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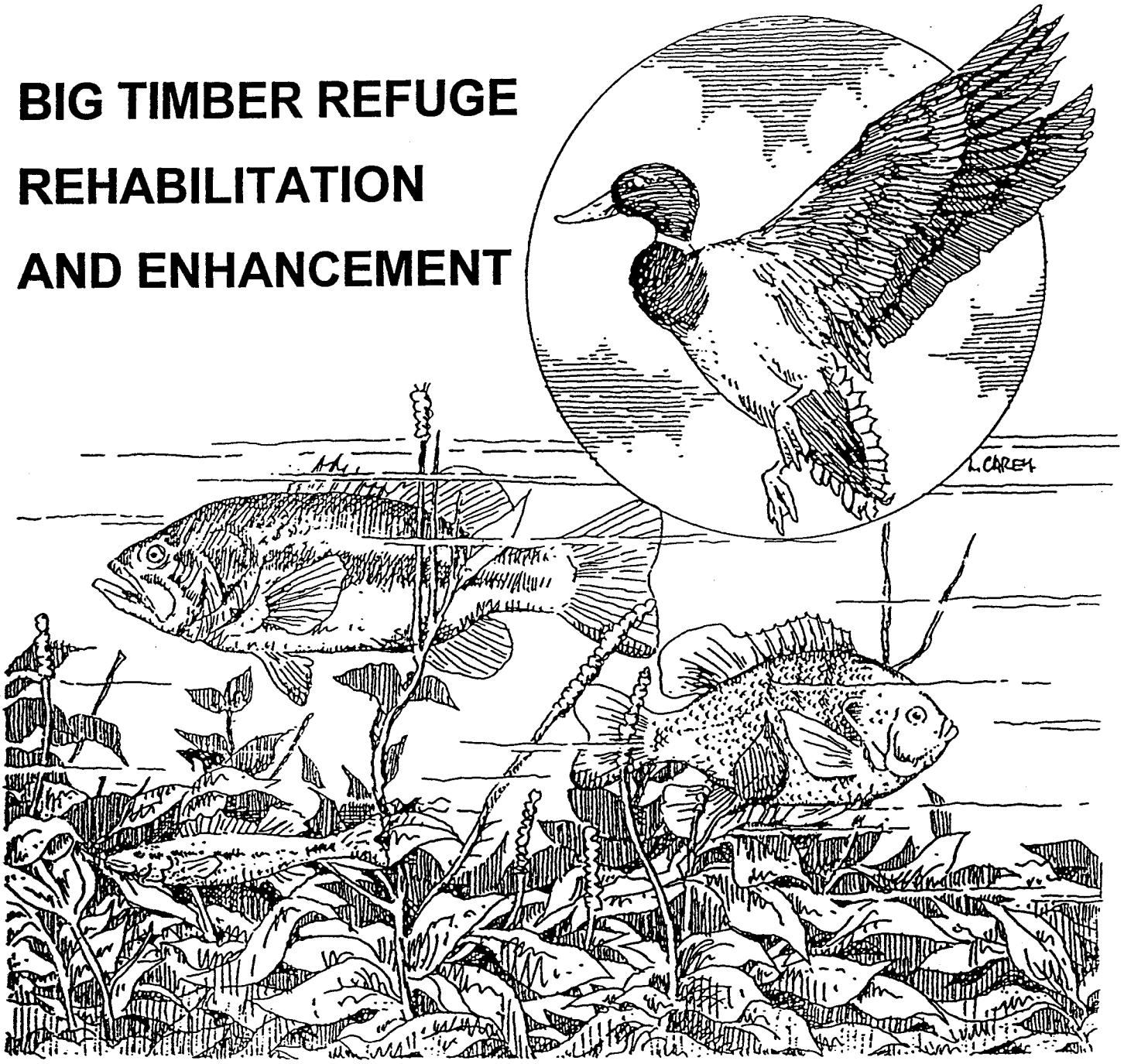
UPPER MISSISSIPPI RIVER SYSTEM
ENVIRONMENTAL MANAGEMENT PROGRAM
POST-CONSTRUCTION PERFORMANCE
EVALUATION REPORT (PER5D)

BIG TIMBER REFUGE REHABILITATION AND ENHANCEMENT



OCTOBER 1995

US Army Corps
of Engineers
Rock Island District

POOL 17
UPPER MISSISSIPPI RIVER
MILE 443-445
LOUISA COUNTY, IOWA

DEPARTMENT OF THE ARMY
ROCK ISLAND DISTRICT, CORPS OF ENGINEERS
CLOCK TOWER BUILDING – P.O. BOX 2004
ROCK ISLAND, ILLINOIS 61204-2004

October 30, 1995

REPLY TO ATTENTION OF:

Planning Division

SEE REPORT DISTRIBUTION LIST (APPENDIX E)

The Rock Island District of the U.S. Army Corps of Engineers has enclosed a draft of the Performance Evaluation Report for the Big Timber, Iowa, Habitat Rehabilitation and Enhancement Project (HREP), as part of the Upper Mississippi River System - Environmental Management Program (UMRS-EMP). The report is being provided for your review and comment. Final distribution of the subject report is scheduled for January 1996.

In addition to your evaluation of the subject report, we request that you make available to the appropriate Rock Island District elements (see report development team members listed below) copies and/or summaries of all data (raw or in final form) or other quantitative or qualitative information pertinent to the subject project but not reflected in this draft report. To both fully incorporate your input and realize the final distribution schedule acknowledged previously, we request that your response be received no later than close of business November 17, 1995.

The HREP Performance Evaluation Reports such as this one are the primary vehicle for communicating project effectiveness and will be the basis for assessing the overall success or failure of the UMRS-EMP's HREP element. For these reasons, we must assure that they are as comprehensive as possible. Your support and cooperation to that end is critical.

Should you have any questions regarding this correspondence, please call Mr. Jerry Skalak of our Waterway Systems Branch, telephone 309/794-5605.

The following is a list of the Performance Evaluation Report Development team members from Planning Division (PD) and Engineering Division (ED). The telephone number is 309/794-XXXX (number as shown in list):

Name	Division/Area of Evaluation	Phone
Joe Jordan	PD (Biological performance)	5697
Jerry Skalak	PD (General coordination)	5605
Celia Kool	ED (Physical performance/ report preparation)	5623
Dave Bierl	ED (Water quality parameters)	5581

Sincerely,

Dudley M. Hanson, P.E.
Chief, Planning Division

Enclosure

DEPARTMENT OF THE ARMY
ROCK ISLAND DISTRICT, CORPS OF ENGINEERS
CLOCK TOWER BUILDING – P.O. BOX 2004
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REPLY TO
ATTENTION OF:

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POOL 17, MISSISSIPPI RIVER MILES 443.5-445.0
LOUISA COUNTY, IOWA

OCTOBER 1995

ACKNOWLEDGMENT

Many individuals of the Rock Island District of the U.S. Army Corps of Engineers, the U.S. Fish and Wildlife Service, and the Iowa Department of Natural Resources contributed to the development of this initial Post-Construction Performance Evaluation Report for the Big Timber Refuge Rehabilitation and Enhancement Project. These individuals are listed below:

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PROJECT ENGINEER:	Celia C. Kool, P.E. Bob Hoffman
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BIG TIMBER REFUGE REHABILITATION AND ENHANCEMENT

POOL 17, MISSISSIPPI RIVER MILES 443.5 - 445.0
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1. INTRODUCTION

The Big Timber Refuge Rehabilitation and Enhancement project, hereafter referred to as "the Big Timber project," is an ongoing part of the Upper Mississippi River System (UMRS) Environmental Management Program (EMP). The Big Timber Project is a U.S. Fish and Wildlife Service (USFWS) management unit of the Louisa Division of the Mark Twain National Wildlife Refuge.

a. Purpose. The purposes of this report are as follows:

(1) Summarize the performance of the Big Timber project, based on the project goals and objectives;

(2) Review the monitoring plan for possible revision;

(3) Summarize project operation and maintenance efforts to date; and

(4) Review engineering performance criteria to aid in the design of future projects.

b. Scope. This report summarizes available project monitoring data, inspection records, and observations made by the U.S. Army Corps of Engineers (Corps), the USFWS, and the Iowa Department of Natural Resources (IADNR) for the period from July 1991 through September 1995.

c. Project References. Published reports which relate to the Big Timber project or which were used as references in the production of this document are presented below.

(1) *Definite Project Report with Integrated Environmental Assessment (R-5), Big Timber Refuge Rehabilitation and Enhancement, Pool 17, Upper Mississippi River, Louisa County, Iowa*, July 1989 (DPR). This report presents a detailed proposal to dredge a channel from Coolegar Slough into Big and Little Denny (isolated backwater ponds) with sidecasting of mechanically excavated material, confined placement of hydraulically dredged material, planting mast trees, and blasting of potholes in the mudflats of the Big Timber Refuge. The report marks the conclusion of the planning process and serves as a

basis for approval of the preparation of final plans and specifications and subsequent project construction.

(2) *Plans and Specifications, Upper Mississippi River System, Environmental Management Program, Pool 17, River Miles 443-445, Big Timber Refuge*, November 1989, Contract No. DACW25-90-C-0040. This document was prepared to provide sufficient detail of project features to allow construction of the dredged channel, sidecasting mechanically excavated material, confined placement of hydraulically dredged material, and blasting of open water holes by a contractor.

(3) *Plans and Specifications, Upper Mississippi River System, Environmental Management Program, Pool 17, River Miles 443-445, Big Timber Refuge*, March 1993, Contract No. DACW25-93-C-0034. This document was prepared to provide sufficient detail of project features to allow planting of mast trees by a contractor.

(4) *Operation and Maintenance Manual, Big Timber Refuge Rehabilitation and Enhancement, Upper Mississippi River Environmental Management Program, Pool 17, River Miles 443-445, Louisa County, Iowa*, June 1994. This manual was prepared to serve as a guide for the operation and maintenance of the Big Timber project. Operation and maintenance instructions for major features of the project are presented.

(5) *Big Timber Habitat Rehabilitation and Enhancement Project, Great Flood of 1993 Damage Assessment*, March 1994. This document was prepared to provide a summary describing the Flood of 1993 damage, proposed corrective action, and estimated cost for repairs.

(6) Letter from Mr. Robert Kelley, Corps, to Mr. William Hartwig, USFWS, August 1995. This letter transmits shop drawings and formally transfers the Big Timber project to the USFWS.

2. PROJECT GOALS, OBJECTIVES, AND MANAGEMENT PLAN

a. General. As stated in the DPR, the Big Timber project was initiated in response to the quantitative and qualitative losses of off-channel aquatic and wetland habitat due to sedimentation.

b. Goals and Objectives. Goals and objectives were formulated during the project design phase and are summarized in Table 2-1.

TABLE 2-1
Project Goals and Objectives

Goals	Objectives	Project Features
Enhance Aquatic Habitat	Restore deep (>6 feet) aquatic habitat	Hydraulic Dredging
	Restore shallow (2-3 feet) aquatic habitat	Mechanical Excavation
	Improve levels of dissolved oxygen during critical seasonal stress periods	Dredging & Excavation
	Provide year-round habitat access (cross-sectional area)	Dredging & Excavation
Enhance Terrestrial Habitat	Produce mast tree dominated areas	Revegetation
Enhance Migratory Waterfowl Habitat	Increase reliable resting and feeding water area	Pothole Creation and Dredging/Excavation
	Provide isolated resting, feeding, and brooding pools	Pothole Creation

c. Management Plan. A formalized management plan was not required for this project. The Big Timber project is operated as generally outlined in the Operation and Maintenance manual.

3. PROJECT DESCRIPTION

a. Project Features. Plate 1 shows a general site plan, and plate 2 shows project features. The constructed project includes:

(1) Creation of Deep Channels. Hydraulic dredging of approximately 94,000 cubic yards to create a 35- to 50-foot-wide by 5,400-foot-long channel to the mouth of Big Denny. Minimum dredge depth was to elevation 528 (8 feet below Pool 17 flat pool of elev. 536). Dredged material was placed in a confined dredged material placement site (CPS) between the Mississippi River and Big and Little Denny;

(2) Shallow Habitat Excavation. Mechanical excavation of approximately 66,000 cubic yards from the mouth of the Willow Chute area to the heads of Big and Little Denny to provide a 40- to 50-foot-wide by 9,400-foot-long shallower area (located immediately adjacent to the hydraulically dredged channel in Willow Chute). Minimum dredge depth was to elevation 532.5 (3.5 feet below Pool 17 flat pool);

(3) Check Dams. Construction of three check dams from mechanically excavated material at those locations where overland flows are depositing sediment at the project site;

(4) Potholes. Creation of 10 potholes by blasting openings in the mudflats where willows were encroaching;

(5) Boater Access Control. Creation of boater access control by the placement of cleared timber at several locations in the dredged channel; and

(6) Mast Tree Planting. Revegetation by planting 900 trees consisting of 11 mast-producing species on the CPS containment dike.

The deep dredging was designed to restore over-winter and summer thermal refuge areas for fish. The shallower areas will increase fish spawning and nursery habitat. Planting mast trees will enhance terrestrial habitat value. The increase in acreage of year-round open water will increase habitat available to wood duck broods, and the creation of potholes in the mudflat area will provide protected areas for wood ducks.

b. Construction and Operation. Following award of the first contract on May 22, 1990, dredging began during late summer and was essentially completed in the fall of 1991. Final inspection of the vegetation at the dredged material placement site was accomplished following the first growing season. This time allowed concerns to be addressed that seeding or earthwork could be needed in sandy areas to induce sufficient vegetative growth. However, adequate vegetation established itself and additional work was not needed. Final inspection of project construction was made in the summer of 1992. Following award of the second contract on June 2, 1993, mast trees were planted during the fall and follow-up maintenance was completed in the spring of 1995. The project requires no operational activities.

4. OPERATION, MAINTENANCE, AND PROJECT MONITORING

a. General. Appendix A presents the Post-Construction Evaluation Plan. This plan was developed during the design phase and serves as a guide to measure and document project performance. Appendix B contains the Monitoring and Performance Evaluation Matrix and Resource Monitoring and Data Collection Summary. This schedule presents the types and frequency of data that have been collected to meet the requirements of the Performance Evaluation Plan.

b. Corps of Engineers. The physical locations of the sampling stations referenced in the Performance Evaluation Plan and the Resource Monitoring and Data Collection Schedule are presented on plate 3. As part of the Flood of 1993 Damage Assessment, soundings (sedimentation transects) were taken by the Corps on January 12, 1994, at the 11 Big Timber project dredged channel sedimentation transects. The sedimentation transect data are shown on plates 4 through 10. The Corps also has collected water quality data at one station. The Corps surveyed pothole sedimentation transects in September 1995; the 10 pothole sedimentation transects are shown on plates 11 through 14. The success of the project relative to original project objectives will be measured using this data along with other data, field observations, and project inspections performed by the USFWS and the IADNR. The Corps has overall responsibility to measure and document project performance.

c. U.S. Fish and Wildlife Service. The USFWS is responsible for operating and maintaining the Big Timber project. The USFWS does not have project-specific monitoring responsibilities. This is a Corps responsibility as identified in the 6th Annual Addendum for the UMRS-EMP. The USFWS Refuge Manager is required to conduct annual inspections of the project and to participate in periodic joint inspections of the project with the Corps.

d. Iowa Department of Natural Resources. The IADNR has collected fish data at the Big Timber project (currently not identified as a project monitoring requirement).

5. EVALUATION OF AQUATIC HABITAT OBJECTIVES

a. Restore Deep (>6 Feet) Aquatic Habitat.

(1) Monitoring Results. Dredged channel sedimentation transects for Round Pond, Timber Chute, Willow Chute, and Big Denny are shown on plates 4 through 8. As shown in Appendix A, Table A-1, the Big Timber project was designed to include 100 acre-feet of deep aquatic habitat at year 50. Changes in project scope between the DPR and construction eliminated the deep dredging in Big and Little Denny described in the DPR. As built, about 78 acre-feet of deep aquatic habitat was constructed (see Appendix D, Table D-1). At year 4, nearly 70 acre-feet of deep water habitat remains available. According to the Corps of Engineers Great Flood of 1993 Damage Assessment for the Big

Timber project, soundings indicated that sedimentation was generally less than 4 inches but up to 2 feet in the reach known as Timber Chute. During the June 1995 USFWS Site Manager's project inspection, bank sloughing (approximately 3 feet) was observed throughout the east bank of Timber Chute (see Appendix C). The trees placed in the water for additional fish structure have remained in place. Aquatic vegetation, such as pondweed (*Potamageton* sp.), has begun to inhabit the deep aquatic habitat.

(2) Conclusions. Based on the advertised project plans and assuming 0.5 inch/year sediment accretion referenced in the DPR, the Big Timber project should have approximately 55 acre-feet of deep aquatic habitat at year 4 and more than 42 acre-feet of deep habitat at year 50 (see Appendix D, Table D-2). Continued monitoring will determine whether the 8 acre-feet of sediment deposition that has occurred since construction was due primarily to the Great Flood of 1993 or from higher than estimated average annual sedimentation rates.

Verbal communication with USFWS and IADNR personnel indicated a positive fisheries response to the Big Timber project.

b. Restore Shallow (2-3 Feet) Aquatic Habitat.

(1) Monitoring Results. Dredged channel sedimentation transects for Willow Chute, Big Denny, and Little Denny are shown on plates 5 through 10. As shown in Appendix A, Table A-1, the Big Timber project was designed to include 30 acre-feet of shallow aquatic habitat at year 50. Changes in project scope between the DPR and construction also included a decrease in the width of shallow dredging for Willow Chute, which affected the quantity of shallow habitat. As built, more than 44 acre-feet of shallow aquatic habitat was constructed (see Appendix D, Table D-1). At year 4, approximately 39 acre-feet of shallow water habitat is available. During the June 1995 Site Manager's project inspection (see Appendix C), pondweed was present, occupying approximately 5% of the surface area, and bank sloughing (approximately 2 feet) was evident along the east bank throughout Little Denny. At the site of Big Denny dredging, pondweed was present and occupied approximately 20% of the surface area. Arrowhead (*Sagittaria* spp.) and an unknown grass species also occurred adjacent to the dredge cut and occupied approximately 5% of the surface area. The boat access control and the trees placed in the water for additional fish structure remain in place.

(2) Conclusions. Based on the advertised project plans and assuming 0.5 inch/year sediment accretion referenced in the DPR, the Big Timber project should have almost 38 acre-feet of deep aquatic habitat at year 4 and nearly 16 acre-feet of deep habitat at year 50 (see Appendix D, Table D-2). Continued monitoring will determine whether the 5 acre-feet of sediment deposition was due primarily to the Great Flood of 1993. The USFWS Site Manager's report noted that pondweed and arrowhead are preferred waterfowl submergents. Quality and quantity of aquatic vegetation will be monitored in the future.

c. Improve Levels of Dissolved Oxygen During Critical Seasonal Stress Periods.

