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UPPER MISSISSIPPI RIVER SYSTEM
ENVIRONMENTAL MANAGEMENT PROGRAM
POST-CONSTRUCTION SUPPLEMENTAL PERFORMANCE
EVALUATION REPORT (SPER501F)

BIG TIMBER REFUGE REHABILITATION AND ENHANCEMENT

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

AUGUST 1998

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

PROGRAM MANAGER
Paul A. Kowalczyk, P.E.

PROJECT ENGINEER
Celia Kool, P.E.

PROJECT ENGINEER
Michael Tarpey

TECHNICAL MGR FOR HABITAT PROJECTS
Jerry Skalak

FORESTRY
Gary Swenson

ENVIRONMENTAL ANALYSIS
Charlene Carmack

WATER QUALITY
Dave Bierl

CADD SUPPORT
Sue Brown

REPORT PREPARATION
Nancy Holling

U.S. FISH AND WILDLIFE SERVICE
MARK TWAIN NATIONAL WILDLIFE REFUGE

EMP COORDINATOR
Karen Westphall

REFUGE MANAGER
Dick Steinbach

IOWA DEPARTMENT OF NATURAL RESOURCES

FISHERIES
Bernie Schonhoff

US Army Corps
of Engineers
Rock Island District

WE'RE PROUD TO SIGN OUR WORK

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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 Wapello District of the Mark Twain National Wildlife Refuge.

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

(1) Supplement monitoring results and project operation and maintenance discussed in the February 1996 Post-Construction Evaluation Report.

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

(3) Review the monitoring plan for possible revision;

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

(5) 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 June 1996 through April 1998.

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 Appendix A.

c. Management Plan. A formalized management plan is 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. The project consists of deep and shallow aquatic habitat, check dams, potholes, boater access control, and mast trees planted on the dredged material containment dike. The project features are illustrated below in Figures 3-1 and 3-2 and on plate 2.

