response will be on the Mississippi River to a large scale drawdown.

Section 5.4.4.5.2 should include two additional statements. At the end of the second paragraph it should say that, "The Corps will work with the Coast Guard to establish a nine-foot draft restriction prior to any drawdown." In addition, it is unclear whether the Brownsville placement site will have to be expanded to accommodate the additional dredged material. If the site would increase in size and fill in additional wetlands that should be stated at the end of paragraph four.

Table 7-6 is an important piece of information when considering where the first drawdown might occur. I believe it is a mistake to include the St. Croix in the percents for distribution of boaters in the St. Paul District. The St. Croix is very heavily used and those users do come to the Mississippi to recreate but not in the portion that is indicated by the table. Many of the 40.4% stay on the St. Croix, so it would more appropriate to use the numbers that just pertain to the Mississippi River. Those numbers are available in the 1995 aerial boating study report.

One final general comment, water level management is still in the planning stages, but it appears that it will become reality on the River. As we proceed down this new path, we must continue to acknowledge that the productivity of the River is dependent on restoring a dynamic system. What this means for any management plan is that we should not "lock" ourselves into only doing one or three foot drawdowns every X number of years or always operate on the high side (0.25 feet) in the winter. While these changes will show some benefits for a time, at some point in the future there will be a point of diminishing return. A couple of examples of this are from moist soil management sites and green tree reservoirs which were drawn down and flooded at the same interval for the same length of time year after year. Eventually they noticed reduced plant productivity and diversity. In the case of green tree reservoirs, growth of new seedlings was almost nonexistent due to flooding out the seedlings every year and the health of existing trees began to deteriorate (including butt swelling). In other words, we will have to be flexible and constantly looking to the resource to give us answers on how we should proceed.

Thanks again for all your hard work. Some folks are comparing this work with the early work of GREAT and EMP, and I am inclined to agree. This may be the start of another important tool for Mississippi River management.

Sincerely,

Gretchen Benjamin

Gretchen L. Benjamin
Mississippi River Planner

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