(1) Monitoring Results. As shown in Appendix A, Table A-1, the Big Timber project was designed to maintain a minimum of 5 mg/l dissolved oxygen at year 50. At year 4, dissolved oxygen levels have rarely fallen below 5 mg/l. Baseline water quality monitoring at site W-M443.6G (see plate 3 and Table B-2) commenced on May 6, 1989, and is currently ongoing. The project's original fact sheet identified several resource problems. Severe summer and winter fish kills attributable to low dissolved oxygen levels and freeze outs, respectively, were reported. The water quality objective of the project was to increase levels of dissolved oxygen during critical seasonal stress periods to a minimum concentration of 5 mg/l. The purpose of the monitoring program was to determine baseline water quality conditions by measuring dissolved oxygen and related parameters and then to perform post-construction monitoring to determine the project's impact.

The water quality monitoring results from samples collected at site W-M443.6G are found in Appendix D. Pre-project monitoring was performed from May 6, 1989, through September 29, 1990. Post-project monitoring was performed from September 24, 1991, to the present. Corps sampling was not performed during project construction or during the summer of 1993. Water quality monitoring was performed by the construction contractor during the construction phase to meet permit requirements.

Pre-project dissolved oxygen measurements were taken on 24 occasions. The minimum, maximum, and average concentrations of these measurements were 0.6 mg/l, 19.70 mg/l and 10.45 mg/l, respectively. Post-project dissolved oxygen measurements were taken on 39 occasions. The minimum, maximum, and average concentrations of these measurements were 2.91 mg/l, 16.61 mg/l and 9.87 mg/l, respectively. The pre-project minimum dissolved oxygen concentration was less than the post-project minimum, while maximum and average values were higher. The differences in the observed pre- and post-project minimum and maximum values could be due to plant respiration and photosynthesis. Prior to the project, aquatic macrophytes were present and there was a greater abundance of phytoplankton (as indicated by the chlorophyll a data). The presence of these plants would result in higher dissolved oxygen concentrations during periods of photosynthesis and lower concentrations during periods of respiration. Therefore, it is hypothesized that the removal of the macrophytes during dredging resulted in a narrower range of dissolved oxygen concentrations. The post-project average dissolved oxygen concentration (9.87 mg/l) was slightly lower than the pre-project average (10.45 mg/l). The reasons for this could be twofold: first, the pre-project monitoring period was only 17 months long, which is a relatively short duration for determining a long-term average; and second, all measurements were made during daytime hours when dissolved oxygen concentrations would be affected by plant photosynthesis. If measurements were taken at night (when photosynthesis is not occurring) the post-project average dissolved oxygen concentration would probably have exceeded the pre-project average.

Two pre-project and five post-project dissolved oxygen concentrations were less than 5 mg/l. None of the five post-project measurements occurred during the winter. Again,

due to the relatively short duration of the pre-project monitoring period, it is difficult to make any statistically valid conclusions concerning these results. To date, the project has been successful in attaining the target level dissolved oxygen concentration of 5 mg/l during the critical winter months; however, this level is not always attained during the summer.

(2) Conclusions. Comparisons of pre-project and post-project data are difficult due to the relatively short duration of the pre-project monitoring period. The project has been successful in attaining the target dissolved oxygen level (5 mg/l) during the critical winter period. On occasion, during the remainder of the year, dissolved oxygen levels have fallen below the target level; however, the post-project minimum value (2.91 mg/l) is considerably higher than the pre-project minimum (0.60 mg/l). It appears that although the project has not always maintained the target level dissolved oxygen concentration, it has been successful in raising the minimum dissolved oxygen concentration. Another indication of the project's success is that discussions with USFWS and IADNR personnel have not observed any fish kills since project completion. Apparently, post-project dissolved oxygen concentrations have not been at a level detrimental to the fishery, or perhaps the dredged channels have allowed for fish egress from the area during periods of low dissolved oxygen.

d. Provide Year-Round Habitat Access (Cross-Sectional Area).

(1) Monitoring Results. Dredged channel sedimentation transects for Round Pond, Timber Chute, and Willow Chute are shown on plates 4 through 8. As shown in Appendix A, Table A-1, the Big Timber project was designed to have 500 square feet of year-round habitat access (cross-sectional area) at year 50. As built, a minimum of 523 square feet cross-sectional area of year-round habitat access was created in Round Pond and Willow Chute, and 381 square feet cross-sectional area of year-round habitat access was created in Timber Chute (see Appendix D, Table D-1). At year 4, a minimum of 427 square feet of year-round habitat access is available in Round Pond and Willow Chute. Timber Chute has 168 square feet of year-round habitat access available at year 4. During the June 1995 USFWS Site Manager's project inspection, bank sloughing (approximately 3 feet) was observed throughout the east bank of Timber Chute (see Appendix C).

(2) Conclusions. The year-round habitat access (cross-sectional area) was overestimated in the DPR and did not take into consideration the different cross-sectional areas in Round Pond and Willow Chute versus Timber Chute. Based on the advertised project plans and assuming 0.5 inch/year sediment accretion referenced in the DPR, Round Pond and Willow Chute should have more than 447 square feet of year-round habitat access at year 4 and 348 square feet of deep habitat at year 50 (see Appendix D, Table D-2). Timber Chute should have almost 330 square feet of year-round habitat access at year 4 and 258 square feet of deep habitat at year 50. The current 168 square feet of year-round habitat in Timber Chute is equivalent to 80 years of sediment deposition at a uniform 0.5 inch/year. Continued monitoring will help determine the extent of sediment deposition

which can be attributed to the Great Flood of 1993 versus estimated annual average sedimentation rates.

6. EVALUATION OF TERRESTRIAL HABITAT OBJECTIVES

a. Produce Mast Tree Dominated Area.

(1) Monitoring Results. As shown in Appendix A, Table A-2, the Big Timber project was designed to include 204 acres of mast trees at year 50. At year 2, 354 acres of mast trees exist. Eleven species of mast-producing trees and shrubs were planted on the containment dike in November 1993 (Table 6-1). Because the site was inundated by floodwaters during the 1993 flood, the planting site was totally free of vegetation at the time of planting. A survey of tree survival in November 1994 indicated some tree mortality. This resulted in the replacement of 50 trees at that time. An influx of wild cucumber vine (*Sicyos angulatus*) during the 1994 growing season had completely overtopped many of the planted trees and shrubs and severely threatened their survival. An additional herbicide treatment, not specified in the original plans and specifications, was conducted in June 1995 to control wild cucumber vine.

During the June 1995 Site Manager's project inspection, an estimated 80% or greater seedling survival was noted. An additional inspection in September 1995 indicated that cucumber vine, while still present on the site, did not threaten the survival of the planted trees and shrubs. Tree heights in September 1995 ranged from 2 to 8 feet. Table 6-1 lists the relative survival and growth rates noted at that time.

TABLE 6-1

Tree and Shrub Plantings
Relative Survival and Growth Rates

Species	Number Planted	Survival	Growth Rate
northern red oak	82	good	excellent
pin oak	82	good	good
bur oak	50	fair	fair
swamp white oak	96	excellent	good
northern pecan	50	fair	poor
black walnut	50	poor	poor
butternut	150	good	good
sycamore	50	good	excellent
serviceberry	75	poor	fair
red osier dogwood	75	fair	good
gray dogwood	75	fair	good
highbush cranberry	75	good	excellent

(2) Conclusions. Survival and growth rates of the planted black walnuts were poor. This species is not recommended to be planted in significant numbers on similar sites in the future until more is known about the factors affecting tree survival. Northern red oak, serviceberry, cranberry, and the dogwood species planted are not typically found in the Mississippi River floodplain and are not recommended to be implemented on future projects until long-term survival information is collected from monitoring. Northern red oak, for example, exhibited an excellent growth rate but is classed as a flood-intolerant tree. Future monitoring will help to determine the flood tolerance of the species planted before final conclusions on acceptability are made.

It was found that the contract specifications were inadequate for the control of competing vegetation by herbicide applications within 4 feet of each planted seedling. Changed site conditions brought about by the Flood of 1993 were contributory to the weed problems that threatened tree and shrub survival during the 1994 growing season. Flood-induced tree mortality in the adjacent forest transformed the planting site from partial shade to a full sun condition. The additional sunlight allowed wild cucumber vine and other weeds to establish and grow aggressively throughout the project area. Although the 4-foot area treated with herbicide around each seedling was evident, the encroachment of cucumber vines from the forest edge had entangled many trees. For this reason, an additional herbicide application covering the entire area within 20 feet of each tree or shrub was conducted in June 1995.

7. EVALUATION OF MIGRATORY WATERFOWL HABITAT OBJECTIVES

a. Increase Reliable Resting and Feeding Water Area.

(1) Monitoring Results. As shown in Appendix A, Table A-1, the Big Timber project was designed to increase reliable resting and feeding water areas by 21 acres at year 50 (11 acres deep aquatic habitat, 10 acres shallow aquatic bed, reference DPR, page 19). Pre-project conditions (plate 15) show that most of the project area was silted in and vegetated with willows, lotus, and mixed grasses. Plate 16 shows the post-construction project in 1994. Currently, 26 acres of reliable resting and feeding water areas exist for waterfowl in the project area. Migratory waterfowl peak populations are shown in Table 7-1.

Recent observations by the USFWS and Corps indicate that preferred waterfowl foods are available such as buttonbush, acorns, duckweed, and invertebrates.

TABLE 7-1

Big Timber Peak Fall Populations

Year	Ducks	Geese
Pre-Project		
1985	5,219	550
1986	2,305	276
1987	4,095	1,100
1988	1,095	280
1989[1/]	626	65
1990[1/]	400	0
Post-Project		
1991[1/]	341	9
1992	1,337	41
1993	N/A (Flood)	N/A (Flood)
1994	276	177

(USFWS, 95)
[1/] Project construction period

(2) Conclusions. Opening up silted-in backwaters has attracted waterfowl use. Vegetation response to the project has been slow because of the 1993 flood. However, in 1994 and 1995, vegetation response has improved, and sustainable and productive vegetation has provided excellent forage and invertebrate forage for waterfowl.

For the final report, the USFWS will provide their views, opinions, and observations on the project and how well the project is performing.

b. Provide Isolated Resting, Feeding, and Brooding Pools.

(1) Monitoring Results. Pothole sedimentation transects are shown on plates 11 through 14. As shown in Appendix A, Table A-1, the Big Timber project was designed to include 10 isolated resting, feeding, and brooding pools (a.k.a. potholes) at year 50. Following construction in the fall of 1991, the USFWS summarized pothole depths and dimensions, shown in Table 7-2, along with Corps 1995 survey data. The Corps Great Flood of 1993 Damage Assessment (93DA) states that, although no soundings of the potholes were obtained, an accumulation similar to that noted on the surface of the dredged material placement site (approximately 4 to 6 inches of new sediment) could be expected in the potholes. While the potholes provide excellent habitat for waterfowl broods, extensive surveys of the potholes to determine waterfowl use have not been completed. With-project conditions are beginning to show positive waterfowl use for the overall Big Timber site, which may be attributed to the project. Waterfowl production (fledged) for the area is shown in Table 7-3.

TABLE 7-2

Big Timber Pothole Data

Dimension, Feet	1991 (USFWS)	1995 (Corps)	Change, Percent
Depth			
Average	3.9	3.2	-18
Minimum	1.4	0.8	-43
Maximum	6.8	5.5	-19
Width			
Average	39	36	-8
Minimum	24	24	0
Maximum	50	51	+2
Length			
Average	67	80	+19
Minimum	55	69	+25
Maximum	80	88	+10

TABLE 7-3

Big Timber Waterfowl Production

Year	Waterfowl Production (Fledged)
Pre-Project	
1985	165
1986	240
1987	400
1988	420
1989[1/]	438
1990[1/]	461
Post-Project	
1991[1/]	470
1992	690
1993	N/A (Flood)
1994	541

(USFWS, 95)

[1/] Project construction period

(2) Conclusions. Pothole habitat is providing resting and feeding opportunity for waterfowl. General increases in waterfowl production have occurred with the project.

Although nongame and nonwaterfowl species were not the emphasis of the Big Timber HREP, these species have benefited greatly. Species such as Great Blue Herons have begun feeding and resting along the dredged channels. The potholes have seen great response from invertebrates, amphibians, and small fish. While these benefits were assumed to occur when waterfowl was highlighted in the DPR, it is important to recognize the overall benefit of the project to a whole host of wildlife species. The final version of this report will contain USFWS vegetation, invertebrate, and seine data from the project.

Differences between USFWS and Corps pothole dimensional data are most likely due to taking measurements at different locations on the pothole perimeter. To eliminate this discrepancy, pothole sediment transect control points will be field surveyed this fall, after leaf drop. The pothole sediment transects will be added to the Resource Monitoring and Data Collection Summary, and data collected at 5-year intervals, starting in 1996.

8. OPERATION AND MAINTENANCE SUMMARY

a. Operation. The project requires no operational activities.

b. Maintenance.

(1) Inspections. Inspections of the Big Timber Project are to be made by the Upper Mississippi Wildlife Refuge District Manager (the USFWS Refuge Manager) at least annually and will follow inspection guidance presented in the Operation and Maintenance Manual. Other project inspections should occur as necessary after high water events or as scheduled by the Site Manager. Joint inspections of the Big Timber Project are to be conducted periodically by the USFWS and the Corps. These inspections are necessary to determine maintenance needs.

(2) Maintenance Based on Inspections. Herbicide treatment for the mast tree revegetation was completed June 12, 1995.

9. CONCLUSIONS AND RECOMMENDATIONS

a. Project Goals, Objectives, and Management Plan. Data and observations collected since project completion suggest that the stated goals and objectives generally are being met. Further data collection will better define sedimentation rates, survival of mast trees in/on/near dredged placement sites, and project utilization by migratory waterfowl and other wildlife.

b. Post-Construction Evaluation and Monitoring Schedules. In general, project monitoring efforts have been performed according to the Post-Construction Performance Evaluation Plan in Appendix A and the Resource Monitoring and Data Collection Summary in Appendix B. USFWS pothole monitoring (vegetation and seine hauls) will be included in the final report. The next Post-Construction Performance Evaluation will be completed in 1996 following collection of data for the first 5-year interval. A Performance Evaluation Supplement will be prepared annually.

(1) Post-Construction Evaluation. The Post-Construction Evaluation Plan Year 50 Targets were based on the project as proposed in the DPR, which included deep dredging in Big and Little Denny (an additional ±5,000 linear feet of deep dredging) and a greater quantity of shallow dredging in Willow Chute. Consequently, the year 50 targets of 4 objectives were revised to reflect as-built conditions. The year 0 acreage of mast trees also will be revised to reflect pre-project forest inventory in the project area.

(a) Restore Deep (>6 Feet) Aquatic Habitat. Based on the as-constructed dimensions, the expected deep aquatic habitat (year 0) was 55.6 acre-feet (see Table D-2 and plate 3). The year 50 target with alternative will be revised to 42.4 acre-feet for this objective.

(b) Restore Shallow (2-3 Feet) Aquatic Habitat. Based on the as-constructed dimensions, the expected shallow aquatic habitat (year 0) was 40 acre-feet (see Table D-2 and plate 3). The year 50 target with alternative will be revised to 15.8 acre-feet for this objective.

(c) Provide Year-Round Habitat Access (Cross-Sectional Area. The expected year-round habitat cross-sectional area (year 0) for this objective is 456 square feet for Round Pond and Willow Chute and 336 square feet for Timber Chute (see Table D-2). The year 50 target with alternative will be revised to 348 square feet for Round Pond and Willow Chute and 258 square feet for Timber Chute.

(d) Produce Mast Tree Dominated Areas. A pre-project forest inventory delineated 348 acres within the project area with an overstory dominated by mast-producing tree species. This acreage is not expected to remain constant, since the dominance of oak, pecan, or walnut is only a temporal stage in the life cycle of a bottomland forest. As the current forest ages, natural succession will bring about a gradual attrition of these species to be replaced by more shade-tolerant species such as silver maple and ash. Therefore, a gradual reduction in mast-producing acreage is expected over the life of the project.

In addition to the 348 acres previously available, the project added an additional 6 acres of mast-producing species. More importantly, the tree and shrub plantings introduced a diverse mixture of mast species in a linear strip traversing a large portion of the project area. By locating the new plantings on the containment dike above the surrounding floodplain, they are protected from damage by most flood events. This feature helps to

assure the availability of these species as a seed source for the future. Silvicultural practices will be performed within the project life span to provide for the regeneration of mast-producing species in the project area. Through proper forest management, a minimum of 204 acres of mast dominated forest stands will be available at year 50. The Year 0 Without Alternative will be revised to reflect the pre-project forest inventory of 348 acres.

(2) Resource Monitoring and Data Collection Schedules. The monitoring schedule will be revised to include pothole monitoring at a 5-year interval. Control points for sedimentation and pothole transects will be field surveyed in the fall of 1995, after leaf drop. The USFWS will provide pothole vegetation, invertebrate, and seine data during the fall of 1995 and 1996.

c. Project Operation and Maintenance. Operation and maintenance has been conducted in accordance with the Operation and Maintenance Manual. There are no operational requirements attached to this project. The maintenance of project features has been adequate.

d. Project Design Enhancement. Discussions with Corps personnel have resulted in the following general conclusion regarding project features which may affect future project design:

(1) Mast Tree Plantings. Measures utilized to control competing vegetation by herbicide applications within 4 feet of each planted seedling were inadequate. Future projects that are similar in nature should include more intensive weed control measures within 15 to 20 feet of each planted tree or shrub.

Survival and growth rates of the planted black walnuts were poor. Planting this species in significant numbers on similar sites is not recommended until more is known about the factors affecting tree survival. Post-Construction Performance Evaluation Information will include collection of information on the survival of planted trees and shrubs in 1996. Future monitoring will be performed to determine the flood tolerance and growth characteristics for each of the 11 species planted.

(2) Timber Chute. Sediment has accumulated in Timber Chute to the point where it is no longer classified as deep habitat ($D \geq 6$ feet; current depth is 5.5 feet). This sediment will require periodic removal in order to provide year-round habitat access to Willow Chute and Big and Little Denny. Sediment removal should be scheduled when water depth approaches 4 feet.

APPENDIX A

POST-CONSTRUCTION EVALUATION PLAN

TABLE A-1

Big Timber Refuge Rehabilitation & Enhancement Project
Post-Construction Evaluation Plan [1]

Enhancement Potential

Goal	Objective	Alternative	Enhancement Feature	Unit	Year 0 (1991) Without Alternative	Year 4 With Alternative	Year 50 Target With Alternative [2]	Feature Measurement	Annual Field Observations by Site Manager
Enhance Aquatic Habitat	Restore deep (≥6 feet) aquatic habitat	Big Timber dredging	Hydraulic dredging	AC-FT	0	69.6	100 [redacted]	Perform hydrographic soundings of transects [3]	Development of emergent vegetation within deep dredged area
	Restore shallow (2-3 feet) aquatic habitat	Big Timber dredging	Mechanical excavation	AC-FT	0	39	30 [redacted]	Perform hydrographic soundings of transects [4]	Encroachment of bank or obvious shoaling in shallow dredged areas
	Improve levels of dissolved oxygen during critical seasonal stress periods	Big Timber dredging/ excavation	Dredging/ excavation	Mg/L	0	≥ 5	5	Perform water quality tests at Station W-M443.6G [3]	Fish stress (at surface) or fish kills
	Provide year-round habitat access (cross-sectional area)	Big Timber dredging/ excavation	Dredging/ excavation	Sq. Ft.	0	Round Pond - Willow Chute: 617 Timber Chute: 168	500 [redacted]	Perform hydrographic soundings of transects [4]	Development of emergent vegetation within access area
Enhance Migratory Waterfowl Habitat	Increase reliable resting and feeding water areas	Blasting of potholes and dredging/ excavation with constructed access limitation	Pothole creation and dredging/ excavation	AC	0		21	Perform hydrographic soundings of transects [4]	Waterfowl presence or absence
	Provide isolated resting, feeding, and brooding pools	Blasting of potholes	Pothole creation	EA	0	10	10	Perform areal survey of project area [5]	Waterfowl presence or absence

TABLE A-1 (Cont'd)

[1/] See Plate 3, Monitoring Plan for active monitoring sites.