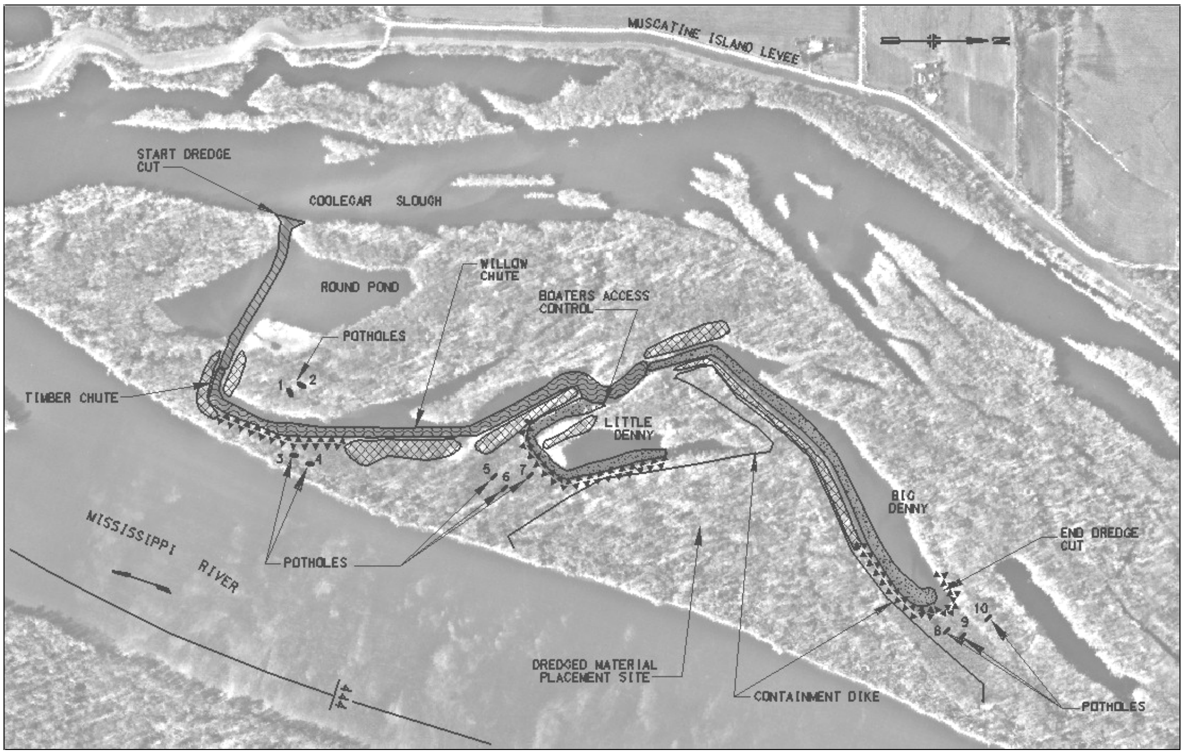

FIGURE 3-1. Project Features.

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.

FIGURE 3-2. Photographs of Selected Project Features.

4. 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 Summary are presented in Figure 4-1 and on plate 3. As part of the Flood of 1993 Damage Assessment, the Corps took soundings (sedimentation transects) on January 12, 1994, at 11 Big Timber project dredged channel sedimentation transects. The 1997 sedimentation transect data include a new section (section D, plate 5) and are shown on plates 4 through 11. The sedimentation transects, as of January 1997, are now located by GPS coordinates. **This means that the distances and areas are different from the first performance evaluation.**

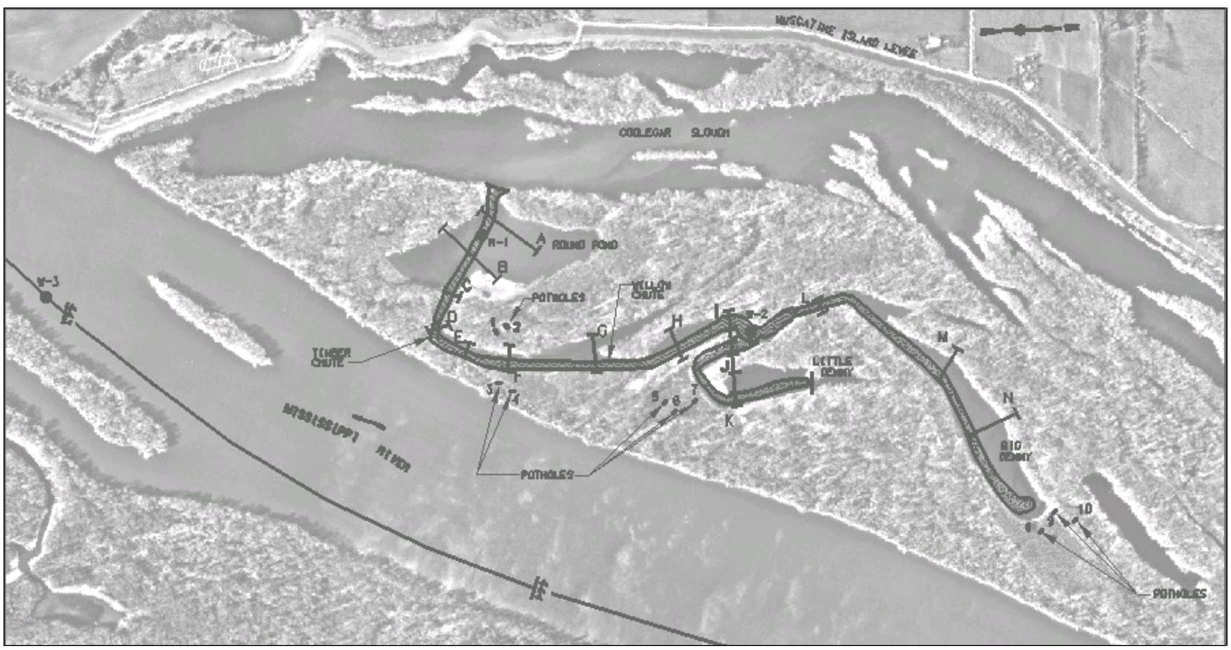

FIGURE 4-1. Big Timber Monitoring Plan.