[2/] Highlighted text is revised Year 50 with alternative to reflect as-built conditions.

[3/] Water Quality Stations

W-M443.6G

[4/] Sedimentation Transects (See Table A-2)

[5/] Mapping

April 17, 1994, Color Aerial Photography

Areal survey of the project area will be performed to determine the amount of waterfowl resting and feeding water areas and to inventory potholes.

TABLE A-2

Big Timber Refuge Rehabilitation and Enhancement Project
Sedimentation Transect Project Objectives Evaluation

Transect	Project Objectives to Be Evaluated			
	Restore Deep Aquatic Habitat	Restore Shallow Aquatic Habitat	Provide Year-Round Habitat Across Cross-Sectional Area	Increase Reliable Resting and Feeding Water Areas
Round Pond -Timber Chute - Willow Chute - Big Denny				
S-M443.7F to S-M443.6G	X		X	X
S-M443.7G to S-M443.5H	X		X	X
S-M443.7J to S-M443.6J	X		X	X
S-M443.7J to S-M443.7K	X	X	X	X
S-M443.8J to S-M443.8K	X	X	X	X
S-M444.0J to S-M444.0K	X	X	X	X
S-M444.2J to S-M444.2K	X	X	X	X
S-M444.3I to S-M444.4K (S1)	X	X	X	X
S-M444.4H to S-M444.5H		X		X
S-M444.7G to S-M444.7H		X		X
S-M444.8H to S-M444.8I		X		X
Little Denny				
S-M444.3I to S-M444.4K (S2)		X		X
S-M444.3I to S-M444.4K (S3)		X		X
Potholes				
1				X
2				X
3				X
4				X
5				X
6				X
7				X
8				X
9				X
10				X

TABLE A-3

Big Timber Refuge Rehabilitation & Enhancement Project

Post-Construction Evaluation Plan [1/]

Enhancement Potential

Goal	Objective	Alternative	Enhancement Feature	Unit	Year 0 (1993) Without Alternative [2/]	Year 2 With Alternative	Year 50 Target With Alternative	Feature Measurement	Annual Field Observations by Site Manager
Enhance Terrestrial Habitat	Produce mast tree dominated areas	Mast tree plantings on dredged material placement site	Revegetation	Acres of mast trees	170 348		204	Perform vegetation transects in mast tree area [3/]	Seedling survival

[1/] See Plate 3, Monitoring Plan for active monitoring sites.

[2/] Highlighted text reflects pre-project forest inventory.

[3/] Vegetation Transects (Post-Construction Phase)

V-M444.5J to V-M444.5M
V-M444.7I to V-M444.7M

Mast tree survey of hardwood trees planted in the dredged material confined placement site.

Sampling locations will be at equal 1/3 increments on each vegetative range. Excluding range end points, sampling will be every 300 feet on the upstream range and every 200 feet on the downstream range for a total of 6 points, 3 on each range.

APPENDIX B

MONITORING AND PERFORMANCE EVALUATION MATRIX
AND
RESOURCE MONITORING AND DATA COLLECTION SUMMARY

TABLE B-1

Monitoring and Performance Evaluation Matrix

Project Phase	Type of Activity	Purpose	Responsible Agency	Implementing Agency	Fu So
Pre-Project	Sedimentation Problem Analysis	System-wide problem definition. Evaluates planning assumptions.	USFWS	USFWS (EMTC)	LTR
	Pre-Project Monitoring	Identifies and defines problems at HREP site. Establishes need of proposed project features.	USFWS	USFWS	US
	Baseline Monitoring	Establishes baselines for performance evaluation.	Corps	Corps	LT
Design	Data Collection for Design	Includes quantification of project objectives, design of project, and development of performance evaluation plan.	Corps	Corps	HR
Construction	Construction Monitoring	Assesses construction impacts; assures permit conditions are met.	Corps	Corps	HI
Post-Construction	Performance Evaluation Monitoring	Determines success of project as related to objectives.	Corps (quantitative) Sponsor (field observation)	Corps USFWS	HI
	Analysis of Biological Responses to Projects	Evaluates predictions and assumptions of habitat unit analysis. Studies beyond scope of performance evaluation, or if projects do not have desired biological results.	Corps	USFWS (EMTC)	HI

[1/] Long-Term Resource Monitoring Program is a component of the UMRS-EMP.
[2/] Habitat Rehabilitation and Enhancement Projects

TABLE B-2

Resource Monitoring and Data Collection Summary [1/]

Type Measurement	Water Quality Data						Engineering Data			Natural Resource Data			Sampling Agency	Remarks
	Pre-Project Phase		Design Phase		Post-Const. Phase		Pre-Project Phase	Design Phase	Post-Const. Phase	Pre-Project Phase	Design Phase	Post-Const. Phase		
	Apr-Sep	Oct-Mar	Apr-Sep	Oct-Mar	Apr-Sep	Oct-Mar								
POINT MEASUREMENTS														
Water Quality Stations [2/]													Corps	
Turbidity	2W		2W		2W	M								
Secchi Disk Transparency	2W		2W		2W	M								
Suspended Solids	2W		2W		2W	M								
Dissolved Oxygen	2W		2W		2W	M								
Specific Conductance	2W		2W		2W	M								
Water Temperature	2W		2W		2W	M								
pH	2W		2W		2W	M								
Total Alkalinity	--		--		2W	M								
Chlorophyll	2W		2W		2W	M								
Velocity	--		--		2W	M								
Water Depth	2W		2W		2W	M								
Water Elevation	2W		2W		2W	M								
Percent Ice Cover						M								
Ice Depth						M								
Percent Snow Cover						M								
Snow Depth						M								
Wind Direction					2W	M								
Wind Velocity					2W	M								
Wave Height					2W	M								
Air Temperature					2W	M								
Percent Cloud Cover					2W	M								

TABLE B-2 (Cont'd)

Type Measurement	Water Quality Data						Engineering Data			Natural Resource Data			Sampling Agency	Remarks
	Pre-Project Phase		Design Phase		Post-Const. Phase		Pre-Project Phase	Design Phase	Post-Const. Phase	Pre-Project Phase	Design Phase	Post-Const. Phase		
	Apr-Sep	Oct-Mar	Apr-Sep	Oct-Mar	Apr-Sep	Oct-Mar								
POINT MEASUREMENTS (Cont'd)														
Sediment Test Stations [1]													Corps	
Elutriate			1											
Bulk Sediment			1											
Column Settling Stations [1]													Corps	
Column Settling Analysis								1						
Boring Stations [1]													Corps	
Geotechnical Borings								1						
TRANSECT MEASUREMENTS														
Sedimentation Transects [2]													Corps	
Hydrographic Soundings							1		5Y					
Vegetation Transects [1]													Corps	
Mast Tree Survey												Y	Corps	
AREA MEASUREMENTS														
Mapping [1]														
Aerial Photography										1		5Y	Corps	

Legend

W = Weekly
M = Monthly
Y = Yearly
nW = n-Week interval
nY = n-Year Interval
1,2,3,.... = Number of times data was collected within designated project phase

TABLE B-2 (Cont'd)

1/ See Plate 3, Monitoring Plan for active monitoring sites. See DPR for Pre-Project and Design Phase station locations.

2/ Water Quality Stations (Design Phase)

W-M443.6G DPR D-1

3/ Sediment Test Stations (Design Phase)

DPR-BT-1
DPR-BT-2
DPR-BT-3
DPR-BT-4

4/ Column Settling Analysis (Design Phase)

DPR-BT-88-2-1
DPR-BT-88-2-2

5/ Geotechnical Borings (Design Phase)

DPR BT-88-1 through BT-88-9

6/ Sedimentation Transects

Pre-Project Phase

DPR Traverse with 27 cross sections

Post-Construction Phase (Pothole transects added 1995) - See Table B-3

7/ Vegetation Transects (Post-Construction Phase)

V-M444.5J to V-M444.5M
V-M444.7I to V-M444.7M

Mast tree survey of hardwood trees planted in the dredged material confined placement site.

Sampling locations will be at equal 1/3 increments on each vegetative range. Excluding range end points, sampling will be every 300 feet on the upstream range and every 200 feet on the downstream range for a total of 6 points, 3 on each range.

8/ Mapping (Post-Construction Phase)

Aerial Photography

Areal survey of the project area will be performed to determine the amount of waterfowl resting and feeding habitat and to inventory potholes.

TABLE B-2 (Cont'd)

The following monitoring was performed by the construction contractor during the construction phase for the purpose of meeting permit requirements.

Station	Frequency
<u>Outlet Weir</u>	
Suspended Solids	Daily
Temperature	Daily
pH	Daily
Ammonia Nitrogen	Daily
<u>Upstream of Outlet Weir</u>	
Suspended Solids	Daily
Temperature	Daily
pH	Daily
Ammonia Nitrogen	Daily
<u>100 Feet Downstream of Above Point</u>	
Suspended Solids	Daily
Temperature	Daily
pH	Daily
Ammonia Nitrogen	Daily

TABLE B-3

Big Timber Refuge Rehabilitation and Enhancement Project
Sedimentation Transect Project Objectives Evaluation

	Project Objectives to Be Evaluated			
Transect	Restore Deep Aquatic Habitat	Restore Shallow Aquatic Habitat	Provide Year-Round Habitat Across Cross-Sectional Area	Increase Reliable Resting and Feeding Water Areas
Round Pond -Timber Chute - Willow Chute - Big Denny				
S-M443.7F to S-M443.6G	X		X	X
S-M443.7G to S-M443.5H	X		X	X
S-M443.7J to S-M443.6J	X		X	X
S-M443.7J to S-M443.7K	X	X	X	X
S-M443.8J to S-M443.8K	X	X	X	X
S-M444.0J to S-M444.0K	X	X	X	X
S-M444.2J to S-M444.2K	X	X	X	X
S-M444.3I to S-M444.4K (S1)	X	X	X	X
S-M444.4H to S-M444.5H		X		X
S-M444.7G to S-M444.7H		X		X
S-M444.8H to S-M444.8I		X		X
Little Denny				
S-M444.3I to S-M444.4K (S2)		X		X
S-M444.3I to S-M444.4K (S3)		X		X
Potholes				
1				X
2				X
3				X
4				X
5				X
6				X
7				X
8				X
9				X
10				X

APPENDIX C

COOPERATING AGENCY CORRESPONDENCE

BIG TIMBER REFUGE REHABILITATION AND ENHANCEMENT
OPERATION AND MAINTENANCE MANUAL

UPPER MISSISSIPPI RIVER ENVIRONMENTAL MANAGEMENT PROGRAM
POOL 16, RIVER MILE 443 THROUGH 445
LOUISA COUNTY, IOWA
SITE MANAGER'S PROJECT INSPECTION AND MONITORING RESULTS

Inspected by: Michael Bornstein, EMP Coordinator Date: 6/16/95

Type of Inspection: Performance Monitoring

1. PROJECT INSPECTION

a. Confined Dredged Material Placement Site

No waste materials or unauthorized structures.

b. Hydraulic Dredging

Little Denny entrance access control remains in place.
No waste materials or unauthorized structures.

c. Mechanical Excavation

Little Denny entrance access control remains in place.
No waste materials or unauthorized structures.

d. Check Dams

No waste materials or unauthorized structures.

e. Pothole Creation

No waste materials or unauthorized structures.

f. Revegetation

Seedling condition very good.
Herbicide treatment scheduled.

2. PROJECT MONITORING (Observations and Project Evaluation)

a. Hydraulic Dredging

The area of hydraulic dredging, from Round Pond through Timber Chute and Big Denny, appears to have depths approaching original dredged depths. Rough measurements were taken throughout these areas, with the observation of little sediment deposition, approximately 3-6". At the site of the Big Denny dredging, pondweed (Potamageton Spp.), a preferred waterfowl submergent, was present and occupied approximately 20% of the surface area. No information has been received from the project co-sponsor, the Iowa Department of Natural Resources (IDNR), regarding fish stress or kills, and field observation does not indicate this has occurred. Verbal communication with IDNR fisheries biologists indicated a positive fisheries response to the HREP, but a report is not available at this time. Waterfowl production and peak fall population estimates for the Big Timber Division are attached (See Attachment). Bank sloughing (approximately 3') was evident throughout the Timber Chute area along the east bank. The trees placed in the water for additional fish structure remain in place.

b. Mechanical Excavation

The area of mechanical dredging, throughout Little Denny, appears to have depths approaching original dredged depths, consistent with rates of sediment deposition of 3-6" found in the hydraulically dredged areas. Approximately 2' of sloughing was evident along the east bank throughout Little Denny. At the site of the Little Denny dredging, pondweed (Potamageton Spp.) was present, occupying approximately 5% of the surface area. An additional preferred waterfowl food, Arrowhead (Sagittaria latifolia), and an unknown grass species also occurred adjacent to the dredge cut, also occupying approximately 5% of the surface area. Field observation has not determined there were any fish kills. Waterfowl production and peak fall population estimates for the Big Timber Division are attached (see attachment). The boat access control remains in place, and trees placed in the water for additional fish structure also remain.

c. Pothole Creation

Potholes remain at the site. Extensive descriptive and water quality data were provided to the Corps of Engineers in a 1991 report. We anticipate follow-up monitoring for dissolved oxygen and temperature in July 1995, and will provide that information as soon as possible. At the time of this performance monitoring, sheet water remained over the potholes constructed in the Big Denny area. The potholes to the west of Timber Chute had duckweed (Lemna Spp.) on approximately 5% of the surface area. Field observations have noted waterfowl leaving the area, and a high abundance of leopard frogs occupying the potholes.

d. Revegetation

Examination of mast tree revegetation within the hydraulic dredge disposal site determined an estimated 80% or greater seedling survival. Sycamores were estimated to be approximately 7-10' tall, while pin oaks exhibited lesser growth rates, currently about 5-6' tall. Small amounts of pin oak mortality were evident, although the entire site was not analyzed. A herbicide treatment is scheduled this summer.

ATTACHMENT

BIG TIMBER WATERFOWL PRODUCTION AND PEAK FALL POPULATIONS*

	Waterfowl Production	Peak Fall Populations
Pre-project		
1985	165	5,219 ducks; 550 geese
1986	240	2,305 ducks; 276 geese
1987	400	4,095 ducks; 1,100 geese
1988	420	1,095 ducks; 280 geese
1989	438	626 ducks; 65 geese
1990	461	400 ducks; 0 geese
Post-project		
1991	470	341 ducks; 9 geese
1992	690	1,337 ducks; 41 geese
1993	N/A (Flood)	N/A (Flood)
1994	541	276 ducks; 177 geese

* All data were obtained from the Mark Twain National Wildlife Refuge Annual Narrative Reports, 1985-1994.

APPENDIX D

CORPS OF ENGINEERS DATA

Table D-1: Big Timber Sedimentation Transects
Table D-2: Average Annual Sediment Accretion
Table D-3: Big Timber Sedimentation Transects Water Quality Data

TABLE D-1

Big Timber Sedimentation Transects

		Provide Year-Round [illegible] (Cross-Sectional Area)						Sedimentation		Restore Deep [illegible] Aquatic Habitat		Restore Shallow Aquatic Habitat	
Round Pond - Timber Chute - Willow Chute - Big Denny	Scaled Distance	Deep Habitat, Square Feet[5/]		Shallow Habitat, Square Feet		Total		Scour, SF	Accretion, SF	Deep Habitat, Acre-Feet[6/]		Shallow Habitat, Acre-Feet	
		As Built (1991)	Year 4 (1994)	As Built (1991)	Year 4 (1994)	As Built (1991)	Year 4 (1994)	91 to 94 (Cut)	91 to 94 (Fill)	As Built (1991)	Year 4 (1994)	As Built (1991)	Year 4 (1994)
Start Dredging		769.5	682.9										
	460									8.1	7.2		
S-M443.7F to S-M443.6G[1/]		769.5	682.9			769.5	682.9	5.2	97.8				
	360									5.5	5.5		
S-M443.7G to S-M443.5H[1/]		563.2	653.7			563.2	653.7	83.9	29.4				
	610									6.6	5.8		
S-M443.7J to S-M443.6J[2/]		381.2	168.1			381.2	168.1	0.0	205.7				
	280									3.2	2.3		
S-M443.7J to S-M443.7K[3/]		616.1	535.4	208.7	157.0	824.8	692.4	25.3	73.8				
	510									7.6	6.8	2.5	2.1
S-M443.8J to S-M443.8K[3/]		685.6	629.7	214.2	198.0	899.9	827.7	25.1	77.7				
	1060									15.9	15.6	5.0	4.5
S-M444.0J to S-M444.0K[3/]		621.1	649.3	195.1	175.4	816.2	824.7	43.0	19.9				
	850									11.3	10.7	3.7	3.2
S-M444.2J to S-M444.2K[3/]		538.9	443.8	186.5	156.8	725.4	600.6	34.0	82.3				
	380									4.6	3.8	2.0	1.7
S-M444.3I to S-M444.4K (S1)[3/]		523.1	426.5	265.8	228.2	789.0	654.7	11.0	82.7				
	1230									14.8	12.0	7.5	6.1
S-M444.4H to S-M444.5H[4/]		523.1	426.5	262.0	205.0	785.1	631.5	21.7	63.5				
	1430											6.8	6.0
S-M444.7G to S-M444.7H[4/]				149.6	157.7	149.6	157.7	17.7	38.6				
	780											2.8	2.8
S-M444.8H to S-M444.8[4/]				161.0	160.0	161.0	160.0	27.7	36.1				
	1070											4.0	3.9
Finish Dredging[4/]				161.0	160.0	161.5	159.9						
	Average	[illegible]	[illegible]	205.4	179.7	624.1	550.4		Total	[illegible]	[illegible]		
Little Denny													
S-M444.3I to S-M444.4K (S2)				243.5	202.1	243.5	202.1	6.54	67.21				
	1850											9.9	8.5
S-M444.3I to S-M444.4K (S3)				221.1	199.7	221.1	199.7	14.5	41.25				
			Average	232.3	200.9						Total	44.0	38.9

[1/] Round Pond
[2/] Timber Chute
[3/] Willow Chute
[4/] Big Denny
[5/] Cross-sectional area of deep habitat = $W_{bottom} * D(\geq 6')$
[6/] Average deep habitat cross-sectional area excludes Timber Chute

TABLE D-2

Average Annual Sediment Accretion[1/]

Year	Expected Deep Aquatic Habitat, Acre-Feet[2/]	Actual Deep Aquatic Habitat, Acre-Feet[4/]	Expected Shallow Aquatic Habitat, Acre-Feet[3/]	Actual Shallow Aquatic Habitat, Acre-Feet[4/]	Timber Chute Expected Year-Round Habitat Access (Cross-Sectional Area), Square Feet[2/]	Timber Chute Actual Year-Round Habitat Access (Cross-Sectional Area), Square Feet[4/]	Round Pond and Willow Chute - Expected Year-Round Habitat Access (Cross-Sectional Area), Square Feet[2/]	Round Pond and Willow Chute - Actual Year-Round Habitat Access (Cross-Sectional Area), Square Feet[4/]
0	55.6	77.7	40.0	44.0	336.0	381.2	456.0	616.8
1	55.3		39.5		334.4		453.8	
2	55.1		39.0		332.9		451.7	
3	54.8		38.4		331.3		449.5	
4	54.5	69.6	37.9	38.9	329.8	168.1	447.4	574.5
5	54.3		37.4		328.2		445.2	
6	54.0		36.9		326.6		443.0	
7	53.8		36.4		325.1		440.9	
8	53.5		35.9		323.5		438.7	
9	53.2		35.4		322.0		436.6	
10	53.0		34.9		320.4		434.4	
11	52.7		34.4		318.8		432.2	
12	52.4		33.9		317.3		430.1	
13	52.2		33.4		315.7		427.9	
14	51.9		32.9		314.2		425.8	
15	51.6		32.4		312.6		423.6	
16	51.4		31.9		311.0		421.4	
17	51.1		31.4		309.5		419.3	
18	50.9		30.9		307.9		417.1	
19	50.6		30.4		306.4		415.0	
20	50.3		29.9		304.8		412.8	
21	50.1		29.4		303.2		410.6	
22	49.8		28.9		301.7		408.5	
23	49.5		28.5		300.1		406.3	
24	49.3		28.0		298.6		404.2	
25	49.0		27.5		297.0		402.0	
26	48.8		27.0		295.4		399.8	
27	48.5		26.5		293.9		397.7	
28	48.2		26.0		292.3		395.5	
29	48.0		25.6		290.8		393.4	
30	47.7		25.1		289.2		391.2	
31	47.4		24.6		287.6		389.0	
32	47.2		24.1		286.1		386.9	
33	46.9		23.7		284.5		384.7	
34	46.7		23.2		283.0		382.6	
35	46.4		22.7		281.4		380.4	

TABLE D-2 (Continued)

Year	Expected Deep Aquatic Habitat, Acre-Feet[2/]	Actual Deep Aquatic Habitat, Acre-Feet[4/]	Expected Shallow Aquatic Habitat, Acre-Feet[3/]	Actual Shallow Aquatic Habitat, Acre-Feet[4/]	Timber Chute Expected Year-Round Habitat Access (Cross-Sectional Area), Square Feet[2/]	Timber Chute Actual Year-Round Habitat Access (Cross-Sectional Area), Square Feet[4/]	H
36	46.1		22.3		279.8		
37	45.9		21.8		278.3		
38	45.6		21.3		276.7		
39	45.3		20.9		275.2		
40	45.1		20.4		273.6		
41	44.8		19.9		272.0		
42	44.5		19.5		270.5		
43	44.3		19.0		268.9		
44	44.0		18.6		267.4		
45	43.8		18.1		265.8		
46	43.5		17.6		264.2		
47	43.2		17.2		262.7		
48	43.0		16.7		261.1		
49	42.7		16.3		259.6		
50	42.4		15.8		258.0		
80					168		

[1/] Assumes an annual sedimentation rate of 0.5 inch (0.04 foot)/year

[2/] $A=(W_{Bottom} * D(>6')*L)/43560$ (Includes side slope areas ≥6'D)

[3/] (A*L)/43560 (Includes side slope areas)

[4/] See Table D-1

TABLE D-3

Big Timber Sedimentation Transects

Round Pond - Timber Chute - Willow Chute - Big Denny	Scaled Distance	Width, Feet						Increase Reliable Resting and Feeding Water Areas			
								Area, Acres			
		Deep Habitat		Shallow Habitat		Total		Deep Habitat		Shallow Habitat	
		As Built (1991)	Year 4 (1994)	As Built (1991)	Year 4 (1994)	As Built (1991)	Year 4 (1994)	As Built (1991)	Year 4 (1994)	As Built (1991)	Year 4 (1994)
Start Dredging		130.0	120.0			130.0	120.0				
	460							1.4	1.3		
S-M443.7F to S-M443.6G		130.0	120.0			130.0	120.0				
	360							1.0	1.1		
S-M443.7G to S-M443.5H		119.0	140.0			119.0	140.0				
	610							1.3	1.5		
S-M443.7J to S-M443.6J[1/]		72.0	70.0			72.0	70.0				
	280							0.5	0.5		
S-M443.7J to S-M443.7K		85.0	86.0	46.0	50.0	131.0	136.0				
	510							1.0	1.1	0.6	0.6
S-M443.8J to S-M443.8K		90.0	94.0	50.0	50.0	140.0	144.0				
	1060							2.3	2.5	1.2	1.2
S-M444.0J to S-M444.0K		100.0	110.0	50.0	50.0	150.0	160.0				
	850							1.8	2.0	1.1	1.0
S-M444.2J to S-M444.2K		80.0	90.0	60.0	50.0	140.0	140.0				
	380							0.7	0.8	0.5	0.4
S-M444.3I to S-M444.4K (S1)		80.0	100.0	60.0	50.0	140.0	150.0				
	1230							2.3	2.8	1.8	1.7
S-M444.4H to S-M444.5H		80.0	100.0	70.0	70.0	150.0	170.0				
	1430							1.3	1.6	2.1	2.6
S-M444.7G to S-M444.7H				60.0	90.0	60.0	90.0				
	780									1.1	1.5
S-M444.8H to S-M444.8I				60.0	80.0	60.0	80.0				
	1070									1.5	2.0
Finish Dredging	4890			60.0	80.0	60.0	80.0				
	Average	102.5	113.6	57.0	61.9	117.5	127.3				
							Total	13.6	15.1	9.9	11.0
Little Denny Start Dredging											
S-M444.3I to S-M444.4K (S2)				80.0	94.0	80.0	94.0				
	1850										
S-M444.3I to S-M444.4K (S3)				80.0	90.0	80.0	90.0				
Finish Dredging											
			Average	80.0	92.0						

TABLE D-3 (Continued)

Potholes		Long Chord, Feet		Short Chord, Feet			Increase Eligible Returning and Flooding Water Areas	
		As Built (1991)[3]	Year 4 (1994)	As Built (1991)[3]	Year 4 (1994)		Area, Acres (Cont'd)[2] As Built (1991)[3]	Year 4 (1994)
1		70	81	27	24		0.04	0.04
2		72	82	24	28		0.04	0.05
3		65	81	26	25		0.04	0.05
4		67	78	28	29		0.04	0.05
5		55	69	42	36		0.05	0.06
6		60	73	50	38		0.07	0.06
7		75	80	50	39		0.09	0.07
8		65	81	48	43		0.07	0.08
9		60	88	45	51		0.06	0.10
10		80	86	50	47		0.09	0.09
	Average	67	80	39	36	Total Pothole	0.44	0.47
						Total[1]	0.5	0.7

[1] Timber Chute

[2] Pothole area (approximate) = Long Chord * Short Chord

[3] USFWS, 1991

WATER QUALITY DATA

Pre-project water quality monitoring results from samples collected at Site W-M443.6G

DATE	WATER DEPTH (FT)	VELOCITY (FT/SEC)	WAVE HEIGHT (FT)	AIR TEMP. (°C)	CLOUD COVER (%)	WIND SPEED (MPH)
5/6/89	1.64	-	-	9	-	-
5/20/89	2.69	-	-	20	-	-
6/3/89	2.26	-	-	22	-	-
6/17/89	1.67	-	-	24	-	-
7/1/89	2.03	-	-	28	-	-
7/15/89	2.03	-	-	27	-	-
7/29/89	1.51	-	-	25	-	-
8/12/89	1.94	-	-	27	-	-
8/26/89	1.61	-	-	27	-	-
9/9/89	2.85	-	-	18	-	-
9/23/89	2.26	-	-	11	-	-
10/14/89	1.51	-	-	21	-	-
10/28/89	2.00	-	-	16	-	-
4/14/90	1.97	-	0.1	9	70	2
5/8/90	1.97	<.250	0.0	24	85	0
5/26/90	3.94	<.250	0.0	16	100	0
6/9/90	2.26	<.113	0.0	20	0	0
6/30/90	3.35	<.113	0.0	32	10	1
7/20/90	1.51	<.113	0.0	27	70	0
8/4/90	2.00	<.113	0.1	28	10	7
8/18/90	2.20	<.113	0.1	32	5	4
9/1/90	-	-	-	30	20	0
9/15/90	4.72	<.113	0.1	24	0	3
9/29/90	4.53	<.113	0.1	18	100	0

MIN.	1.51	<.113	0.0	9	0	0
MAX.	4.72	<.250	0.1	32	100	7
AVG.	2.37	-	0.0	22	43	2

Pre-project water quality monitoring results from samples collected at Site W-M443.6G

DATE	WIND DIRECTION	WATER TEMP. (°C)	DISSOLVED OXYGEN (MG/L)	pH (SU)	TOTAL ALKALINITY (MG/L as CaCO3)
5/6/89	-	12.0	12.40	8.80	134
5/20/89	-	22.0	13.10	8.90	144
6/3/89	-	25.0	11.60	8.70	118
6/17/89	-	25.0	17.30	9.00	120
7/1/89	-	31.0	19.70	9.20	124
7/15/89	-	21.0	7.10	7.90	124
7/29/89	-	29.0	9.00	8.10	124
8/12/89	-	29.0	11.70	8.60	130
8/26/89	-	27.0	7.90	8.40	120
9/9/89	-	22.0	12.20	8.60	128
9/23/89	-	16.0	9.40	8.30	136
10/14/89	-	20.0	10.90	8.60	148
10/28/89	-	16.0	10.40	8.10	154
4/14/90	SW	9.0	11.50	8.60	122
5/8/90	-	22.0	0.60	9.20	110
5/26/90	-	17.0	7.70	7.60	112
6/9/90	-	22.0	3.80	7.60	120
6/30/90	W	27.0	8.00	7.70	118
7/20/90	-	30.0	13.90	8.30	188
8/4/90	N	27.0	8.80	7.90	146
8/18/90	S	32.0	12.60	8.20	162
9/1/90	-	30.0	9.30	8.00	148
9/15/90	W	25.0	10.10	8.10	158
9/29/90	-	19.0	11.90	8.50	140

MIN.	-	9.0	0.60	7.60	110
MAX.	-	32.0	19.70	9.20	188
AVG.	-	23.1	10.45	-	135

Pre-project water quality monitoring results from samples collected at Site W-M443.6G

DATE	SPECIFIC CONDUCTANCE (µMHOS/CM @ 25°C)	SECCHI DISK DEPTH (FT)	TURBIDITY (NTU)	SUSPENDED SOLIDS (MG/L)
5/6/89	240	0.98	19	32.0
5/20/89	320	1.18	16	35.0
6/3/89	250	1.18	19	34.0
6/17/89	240	1.18	28	32.0
7/1/89	307	0.75	33	18.0
7/15/89	330	1.44	19	39.0
7/29/89	338	1.51	29	36.0
8/12/89	355	1.08	27	54.0
8/26/89	321	1.61	14	15.0
9/9/89	368	1.18	20	41.0
9/23/89	352	1.74	13	19.0
10/14/89	352	1.51	14	20.0
10/28/89	377	1.35	20	28.0
4/14/90	335	1.18	26	34.0
5/8/90	322	1.51	13	21.0
5/26/90	330	1.25	22	24.0
6/9/90	332	2.26	6	9.0
6/30/90	335	3.02	6	5.0
7/20/90	438	0.69	72	93.0
8/4/90	399	0.75	49	72.0
8/18/90	420	0.59	62	93.0
9/1/90	413	-	5	14.0
9/15/90	421	0.92	30	38.0
9/29/90	390	0.85	42	64.0

MIN.	240	0.59	5	5.0
MAX.	438	3.02	72	93.0
AVG.	345	1.29	25	36.3

Pre-project water quality monitoring results from samples collected at Site W-M443.6G

DATE	CHLOROPHYLL a (MG/M3)	CHLOROPHYLL b (MG/M3)	CHLOROPHYLL c (MG/M3)	PHEOPHYTIN a (MG/M3)
5/6/89	160.0	5.0	28.0	141.0
5/20/89	125.0	7.0	19.0	158.0
6/3/89	76.0	4.0	5.0	58.0
6/17/89	130.0	4.0	10.0	66.0
7/1/89	195.0	1.0	1.0	1.0
7/15/89	60.0	5.0	3.0	50.0
7/29/89	26.0	2.0	2.0	26.0
8/12/89	46.0	12.0	3.0	53.0
8/26/89	28.0	2.0	2.0	23.0
9/9/89	160.0	1.0	24.0	173.0
9/23/89	33.0	3.0	1.0	43.0
10/14/89	15.0	3.0	3.0	15.0
10/28/89	21.0	2.0	2.0	26.0
4/14/90	35.0	1.0	9.0	65.0
5/8/90	26.0	1.0	7.0	56.0
5/26/90	17.0	8.0	6.0	15.0
6/9/90	6.0	2.0	3.0	3.0
6/30/90	34.0	11.0	7.0	5.0
7/20/90	84.0	21.0	12.0	38.0
8/4/90	81.0	10.0	9.0	23.0
8/18/90	129.0	20.0	12.0	24.0
9/1/90	13.0	5.0	5.0	2.0
9/15/90	69.0	21.0	2.0	34.0
9/29/90	49.0	22.0	20.0	53.0

MIN.	6.0	1.0	1.0	1.0
MAX.	195.0	22.0	28.0	173.0
AVG.	67.4	7.2	8.1	48.0

Post-project water quality monitoring results from samples collected at Site W-M443.6G

DATE	WATER DEPTH (FT)	VELOCITY (FT/SEC)	WAVE HEIGHT (FT)	AIR TEMP. (°C)	CLOUD COVER (%)	WIND SPEED (MPH)
9/24/91	10.00	0.163	0.1	13	60	10
10/10/91	9.10	0.102	0.0	9	10	0
10/22/91	8.80	0.108	0.2	24	20	12
11/5/91	10.10	0.058	0.0	4	100	10
11/26/91	12.00	0.073	0.0	-4	100	12
12/13/91	12.15	0.073	**	-2	0	0
2/3/92	8.80	0.000	**	3	95	0
4/7/92	11.55	*	0.2	17	75	5
5/12/92	10.00	0.093	0.0	17.5	100	0
6/4/92	9.00	0.000	0.0	22	100	0
6/16/92	8.50	0.202	0.0	24	100	5
7/10/92	9.08	0.133	0.0	31	25	5
7/22/92	10.50	0.000	0.0	23.5	100	0
7/27/92	9.60	0.000	0.0	28.5	0	0
8/12/92	9.25	0.113	0.2	19.4	100	5
8/25/92	8.50	0.080	0.6	32	30	15
8/31/92	6.10	0.000	0.0	24	0	0
9/15/92	9.50	0.000	0.0	27.5	90	0
9/28/92	10.60	0.280	0.6	14	0	10
10/13/92	9.40	0.000	0.0	17.5	0	0
11/24/92	12.55	0.068	0.0	6	100	4
1/25/93	10.90	0.000	**	-7	5	5
11/10/93	8.30	0.075	0.0	3	5	3
1/10/94	9.00	0.000	**	-3	100	10
2/24/94	12.40	0.040	**	-9	15	5
3/9/94	11.75	0.000	**	-2	15	5
4/19/94	9.00	0.088	0.1	14	0	7
5/10/94	12.70	0.125	0.0	17	2	1
5/24/94	9.05	0.037	0.0	23	95	2
6/14/94	8.35	0.140	0.2	28	25	6
7/7/94	8.55	0.000	0.1	26	20	3
7/19/94	8.00	0.202	0.2	24	85	7
8/9/94	7.50	*	0.1	71	90	3
8/30/94	7.70	0.041	0.0	18	100	0
9/13/94	7.00	0.107	0.0	23	10	3
10/4/94	6.30	0.042	0.1	14	100	3
10/25/94	7.80	0.119	0.1	6	95	3
12/6/94	8.00	0.072	0.1	-2	100	5
2/14/95	8.42	0.070	**	-4	100	6
3/14/95	7.15	0.000	0.0	14	75	0
4/11/95	10.00	0.081	0.1	9	100	4
6/13/95	9.70	0.044	0.0	19	30	1

MIN.	6.10	0.000	0.0	-9	0	0
MAX.	12.70	0.280	0.6	71	100	15
AVG.	9.40	0.071	0.0	15	56	4

* Meter malfunction

** Not applicable, ice cover

*** Too windy to take measurement

**** Field/Laboratory accident

Post-project water quality monitoring results from samples collected at Site W-M443.6G

DATE	WIND DIRECTION	WATER TEMP. (°C)	DISSOLVED OXYGEN (MG/L)	pH (SU)	TOTAL ALKALINITY (MG/L as CaCO3)
9/24/91	S	16.0	10.30	8.94	145
10/10/91	-	14.7	9.18	8.64	156
10/22/91	S	15.2	13.95	8.60	149
11/5/91	SW	2.7	11.50	8.18	156
11/26/91	SE	2.9	12.60	*	143
12/13/91	-	2.0	11.72	7.64	138
2/3/92	-	3.3	13.72	7.52	163
4/7/92	NW	14.2	15.82	8.80	140
5/12/92	-	19.0	16.61	4.53	95
6/4/92	-	22.5	*	8.60	120
6/16/92	SE	25.0	3.06	7.85	150
7/10/92	NW	15.0	7.82	8.27	150
7/22/92	-	24.0	7.51	7.70	100
7/27/92	-	27.5	8.01	8.70	110
8/12/92	NW	24.5	7.83	8.32	125
8/25/92	S	28.0	8.66	8.40	135
8/31/92	-	25.5	9.75	9.00	125
9/15/92	-	24.0	7.95	8.49	135
9/28/92	W	17.5	9.44	8.00	130
10/13/92	-	13.0	8.88	8.12	140
11/24/92	NE	4.8	*	8.00	162
1/25/93	E	0.7	12.40	8.19	181
11/10/93	NW	4.9	13.74	8.94	210
1/10/94	SE	1.5	11.30	8.24	189
2/24/94	W	-0.3	11.62	7.78	142
3/9/94	N	2.6	9.92	7.91	146
4/19/94	NW	15.8	8.29	8.31	166
5/10/94	W	16.0	14.72	8.70	139
5/24/94	S	22.8	2.91	7.47	170
6/14/94	S	26.7	3.84	7.64	175
7/7/94	S	28.4	6.67	7.98	165
7/19/94	SE	27.3	4.95	7.97	177
8/9/94	E	25.0	4.88	8.28	176
8/30/94	-	23.3	7.17	8.40	172
9/13/94	SE	24.0	6.83	8.51	196
10/4/94	N	16.9	7.86	8.34	165
10/25/94	NW	12.0	10.22	9.23	170
12/6/94	N	4.2	11.80	8.57	178
2/14/95	SE	2.9	12.30	8.15	183
3/14/95	-	9.6	16.44	8.88	140
4/11/95	SE	7.9	12.75	9.47	122
6/13/95	W	22.2	*	7.95	178