The Corps has also collected water quality data at one station located near the mouth of Round Pond. A second water quality station, located near the mouth of Little Denny, was added in November 1995. A third station, located near the confluence of Coolegar Slough and the Mississippi River, was added in August 1998 for purposes of comparing main channel water quality parameters with those of the project channels. Monitoring at this third site will be limited to summer dissolved oxygen (D.O.) and temperature parameters. The Corps surveyed pothole sedimentation transects in June 1997. The 10 pothole sedimentation transects are shown on plates 12 through 15. The success of the project relative to original project objectives will be measured using these 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 Wapello District Manager of the Mark Twain National Wildlife Refuge (USFWS Site Manager) is required to conduct annual inspections of the project and submit a project inspection checklist immediately following the project inspection. The Site Manager is also required 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, and Willow Chute are shown on plates 4 through 8. As shown below in Table 5-1, over 67 acre-feet of deep water habitat is available at year 6.

TABLE 5-1

Restore Deep Aquatic Habitat

Year	Deep Aquatic Habitat, Acre-Feet
0	82.4
3	75.1
6	67.2
50 (Target)	42.4

Based on data available to date, annual sedimentation rates were determined as shown below in Table 5-2.

TABLE 5-2

Annual Deep Aquatic Habitat Sedimentation Rates

Year	Annual Sediment Deposition, Acre-Feet
0-3	2.43
3-6	2.63
0-6	2.53

Based on 1938 and 1988 data, the DPR estimated an average annual sediment deposition rate of 0.51 inch per year over the Big Timber area. However, DPR estimates of sedimentation rates in channelized areas (Round Pond) showed an increase in sedimentation rate over the average. This rate was estimated to be about 0.62 inch per year. The DPR also stated that detailed historical records of sedimentation rates were practically nonexistent. A paper by J. Roger McHenry dated March 1981 entitled “Sedimentation Rates in Two Backwater Channel Lakes, Pool 14, Mississippi River” indicated widely varying deposition rates, with an average of 1.2 inch per year. In general, deep aquatic habitat depths in 1991 (post-construction) averaged 9 feet. In 1997, deep aquatic habitat depths averaged 7 feet, Timber Chute excepted. The depth of the 1997 Timber Chute sediment transect was approximately 5 feet. This equates to an average annual sediment deposition rate of 4 inches/year for the majority of the project and 8 inches/year for Timber Chute. (Depths were determined visually from plates 4-8.)

An aid in the evaluation of sediment deposition rates is the hydrologic data. Three sets of hydrologic data were reviewed. The first set was the data used in planning the project, which included the Mississippi River stage data from 1969 through 1987. The project was constructed in 1991; therefore, two other sets of data helpful in analysis would be pre- (1969 to 1991) and post- (1992 to 1997) construction data. The data reviewed are from the Muscatine gage, 8 miles upstream.

Two stage levels were used for reference. One was the point at which the excavated channel material ("berm") is overtopped. This is at elevation 544.0 and corresponds to elevation 546.0 at the Muscatine gage. The 1969-1987 data show that the berm elevation had historically been exceeded 5% of the time. The 1969-1991 data show that the berm elevation had been exceeded 4% of the time. The 1992-1997 data, however, show exceedance 7.5% of the time. Therefore, since construction, the berm has been overtopped about twice the amount of time one would expect.

The other stage level is the elevation where overland flow initiates. This is approximately elevation 541, and corresponds to elevation 543 at the Muscatine gage. The 1969-1987 data show that the elevation where overland flow initiates had historically been exceeded 13% of the time. The 1969-1991 data show that the overland flow level had been exceeded 12% of the time. The 1992-1997 data show exceedance 18% of the time. Therefore, since construction, the overland flow level has been exceeded 50% more than one would expect.

As previously mentioned, the average sediment deposition rate at Timber Chute is twice the rate of the rest of the Big Timber project. A number of factors may explain this occurrence. The sediment transects show channel sedimentation in conjunction with channel top width widening. This suggests that the banks have sloughed and taken on a more gradual slope. It appears logical to assume that a large portion of the channel bottom deposits have come from the bank or the excavated channel material. Other factors that may explain more bank erosion at this site as compared to other areas of the project include greater shade (less vegetative growth), the site being perpendicular to Mississippi River flow, and the fact that the channel did not exist pre-project. This would make it more susceptible to erosion during overtopping events.