MIN.	-	-0.3	2.91	4.53	95
MAX.	-	28.4	16.61	9.47	210
AVG.	-	15.1	9.87	8.22	153

* Meter malfunction

** Not applicable, ice cover

*** Too windy to take measurement

**** Field/Laboratory accident

Post-project water quality monitoring results from samples collected at Site W-M443.6G

DATE	SPECIFIC CONDUCTANCE (µMHOS/CM @ 25°C)	SECCHI DISK DEPTH (FT)	TURBIDITY (NTU)	SUSPENDED SOLIDS (MG/L)
9/24/91	408	1.30	12	25.0
10/10/91	398	1.00	14	24.0
10/22/91	388	1.20	16	26.0
11/5/91	343	2.05	6	5.0
11/26/91	311	1.95	7	7.0
12/13/91	326	2.45	5	<6
2/3/92	357	**	2	<10
4/7/92	327	1.25	14	30.0
5/12/92	346	1.18	23	21.0
6/4/92	368	1.08	30	26.0
6/16/92	393	0.49	56	56.0
7/10/92	490	0.49	95	121.0
7/22/92	404	1.41	19	22.0
7/27/92	448	0.89	17	51.0
8/12/92	402	0.82	37	38.0
8/25/92	412	1.21	22	25.0
8/31/92	410	1.20	18	19.0
9/15/92	421	0.89	22	24.0
9/28/92	423	0.89	19	19.0
10/13/92	400	1.10	26	38.0
11/24/92	379	1.71	12	14.4
1/25/93	401	**	4	7.5
11/10/93	406	1.00	20	6.6
1/10/94	417	**	6	5.1
2/24/94	300	**	32	36.9
3/9/94	351	**	5	8.8
4/19/94	371	0.50	52	110.0
5/10/94	330	2.25	7	9.0
5/24/94	422	0.70	28	51.0
6/14/94	448	0.45	48	80.0
7/7/94	455	0.85	30	53.0
7/19/94	437	0.55	30	60.0
8/9/94	449	0.65	29	46.0
8/30/94	422	0.95	25	38.0
9/13/94	436	1.00	10	23.0
10/4/94	395	1.20	15	27.0
10/25/94	374	1.10	17	28.0
12/6/94	338	1.55	13	18.0
2/14/95	352	**	9	7.0
3/14/95	335	1.15	14	35.0
4/11/95	254	1.40	14	30.0
6/13/95	424	0.95	19	35.0

MIN.	254	0.45	2	5.0
MAX.	490	2.45	95	121.0
AVG.	387	1.13	21	-

* Meter malfunction

** Not applicable, ice cover

*** Too windy to take measurement

**** Field/Laboratory accident

Post-project water quality monitoring results from samples collected at Site W-M443.6G

DATE	CHLOROPHYLL a (MG/M3)	CHLOROPHYLL b (MG/M3)	CHLOROPHYLL c (MG/M3)	PHEOPHYTIN a (MG/M3)
9/24/91	23.8	0.6	3.3	7.2
10/10/91	20.2	1.2	2.8	9.3
10/22/91	48.5	5.1	6.7	<0.2
11/5/91	12.2	1.2	1.1	9.2
11/26/91	6.1	0.6	0.9	4.7
12/13/91	3.1	<1	<1	<1
2/3/92	21.0	<1	16.0	34.0
4/7/92	40.0	<1.6	6.2	15.0
5/12/92	54.4	23.0	7.7	12.0
6/4/92	34.5	5.3	5.3	45.5
6/16/92	29.6	8.9	10.9	<0.2
7/10/92	69.3	11.4	6.1	38.2
7/22/92	42.1	4.9	4.7	5.0
7/27/92	76.7	15.1	8.5	10.5
8/12/92	58.4	1.5	6.6	29.2
8/25/92	19.6	4.8	1.9	26.4
8/31/92	24.6	4.1	4.1	<0.2
9/15/92	95.9	27.1	9.9	13.6
9/28/92	33.3	2.5	4.0	0.5
10/13/92	11.8	<0.2	1.6	4.1
11/24/92	9.5	4.4	4.3	<2
1/25/93	22.0	<1.2	18.5	80.3
11/10/93	35.5	6.5	8.8	<2.7
1/10/94	12.1	<1.3	<1.6	10.9
2/24/94	6.1	7.5	11.6	<2.7
3/9/94	-	-	-	-
4/19/94	67.0	<1	6.0	13.0
5/10/94	60.0	3.9	6.2	7.8
5/24/94	21.0	1.9	<1	13.0
6/14/94	26.0	2.0	1.7	10.0
7/7/94	40.0	2.6	2.3	15.0
7/19/94	32.0	<1	<1	6.3
8/9/94	46.0	1.3	3.0	3.2
8/30/94	27.0	<1	<1	2.9
9/13/94	57.0	<1	<1	<1
10/4/94	36.0	<1	<1	11.0
10/25/94	39.0	<1	6.1	3.8
12/6/94	9.2	<1	<1	9.0
2/14/95	20.0	<1	1.1	7.8
3/14/95	57.0	<1	6.5	5.9
4/11/95	140.0	<1	17.0	<1
6/13/95	58.0	<1	<1	<1

MIN.	3.1	<0.2	0.9	<0.2
MAX.	140.0	27.1	18.5	80.3
AVG.	37.7	-	-	-

* Meter malfunction

** Not applicable, ice cover

*** Too windy to take measurement

**** Field/Laboratory accident

APPENDIX E

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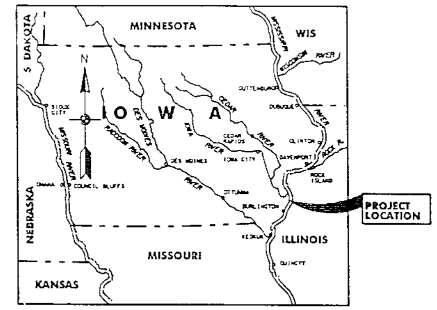
PLATES



VICINITY MAP

800 400 0 800 1600

SCALE: 1" = 800'

Revisions			
Symbol	Description	Date	Approved

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS

UPPER MISSISSIPPI RIVER SYSTEM
BIG TIMBER PERFORMANCE EVALUATION
POOL 17, RIVER MILES 443.5-445

GENERAL PLAN

Designed by: MOC
Drawn by: SDH
Checked by: BLK
Reviewed by: DJH
Approved by: CHARLES S. COX COL., CORPS OF ENGINEERS

Scale: AS SHOWN
Date: 3 APRIL '95
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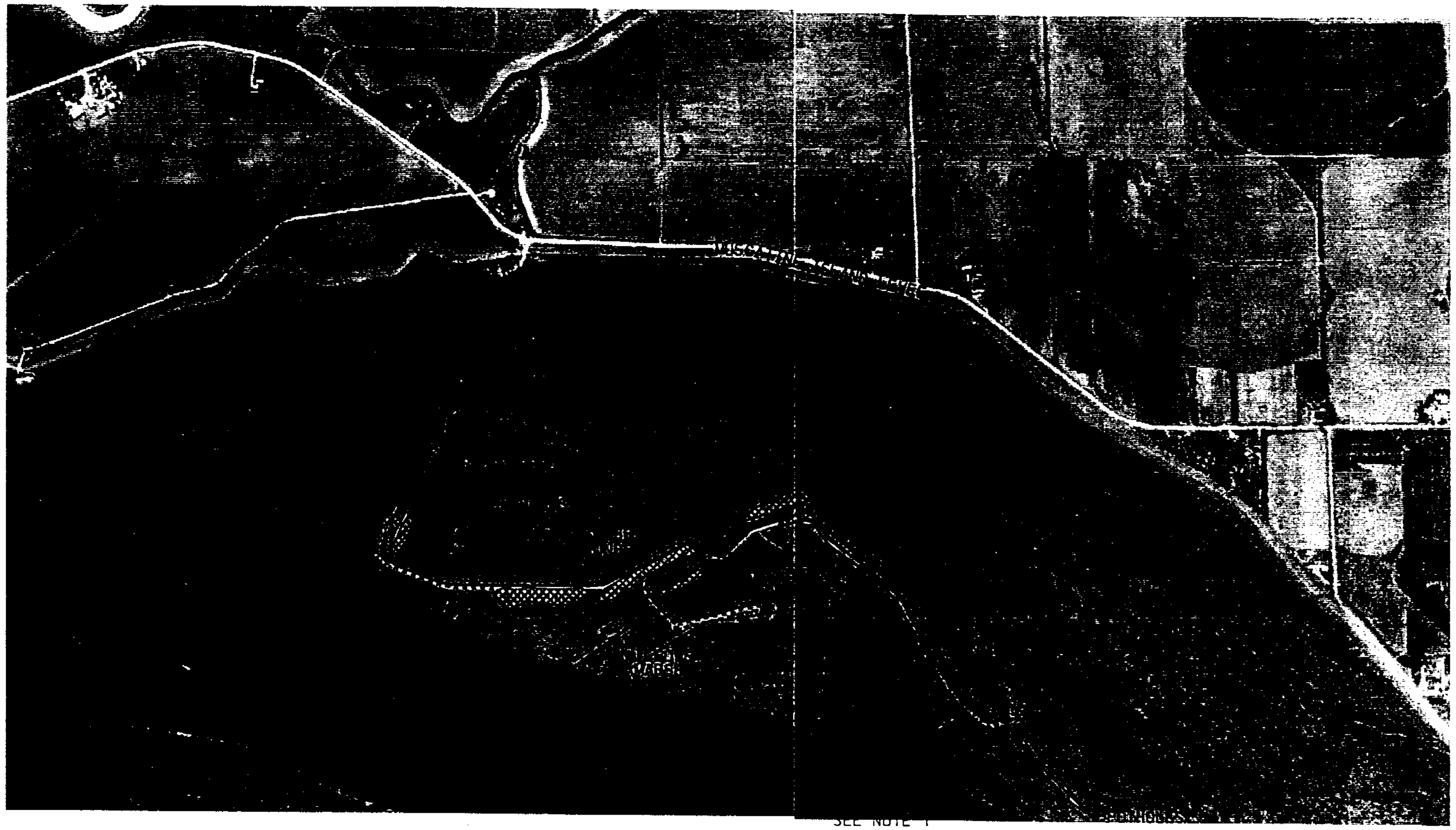
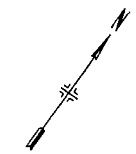
Sheet of

PLATE 1





600 300 0 600 1200FT

SCALE: 1" = 600'

LEGEND

NOTES:

1. MAST TREES PLANTED ON THE CONTAINMENT DIKE.
2. DATE OF AERIAL PHOTOGRAPHY: 4-17-94

- SHALLOW AQUATIC HABITAT
- COMBINATION SHALLOW/DEEP AQUATIC HABITAT
- DEEP AQUATIC HABITAT
- EXCAVATED SIDECAST MATERIAL
- CHECK DAM

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U.S. ARMY ENGINEER DISTRICT
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US Army Corps of Engineers

UPPER MISSISSIPPI RIVER SYSTEM
BIG TIMBER PERFORMANCE EVALUATION
POOL 17, RIVER MILES 443.5-445

PROJECT FEATURES

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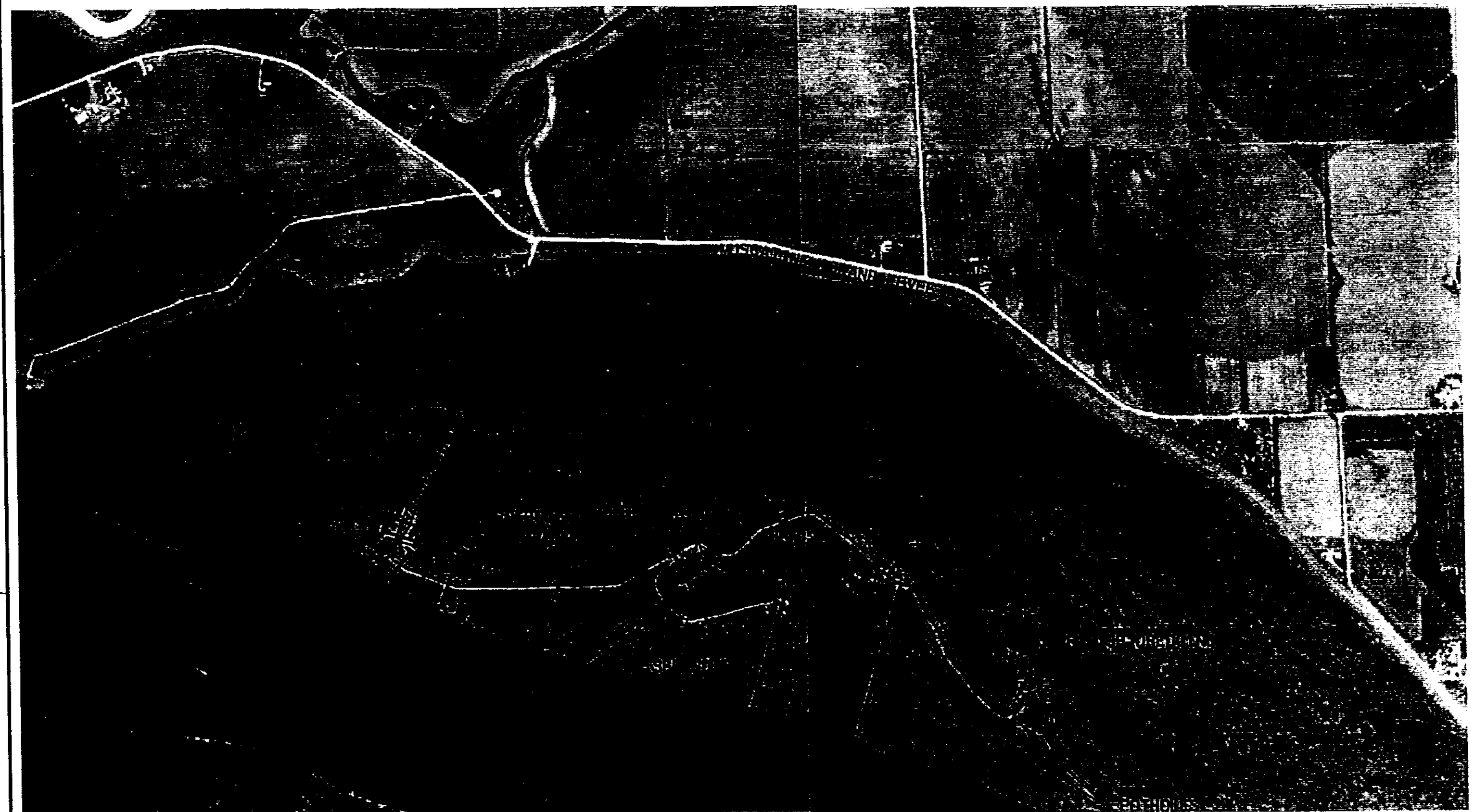
PLATE 2



LEGEND:

- DEEP AQUATIC HABITAT
- SHALLOW AQUATIC HABITAT
- COMBINATION SHALLOW/DEEP AQUATIC HABITAT

NOTES:

1. DATE OF AERIAL PHOTOGRAPHY: 4-17-94

600 300 0 600 1200FT
SCALE: 1"= 600'

SEDIMENTATION TRANSECT ALIGNMENT	
ROUND POND-TIMBER CHUTE-WILLOW CHUTE-BIG DENNY	SCALED DISTANCE
START DREDGING	460
S-M443.7F TO S-M443.6G	360
SM443.7G TO S-M443.5H	610
S-M443.7J TO S-M443.6J	280
S-M443.7J TO S-M443.7K	510
S-M443.8J TO S-M443.8K	1060
S-M444.0J TO S-M444.0K	850
S-M444.2J TO S-M444.2K	380
S-M444.3I TO S-M444.4K (SI)	1230
S-M444.4H TO S-M444.5H	1450
S-M444.7G TO S-M444.7H	780
S-M444.8H TO S-M444.8I	1070
FINISH DREDGING	

		AS BUILT DREDGING AND EXCAVATION CHANNEL OCT. 21, 1991					
LOCATION	REACH	LENGTH IN FEET	BOTTOM WIDTH IN FEET		BOTTOM ELEVATION		SIDE SLOPES
			HYDRAULIC	MECHANICAL	HYDRAULIC	MECHANICAL	
ROUND POND	A-B	1120	50	-	528	-	2H:1V
TIMBER CHUTE	B-C	327	35	-	528	-	2H:1V
WILLOW CHUTE	C-D	3200	50	40	528	532.5	2H:1V
WILLOW CHUTE	D-E	750	50	40	528	532.5	2H:1V
BIG DENNY	E-F	3625	-	50	-	532.5	2H:1V
LITTLE DENNY	D-G	1850	-	50	-	532.5	2H:1V
TOTALS		10,872					

TYPE OF MEASUREMENT

POINT

E = BULK SEDIMENT ANALYSIS
W = WATER QUALITY
C = COLUMN SETTLINGS ANALYSIS
B = BORING

TRANSECT

S = SEDIMENTATION
V = VEGETATION
1938, 1977 EXISTING DATA

LOCATION CODE

- M ... = MISSISSIPPI RIVER
- 545.8 = RIVER MILE
- ...H = ALPHA DESIGNATOR
Z = LEFT DECENDING BANK
A = RIGHT DECENDING BANK

Revisions			
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U.S. ARMY ENGINEER DISTRICT
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ROCK ISLAND, ILLINOIS

US Army Corps of Engineers

UPPER MISSISSIPPI RIVER SYSTEM
BIG TIMBER PERFORMANCE EVALUATION
POOL 17, RIVER MILES 443.5-445

MONITORING PLAN

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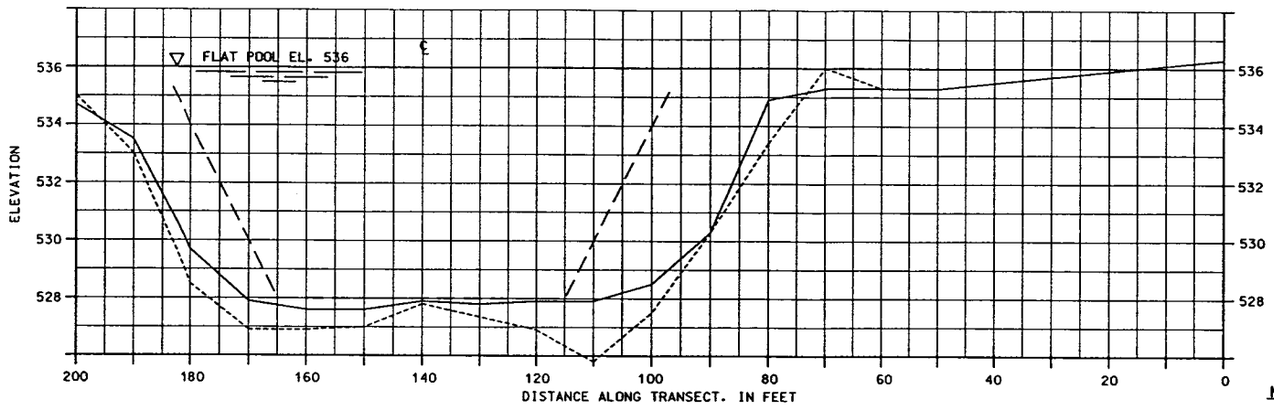
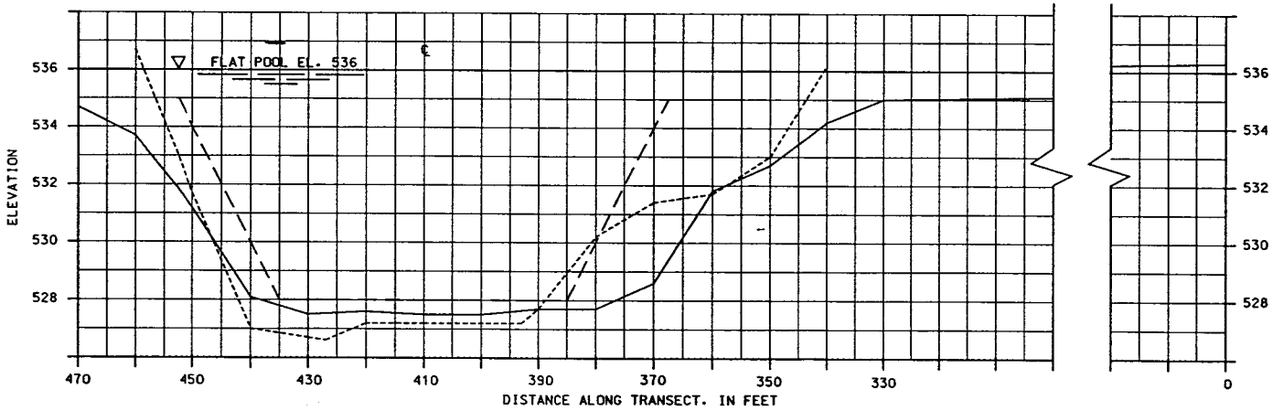
PLATE 3



SEDIMENTATION TRANSECT S-M443.7F to S-M443.6G (STA. 0+00)



SEDIMENTATION TRANSECT S-M443.7G to S-M443.5H (STA. 0+00)

KEY

— — — — CHANNEL SECTION, AS DESIGNED

---------- CHANNEL SECTION, AS COMPLETED IN JULY 1991

———— CHANNEL SECTION, AS SOUNDED IN JANUARY 1994

℄ CENTER LINE OF AS-DESIGNED AND AS-COMPLETED SECTIONS

NOTE : THE WATER SURFACE AT THE TIME OF THE JANUARY 1994 SOUNDING WAS 536.3

Revisions			
Symbol	Description	Date	Approved

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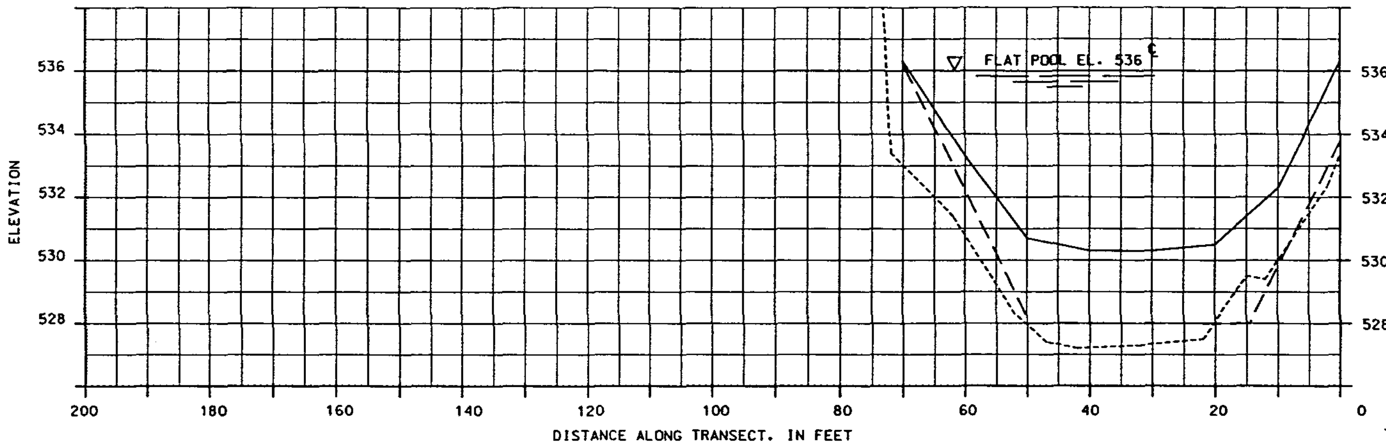
Drawn by: SDH	BIG TIMBER PERFORMANCE EVALUATION POOL 17, RIVER MILES 443.5 - 445
Checked by: CCK	DREDGED CHANNEL SEDIMENTATION TRANSECTS ROUND POND
Reviewed by: DJJ	Scale:
Approved by: CHARLES S. COX CO., CORPS OF ENGINEERS	Date:
	Drawing Code:
	Sheet reference number:
	Solicitation Number: DACW25-9 -B-
	Sheet of

PLATE 4



SEDIMENTATION TRANSECT S-M443.7J to S-M443.6J (STA. 0+00)

KEY

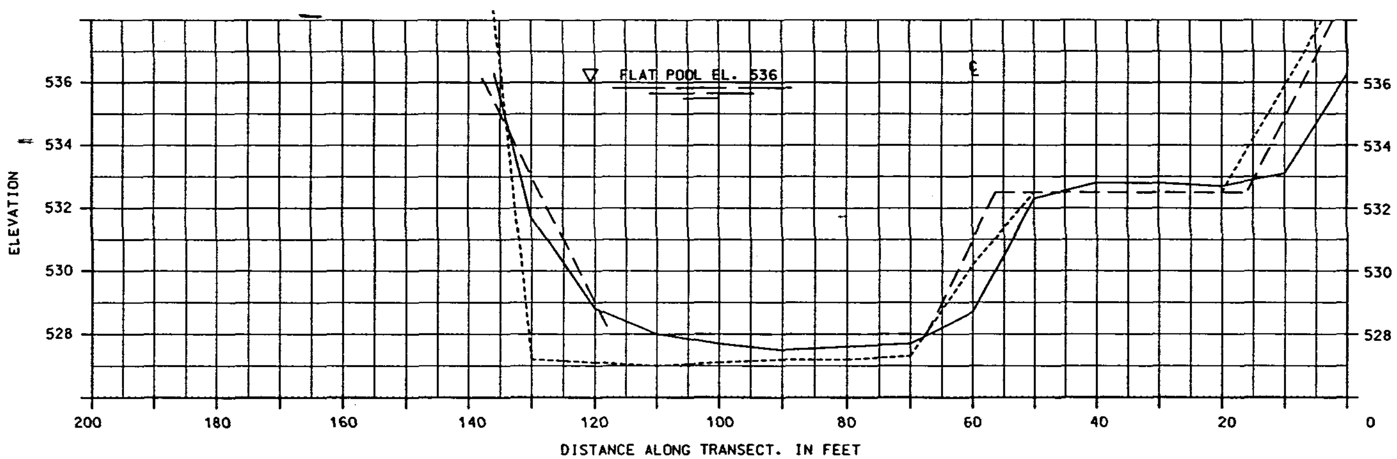
— — — CHANNEL SECTION, AS DESIGNED

------------ CHANNEL SECTION, AS COMPLETED IN JULY 1991

———— CHANNEL SECTION, AS SOUNDED IN JANUARY 1994

℄ CENTER LINE OF AS-DESIGNED AND AS-COMPLETED SECTIONS

NOTE : THE WATER SURFACE AT THE TIME OF THE JANUARY 1994 SOUNDING WAS 536.3



SEDIMENTATION TRANSECT S-M443.7J to S-M443.7K (STA. 0+00)

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UPPER MISSISSIPPI SYSTEM
BIG TIMBER PERFORMANCE
EVALUATION POOL 17,
RIVER MILES 443.5 - 445

DREDGED CHANNEL SEDIMENTATION TRANSECTS TIMBER CHUTE-WILLOW CHUTE

Scale:
Date:
Drawing Code:
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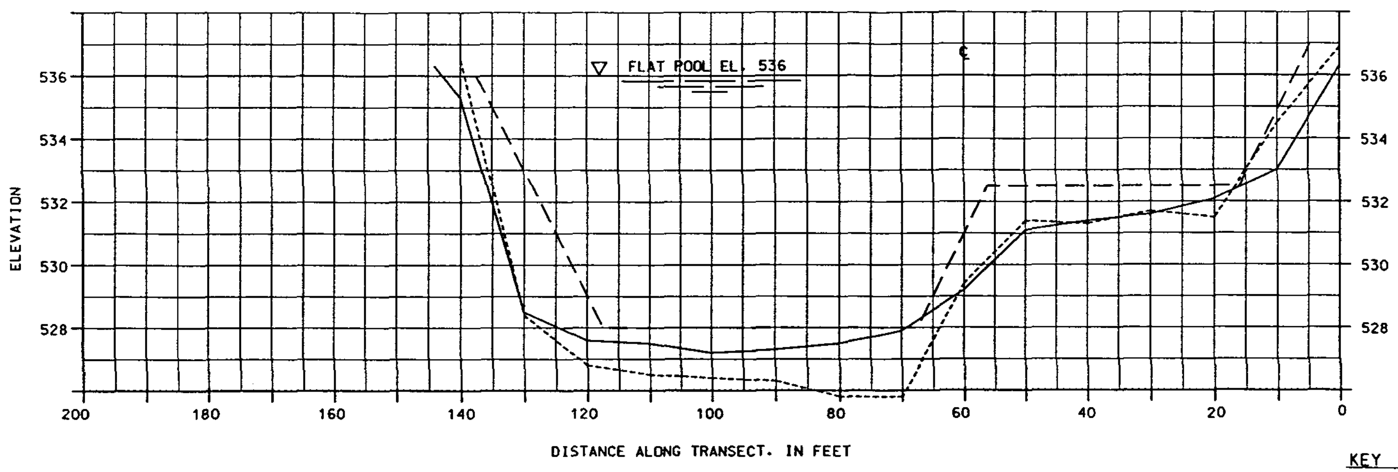
Solicitation Number: DACW25-9 -B-
Sheet of

PLATE 5

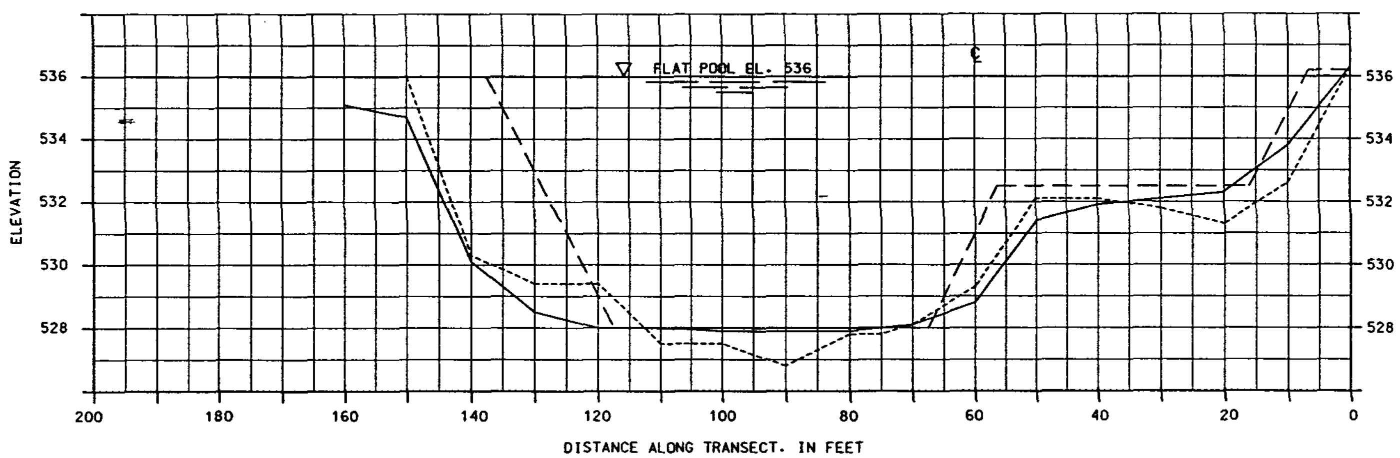


SEDIMENTATION TRANSECT S-M443.8J to S-M443.8K (STA. 0+00)

KEY

— — — —	CHANNEL SECTION, AS DESIGNED
------------	CHANNEL SECTION, AS COMPLETED IN JULY 1991
————	CHANNEL SECTION, AS SOUNDED IN JANUARY 1994
℄	CENTER LINE OF AS-DESIGNED AND AS-COMPLETED SECTIONS

NOTE : THE WATER SURFACE AT THE TIME OF THE JANUARY 1994 SOUNDING WAS 536.3



SEDIMENTATION TRANSECT S-M444.0J to S-M444.0K (STA. 0+00)

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US Army Corps of Engineers

UPPER MISSISSIPPI SYSTEM
BIG TIMBER PERFORMANCE
EVALUATION POOL 17,
RIVER MILES 443.5 - 445

DREDGED CHANNEL SEDIMENTATION TRANSECTS WILLOW CHUTE

Scale:
Date:
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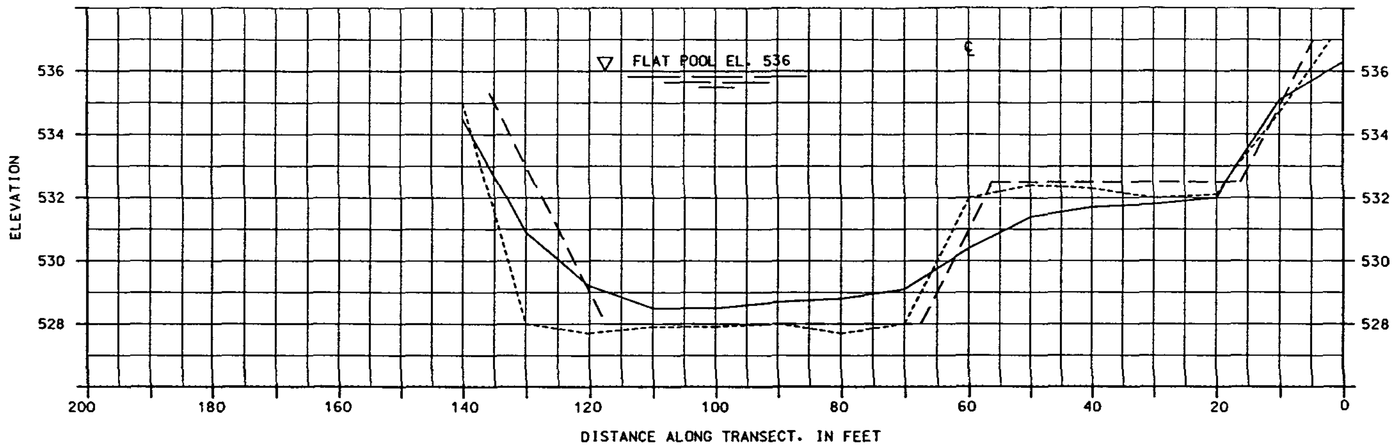
PLATE 6



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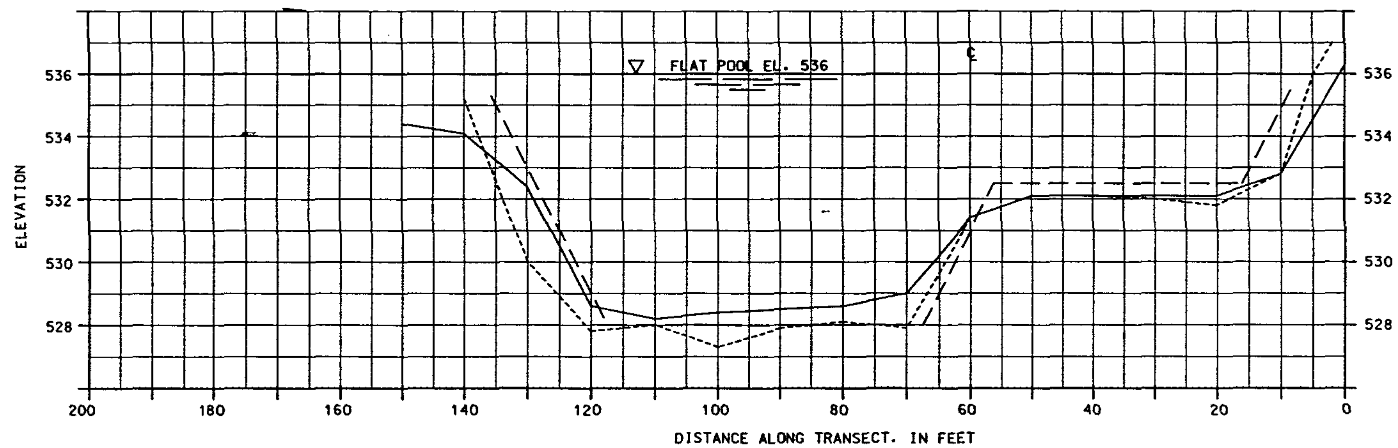

SEDIMENTATION TRANSECT S-M444.3I to S-M444.4K (SEGMENT 1) - SEE NOTE 2

KEY

- — — — CHANNEL SECTION, AS DESIGNED
- - - - - - CHANNEL SECTION, AS COMPLETED IN JULY 1991
- ——— CHANNEL SECTION, AS SOUNDED IN JANUARY 1994
- ℄ CENTER LINE OF AS-DESIGNED AND AS-COMPLETED SECTIONS

NOTES :

1. THE WATER SURFACE AT THE TIME OF THE JANUARY 1994 SOUNDING WAS 536.3
2. THIS TRANSECT WAS SOUNDED IN 3 SEGMENTS SEGMENT 1 IS SOUTHERN MOST (FURTHEST FROM RIVER)