During the April 1, 1998, site visit, it was noted that the topography near Timber Chute differed from the rest of the project. As shown on plate 2, a check dam was constructed at the beginning of Willow Chute, and excavated sidecast material was placed adjacent to Timber Chute. The as-built drawings indicate that placement of excavated sidecast material adjacent to Timber Chute was limited in height to 2 feet above existing ground (approximate elevation 538), resulting in an approximate excavated sidecast material elevation of 540. In contrast, the approximate minimum elevation of the check dams was 541. A natural swale coming from the river at Timber Chute results in the adjacent excavated sidecast material being noticeably lower than the Willow Chute check dam. The area just downstream of the excavated sidecast material bordering Timber Chute is where the main channel expands, and one would expect deposition to occur at this location. The lower elevation of the excavated sidecast material renders Timber Chute more susceptible to sediment deposition than the remainder of the project.

Visual evidence also suggests the specified 2H:1V side slopes of the original channel were too steep and the dredged material was placed too close to the edge of bank (as-builts say the excavated sidecast material was to be a minimum of 10 feet from the edge of bank). Either the dredged material was placed nearer the bank than 10 feet or excessive slumping has occurred. The vertical slopes of the dredge cut probably have been trying to reach their angle of repose and have caused the usually emergent bank portion to slump as well, giving the impression that the excavated sidecast material is on the edge of the bank.

Staff at the Iowa Department of Natural Resources' Fairport Biological station conducted creel surveys in the 94.3 ha (233-acre) site known as Big Timber, including the project area, during 1989 (pre-project) and 1994 (post-project) to evaluate changes in angler behavior after restoration of deep water habitat as a result of this project and an increase in largemouth bass length limits. Results of the creel surveys were documented in a report titled, C*reel Surveys in the Big Timber Area of the Mississippi River, Pool 17*, by Bernard Schonhoff and Mark Cornish, published in 1996 Fisheries Management Investigations, Iowa Department of Natural Resources, Des Moines, Iowa. These surveys documented a decline in the number of anglers utilizing the Big Timber area, yet an increase in the number of anglers using the project area. Overall, harvest of bullheads and channel catfish increased, while harvest of all other species declined. Crappie and bluegill were the two species most targeted by anglers during both 1989 and 1994. Notwithstanding a decline in effort and harvest, angler rating of the fishing experience remained the same between the two years.

In addition, a study of overwintering bluegill conducted in February and March 1994 at both Big Timber and Patterson Lake (an unrehabilitated backwater area in Pool 16) was documented in *Bluegill Dynamics of a Rehabilitated Mississippi River Backwater After Ice-Out,* by Mark Alan Cornish (Master's thesis submitted to the School of Graduate Studies of Western Illinois University, Macomb, IL, 1996). Based on length-frequency, proportional stock density (PSD), age, relative weight (W_r), condition factor (K_{tl}), and autopsy summaries, bluegill populations from the project area in Big Timber and in Patterson Lake were very similar. The winter habitat suitability index (HSI) for Big Timber was calculated as 0.91, as compared with a calculated HSI of 0.37 for Patterson Lake. Abundance as measured by catch per unit effort (CPUE) of fyke nets was higher in the Big Timber HREP area, at 23.0 bluegill/net day, compared with 16.3 bluegill/net day at Patterson Lake.

Despite concerns about the high sedimentation rate, the project has benefited fish and wildlife habitat quality. Before the project, there was no year-round fisheries access in most of the area. The creel survey did show a decrease in harvest of all fish species other than bullhead and channel catfish. However, the recent flooding regime has undoubtedly slowed vegetation response and the associated fisheries and waterfowl benefits that otherwise would have been realized by now. The overwintering bluegill study conducted in March 1994 supports the intuitive conclusion that fisheries habitat in the project area has improved. A series of normal flow years is needed before project benefits are fully realized.