Revisions			
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Checked by: CCK	
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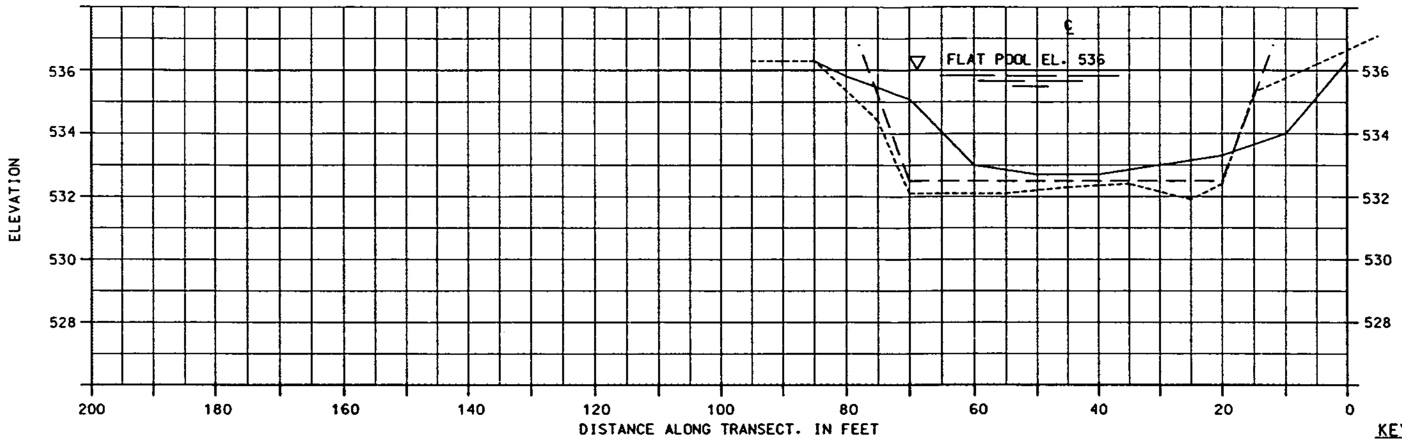
Approved by: CHARLES S. COX COL., CORPS OF ENGINEERS	Drawing Code: / Sheet of

PLATE 7



SEDIMENTATION TRANSECT S-M444.4H to S-M444.5H (STA. 0+00)

KEY

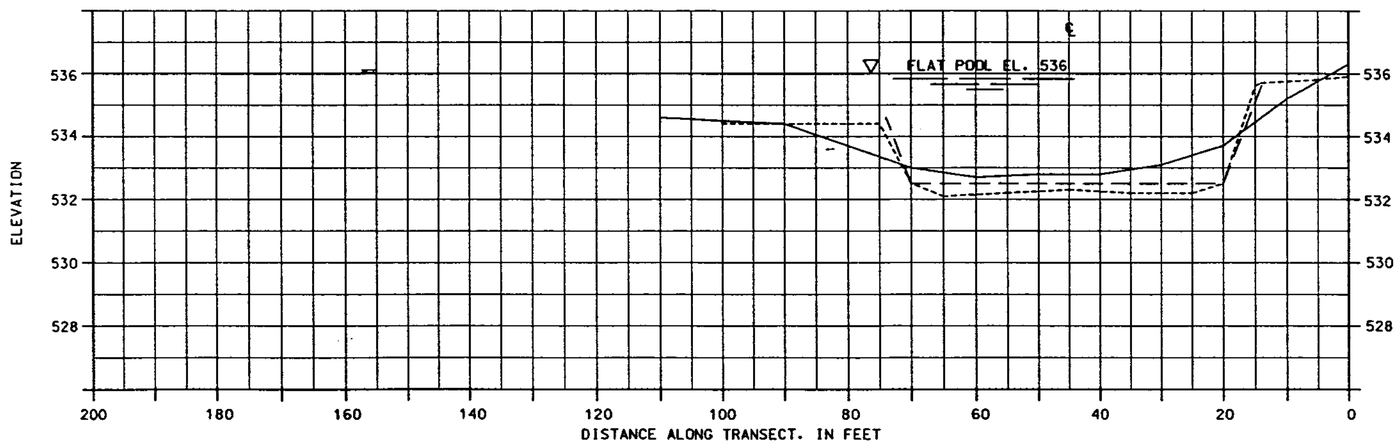
— — — — CHANNEL SECTION, AS DESIGNED

------------ CHANNEL SECTION, AS COMPLETED IN JULY 1991

———— CHANNEL SECTION, AS SOUNDED IN JANUARY 1994

℄ CENTER LINE OF AS-DESIGNED AND AS-COMPLETED SECTIONS

NOTE : THE WATER SURFACE AT THE TIME OF THE JANUARY 1994 SOUNDING WAS 536.3



SEDIMENTATION TRANSECT S-M444.7G to S-M444.7H (STA. 0+00)

Revisions			
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ROCK ISLAND, ILLINOIS

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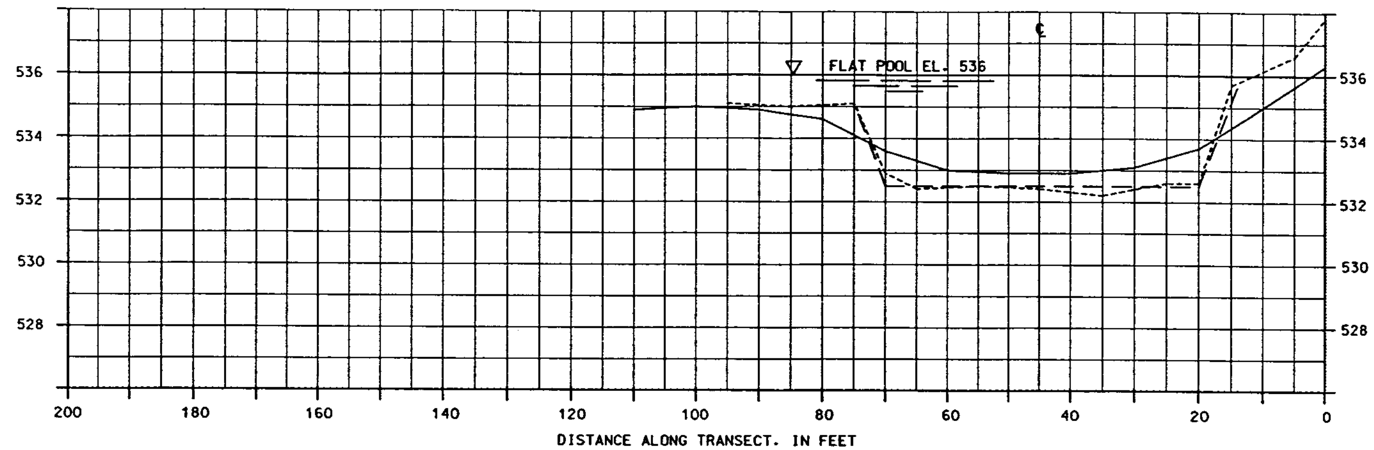
UPPER MISSISSIPPI SYSTEM
BIG TIMBER PERFORMANCE
EVALUATION POOL 17,
RIVER MILES 443.5 - 445

DREDGED CHANNEL SEDIMENTATION TRANSECTS WILLOW CHUTE-BIG DENNY

Scale:
Date:
Drawing Code:
Sheet reference number:
Solicitation Number: DACW25-9 -8-
Sheet of



SEDIMENTATION TRANSECT S-M444.8H to S-M444.8I (STA. 0+00)

KEY

— — — — CHANNEL SECTION, AS DESIGNED

------------ CHANNEL SECTION, AS COMPLETED IN JULY 1991

———— CHANNEL SECTION, AS SOUNDED IN JANUARY 1994

℄ CENTER LINE OF AS-DESIGNED AND AS-COMPLETED SECTIONS

NOTE : THE WATER SURFACE AT THE TIME OF THE JANUARY 1994 SOUNDING WAS 536.3

Revisions			
Symbol	Description	Date	Approved

U.S. ARMY ENGINEER DISTRICT
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ROCK ISLAND, ILLINOIS

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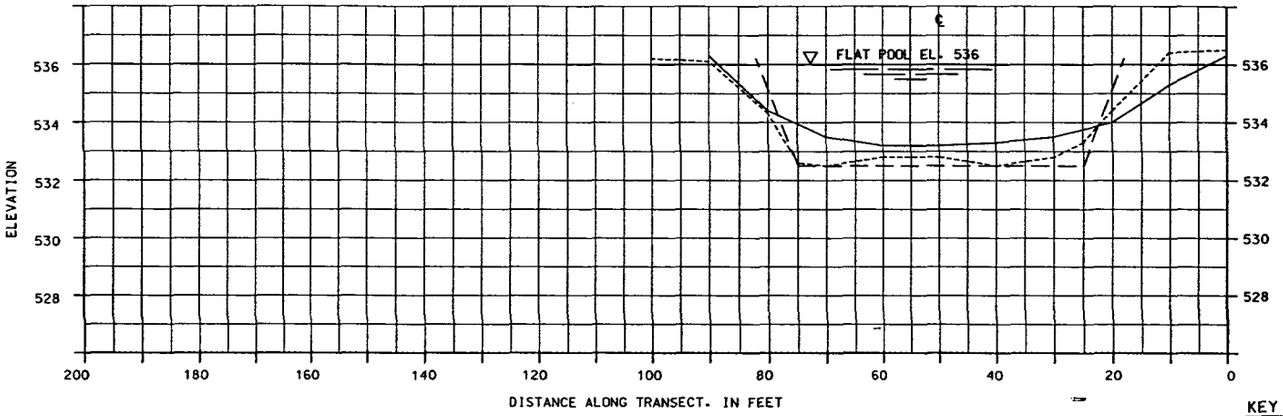
Checked by: CCK
Reviewed by: DJJ
Approved by: CHARLES S. COX COL., CORPS OF ENGINEERS

UPPER MISSISSIPPI SYSTEM
BIG TIMBER PERFORMANCE
EVALUATION POOL 17,
RIVER MILES 443.5 - 445

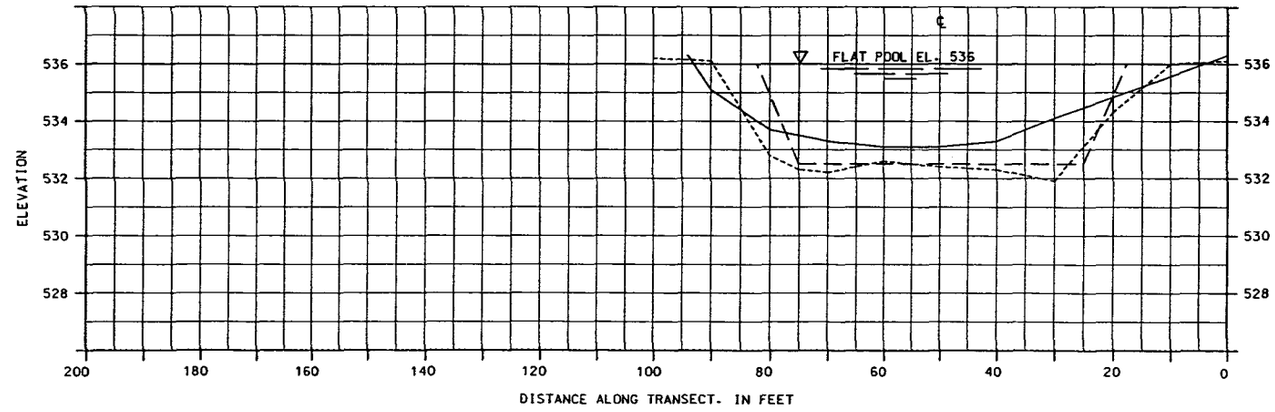
DREDGED CHANNEL SEDIMENTATION TRANSECTS BIG DENNY

Scale:
Date:
Drawing Code:
Sheet reference number:
Solicitation Number: DACW25-9 -0-
Sheet of

PLATE 9



SEDIMENTATION TRANSECT S-M444.3I to S-M444.4K (SEGMENT 3) - SEE NOTE 2



SEDIMENTATION TRANSECT S-M444.3I to S-M444.4K (SEGMENT 2) - SEE NOTE 2

KEY

- — — — — CHANNEL SECTION, AS DESIGNED
- ---------- CHANNEL SECTION, AS COMPLETED IN JULY 1991
- ———— CHANNEL SECTION, AS SOUNDED IN JANUARY 1994
- ℄ CENTER LINE OF AS-DESIGNED AND AS-COMPLETED SECTIONS

NOTES :
1. THE WATER SURFACE AT THE TIME OF THE JANUARY 1994 SOUNDING WAS 536.3
2. THIS TRANSECT WAS SOUNDED IN 3 SEGMENTS SEGMENT 2 IS BETWEEN SEGMENTS 1 & 3. SEGMENT 3 IS NORTHERN MOST (CLOSEST TO RIVER)

Revisions			
Symbol	Description	Date	Approved

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS

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Drawn by: SDH	DREDGED CHANNEL SEDIMENTATION TRANSECTS LITTLE DENNY
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Reviewed by: DJJ	Scale: / Sheet reference number: / Solicitation Number: DACW25-9 -C-
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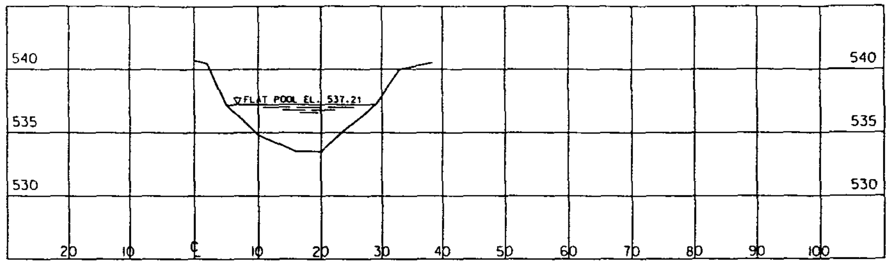
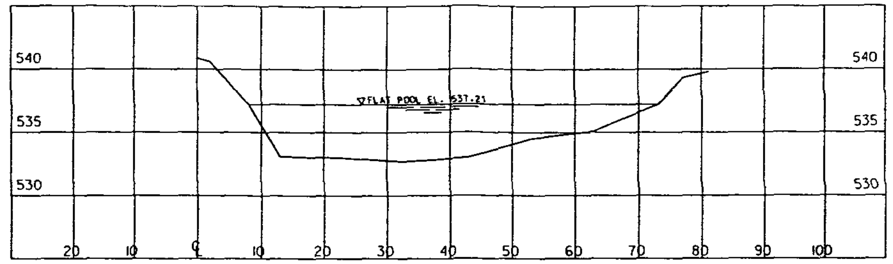
PLATE 10



POTHOLE #1 - SHORT CHORD



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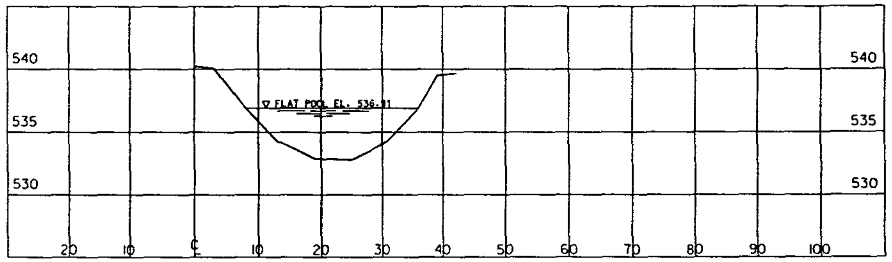

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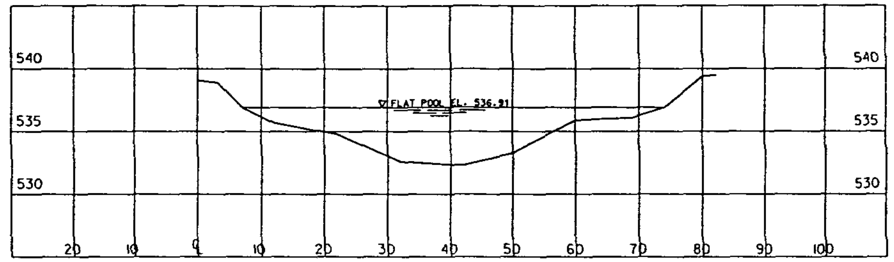

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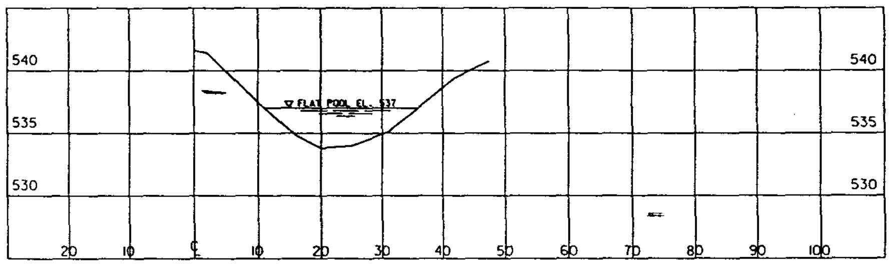

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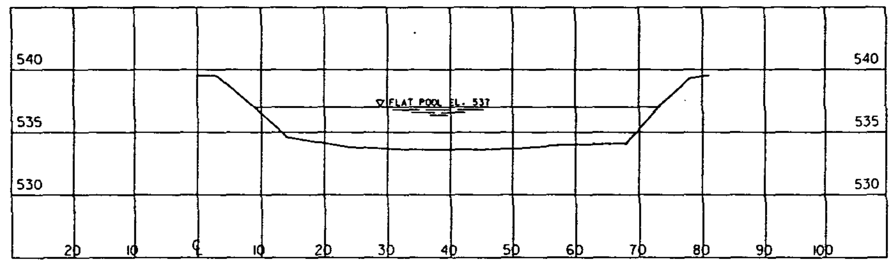

POTHOLE #3 - LONG CHORD

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ROCK ISLAND, ILLINOIS

US Army Corps of Engineers

UPPER MISSISSIPPI SYSTEM
BIG TIMBER PERFORMANCE
EVALUATION POOL 17,
RIVER MILES 443.5 - 445

SEDIMENTATION TRANSECTS
POTHOLES 1-3

Designed by: CCK
Drawn by: SDH
Checked by: CCK
Reviewed by: DJJ
Approved by: CHARLES S. COX, COL., CORPS OF ENGINEERS

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Sheet reference number:
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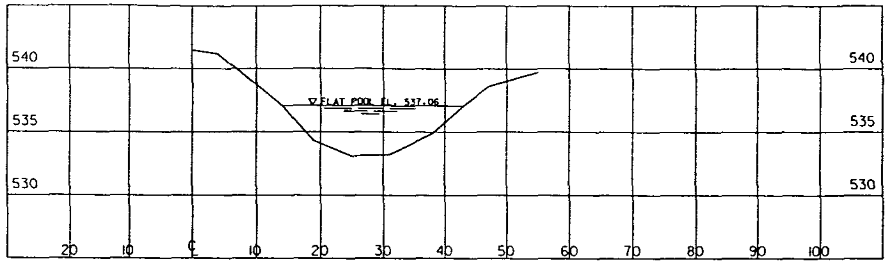
PLATE 11



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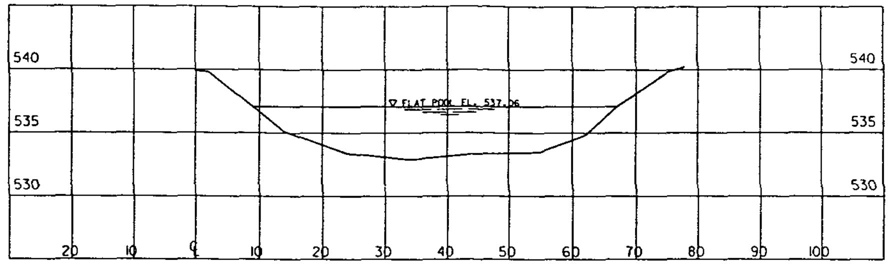

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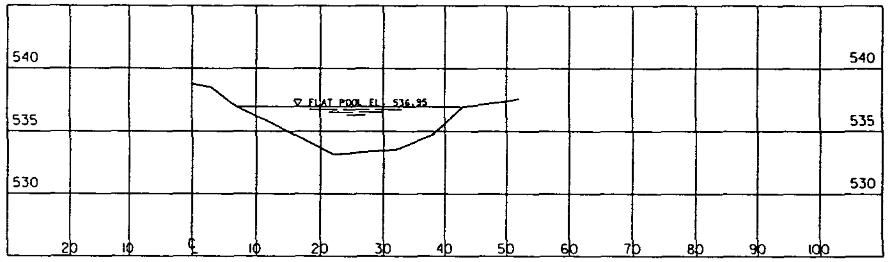

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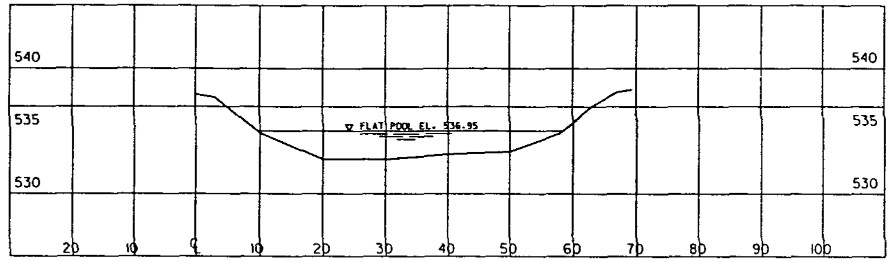

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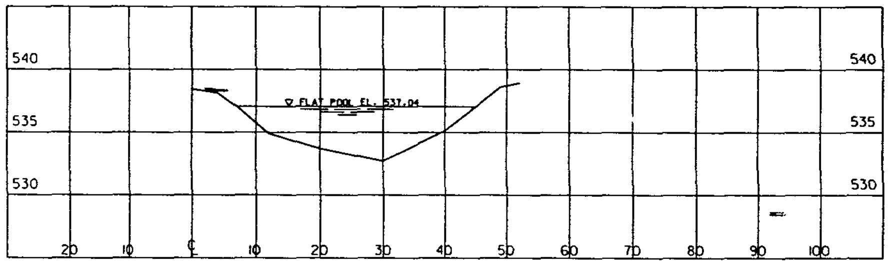

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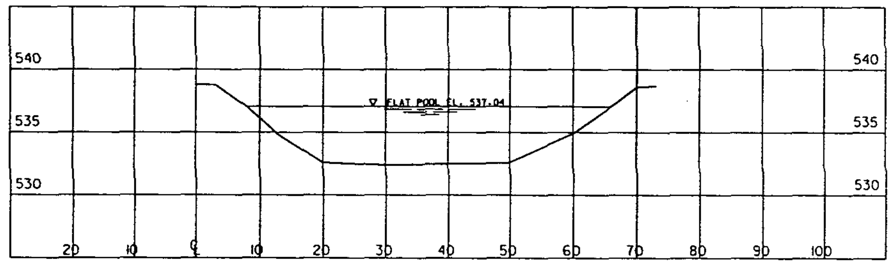

POTHOLE #6 - LONG CHORD

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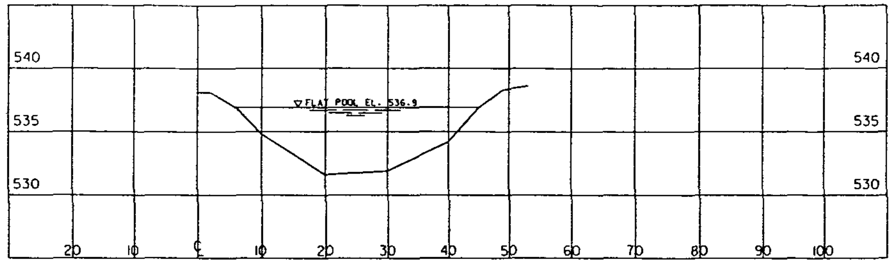
Designed by: CCK	US Army Corps of Engineers UPPER MISSISSIPPI SYSTEM BIG TIMBER PERFORMANCE EVALUATION POOL 17, RIVER MILES 443.5 - 445 **SEDIMENTATION TRANSECTS POTHOLES 4-6**
Drawn by: SDH	
Checked by: CCK	
Reviewed by: DJJ	Scale: / Date: / Sheet reference number: / Solicitation Number: DACW25-9 -0-
Approved by: CHARLES S. COX COL., CORPS OF ENGINEERS	Drawing Code: / Sheet of

PLATE 12



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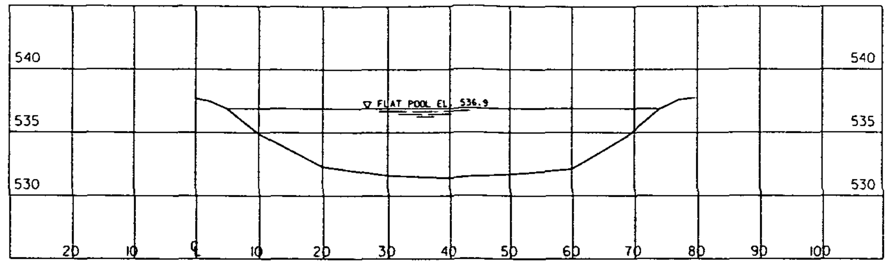

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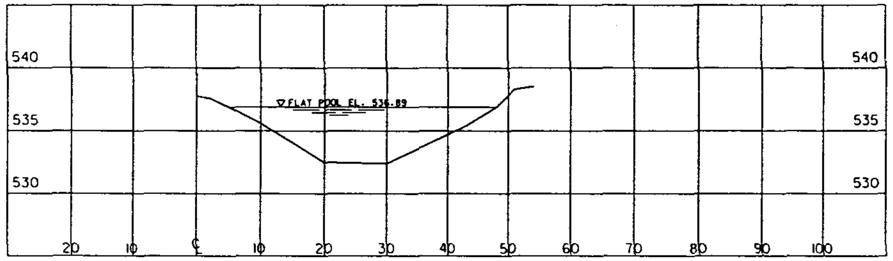

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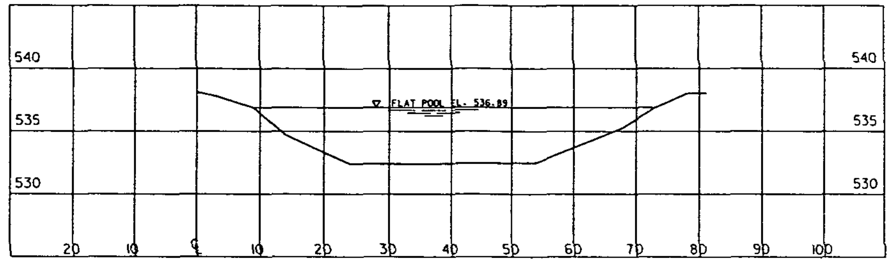

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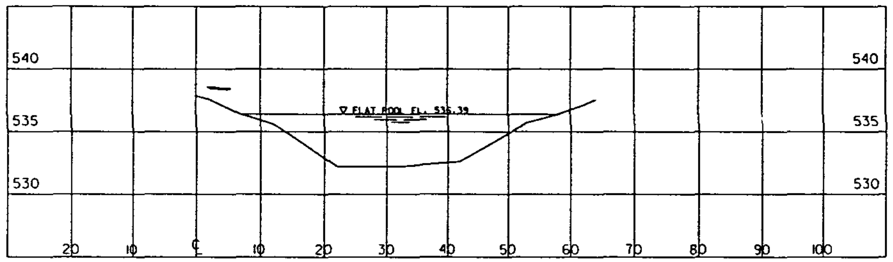

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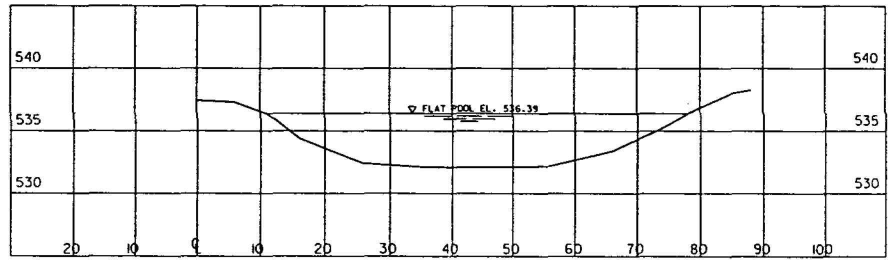

POTHOLE #9 - LONG CHORD

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U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS

Designed by: CCK
Drawn by: SDH
Checked by: CCK
Reviewed by: DJJ
Approved by: CHARLES S. COX COL., CORPS OF ENGINEERS

US Army Corps of Engineers Rock Island District

UPPER MISSISSIPPI SYSTEM
BIG TIMBER PERFORMANCE
EVALUATION POOL 17,
RIVER MILES 443.5 - 445

SEDIMENTATION TRANSECTS POTHOLES 7-9

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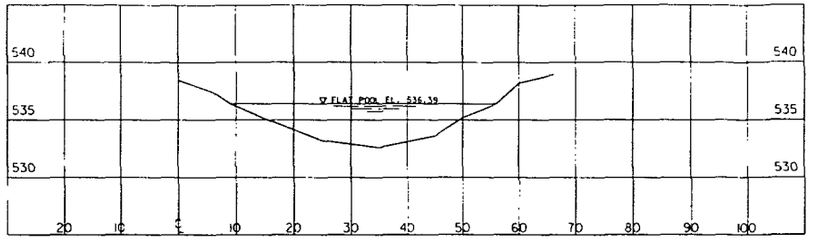
Solicitation Number: DACW25-9 -0-
Sheet of

PLATE 13

26-OCT-1995 13:06



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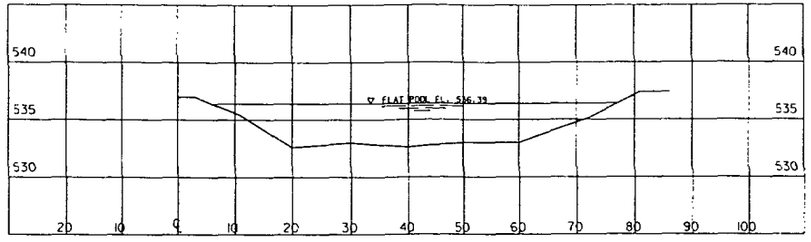

POTHOLE #10 - LONG CHORD

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Symbol	Description	Date	Approved

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS

Designed by: CCK
Drawn by: SDH
Checked by: CCK
Reviewed by: DJJ
Approved by: CHARLES S. COX
COL., CORPS OF ENGINEERS

UPPER MISSISSIPPI SYSTEM
BIG TIMBER PERFORMANCE
EVALUATION POOL 17,
RIVER MILES 443.5 - 445

SEDIMENTATION TRANSECTS
POTHOLE 10

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Datum:
Drawing Code:
Sheet Reference Number:
Solicitation Number: DACW25-9 -0-
Sheet of

PLATE 14

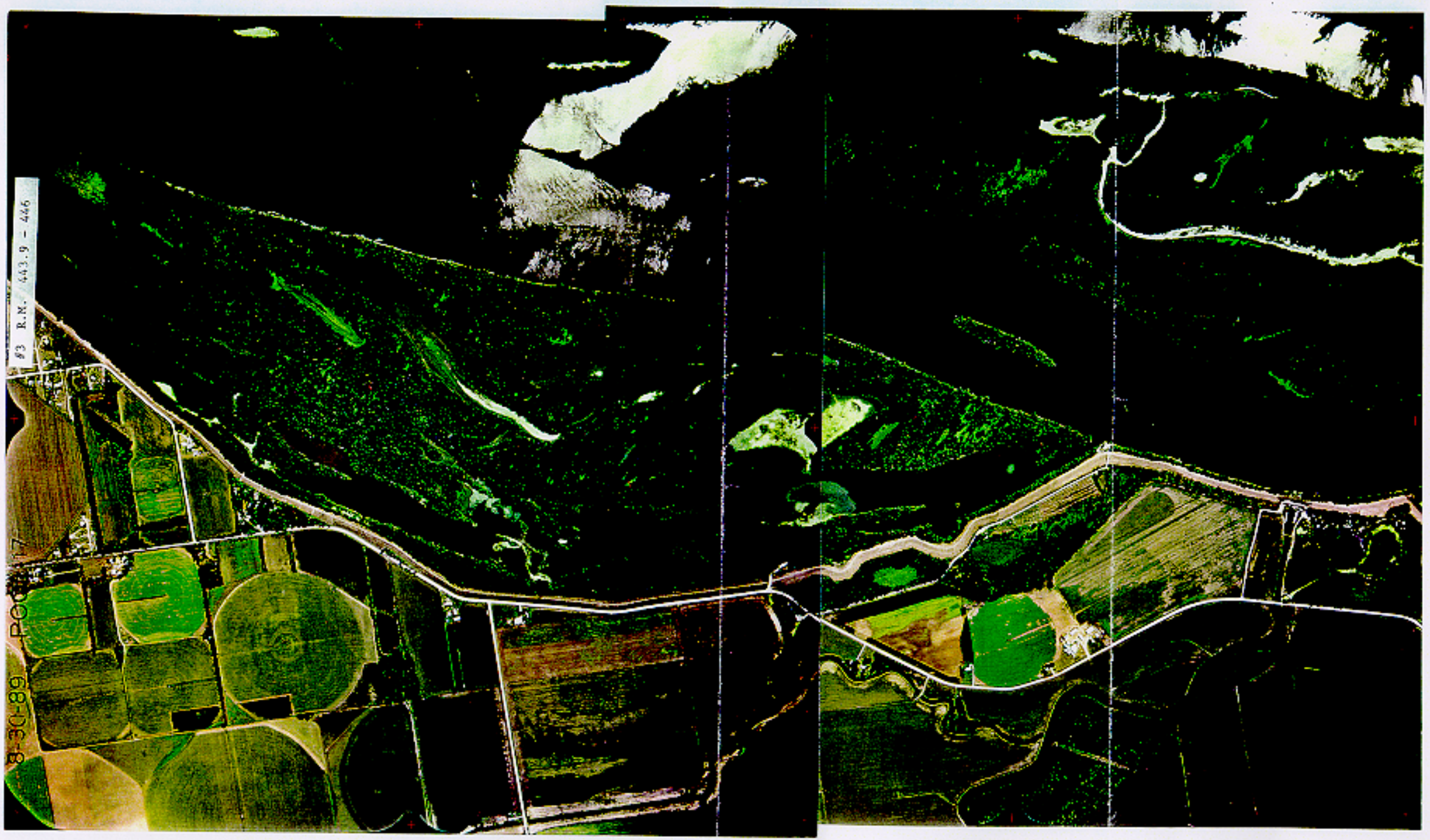

PLATE 15 - 1989 Aerial Photo - Pre-Project Conditions

Big Timber, Iowa EMP-HREP
Pool 17, Mississippi River Mile 444

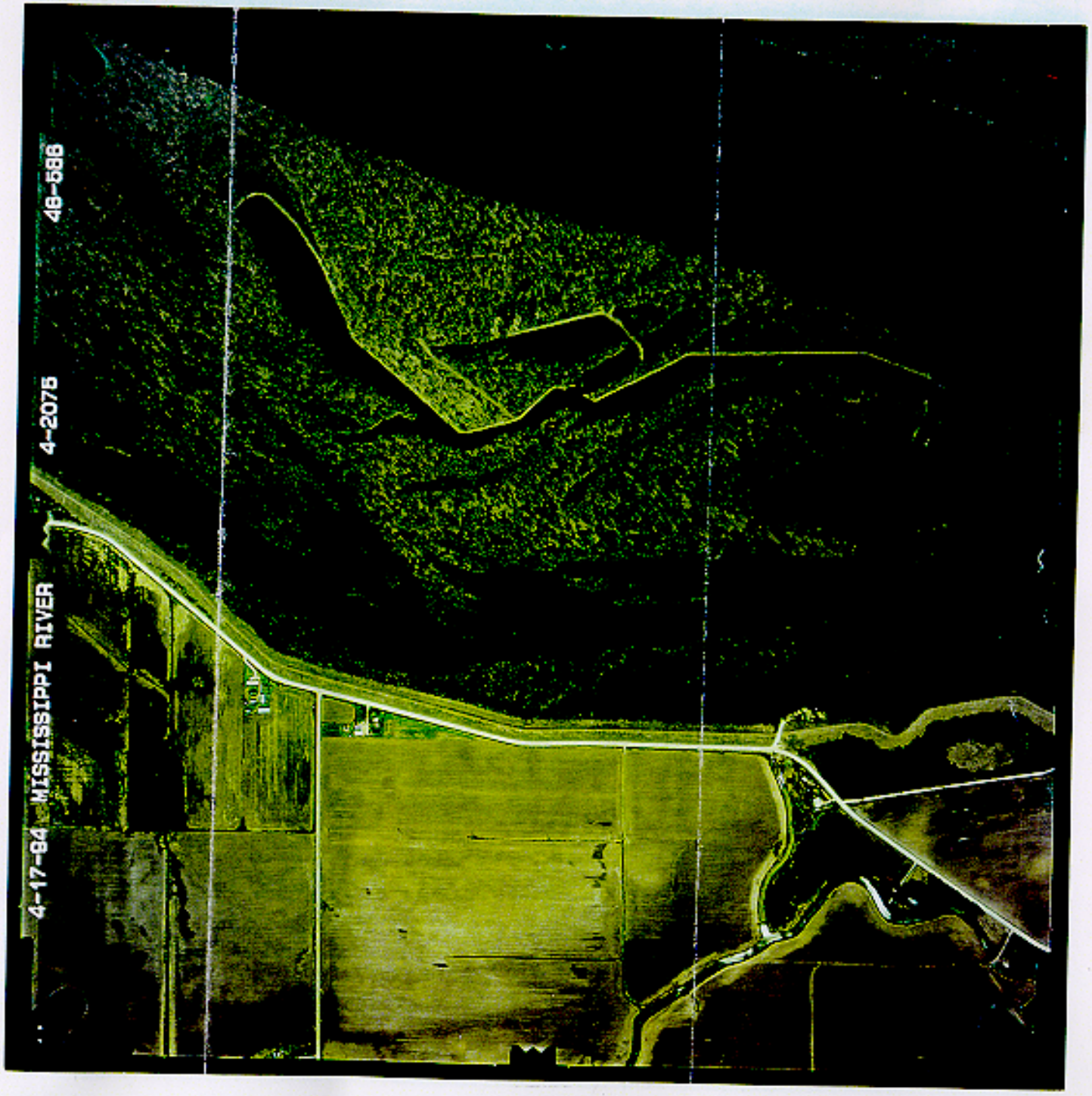

PLATE 16 - 1994 Aerial Photo - Post Project Conditions

Big Timber, Iowa EMP-HREP
Pool 17, Mississippi River Mile 444