(2) Conclusions. With the exception of Timber Chute, the Big Timber project is meeting the objective of restoring deep (>6 feet) aquatic habitat. Average annual sedimentation rates are markedly higher than estimated in the DPR; however, reviewing

sedimentation rates on a linear basis is not appropriate in the early years of a project when the channel is relatively new and has not stabilized. The sedimentation rate should stabilize over time and may more closely approach predicted levels as the project ages.

Since construction, the berm has been overtopped twice the amount of time one would expect. It is expected that over the life of the project the berm exceedance should approach the historical average of 4%. In addition, the overland flow level has been exceeded 50% more post-construction in comparison with the data used for design. It is expected that over the life of the project the overland flow level exceedance should approach the historical average of 12%.

Variable annual sediment deposition rates shown in Table 5-2 can be expected and may be due to the type of flood hydrograph (a long flood, such as 1993, or a fast and short flood, such as 1997). Flood types (rainfall, such as 1993, or snowmelt, such as 1997) can also contribute to variability in annual sediment deposition rates. Suspended sediment loads also vary throughout the year depending on rainfall and absence or presence of vegetation. Variations in annual sediment deposition rates are also partially due to the absence of transect survey control in year 0 and year 3. To assist in future monitoring efforts, control points were established when the year 6 transect data were collected. Continued monitoring will better define sedimentation rates and patterns.

Results of the creel survey documented angler use of the Big Timber HREP area both before and after project construction. The survey showed a substantial decline in angler use and harvest from 1989 to 1994. However, the HREP is not considered to be responsible for this decline. Angler activity is not necessarily dependent on habitat availability, but may be influenced by other factors. Statewide declines in the number of fishing licenses sold from 1981-1994; residual impact of the 1993 flood of record on angler behavior; bass tournament activity originating outside of Big Timber; and changes in minimum size limits for harvested fish between the two survey periods, were all cited by IADNR researchers as potential causes for the differences in pre- and post-construction survey results. A study titled, *Evaluation of Largemouth Bass Length Limits in Big Timber Area of the Mississippi River, Pool 17,* by Bernard Schonhoff and Mark Cornish, published in 1996 Fisheries Management Investigations, Iowa Department of Natural Resources, Des Moines, Iowa, documented an increase in the largemouth bass population after the change in the size limit regulations. The 1996 bluegill dynamics study referenced in section 5(a)(1) above concluded that the Big Timber HREP was successful in creating a bluegill overwintering area. Overall, the results of these investigations suggest a positive response by fisheries to the channel dredging component.

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 11. As shown in Table 5-3, almost 29 acre-feet of shallow water habitat is available at year 6.

TABLE 5-3

Restore Shallow Aquatic Habitat

Year	Shallow Aquatic Habitat, Acre-Feet
0	40.2
3	36.0
6	28.9
50 (Target)	15.8

Based on data available to date, annual sedimentation rates were determined as shown in Table 5-4.

TABLE 5-4

Annual Shallow Aquatic Habitat Sedimentation Rates

Year	Annual Sediment Deposition, Acre-Feet
0-3	1.40
3-6	2.37
0-6	1.88

Shallow aquatic habitat depths in 1991 averaged 4 feet throughout the Big Timber project. In 1997, shallow aquatic habitat depths averaged 4 feet in Willow Chute and about 2 feet in Big and Little Denny (depths were visually determined from plates 9-11). As with the deep aquatic habitat, the average sediment deposition rate for the Big and Little Denny shallow aquatic habitat is about 4 inches/year. The transition from shallow to deep aquatic habitat along the Willow Chute transects has softened (plates 6-8), trending toward a narrower shallow aquatic habitat bench.

(2) Conclusions. Although the Big Timber project is meeting the objective of restoring shallow (2-3 feet) aquatic habitat, monitoring efforts indicate higher than expected annual sedimentation rates. It is evident the channel has not stabilized in Willow Chute as the shallow aquatic habitat bench has narrowed and the transition to deep aquatic habitat is no longer well defined. Another factor contributing to higher than expected sedimentation rates is that pre-project permanent or year-round aquatic habitat was essentially limited to

Coolegar Slough and a portion of Round Pond. Big Denny, Little Denny, and Willow Chute were subject to drying or freeze-out during normal or low water stages in Pool 17. Although the check dams and excavated channel material should provide a resultant decrease in sedimentation from overland flow, sediments are no longer subject to consolidation due to drying, and may be a contributing factor in the marked decrease in shallow aquatic habitat in Big and Little Denny. As previously discussed in the Deep Aquatic Section, variable annual sediment deposition rates can be expected. Sedimentation rates should stabilize and may more closely approach predicted levels as the project ages.

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

(1) Monitoring Results. The Big Timber project was designed to maintain a minimum dissolved oxygen (D.O.) concentration of 5 mg/l at year 50 (see Appendix A, Table A-1). A pre-project baseline water quality monitoring program was initiated at site W-1 (see plate 3 and Table B-2) on May 6, 1989. Post-project water quality monitoring commenced at site W-1 on September 24, 1991 and is currently ongoing. An additional post-project water quality monitoring site (W-2) was added on November 7, 1995. A third site (W-3) was added in August 1998 in response to an identified need for comparative main channel water quality data. Monitoring at this site will be limited to D.O. and temperature during the summer. The project's original fact sheet identified several resource problems. Severe summer and winter fish kills attributable to low D.O. levels and freeze outs, respectively, were reported. The water quality objective of the project was to increase levels of D.O. 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 D.O. and related parameters and then perform post-construction monitoring to determine the project's impact. A March 1996 site inspection noted a large die-off of gizzard shad. Ross Adams of the USFWS noted that the winter die-off was a common occurrence in the Upper Mississippi River System and is not normally cause for concern unless mortality of other species is also noted. In fact, only gizzard shad were seen in the 1996 Big Timber die-off. However, the species is very sensitive to both low temperatures and low D.O. levels, so we cannot definitely eliminate low D.O. as a partial cause of the 1996 die-off.

The original post-construction performance evaluation report, which addressed data collected through January 1996, indicated that the project had been successful in attaining the target D.O. level (5 mg/l) during the critical winter period. During the remainder of the year, D.O. concentrations occasionally fell below the target level. This report discusses data collected from June 19, 1996, through July 17, 1997. Post-project water quality monitoring results from samples collected at both sites are found in Appendix E. Data were obtained through a combination of manual sampling and the use of *in-situ* continuous monitors (YSI model 6000UPG). Manual sampling was performed at the two sampling sites on 12 occasions from June 19, 1996, through July 17, 1997. *In-situ* monitors were deployed at site W-1 on three occasions and at site W-2 on five occasions. The monitors have water quality measuring and data logging capabilities. Typically, a YSI 6000UPG monitor was positioned 3 feet above the bottom and collected data for a period of about two weeks before the unit was retrieved and the data downloaded.

The results from manually collected samples are shown in Tables E-1 (site W-1) and E-2 (site W-2). The minimum, maximum and average D.O. concentrations at site W-1 were 3.40 mg/l, 17.64 mg/l and 8.89 mg/l, respectively, while at site W-2 these values were 1.63 mg/l, 10.46 mg/l and 6.29 mg/l. As shown in Table 5-5 and Figures E-1 and E-2, three of the 11 D.O. concentrations measured at each site were below the target level of 5 mg/l. All excursions below 5 mg/l occurred during the summer. The D.O. results collected by *in-situ* monitors are given in Figures E-3 through E-10. The monitors were programmed to take D.O. measurements every 2 hours. The data have been compensated to correct for drift. The maximum drift that occurred during any deployment was 0.90 mg/l, while the average drift for the eight deployments was 0.53 mg/l. Figures E-3 and E-4 show the results from two summer deployments at site W-2. Data were collected for a period less than 3 days during these deployments because of problems experienced by the monitors. On both occasions, D.O. concentrations below 5 mg/l were measured. The results from four winter deployments at sites W-1 and W-2 are given in Figures E-5 through E-8. All D.O. concentrations were above the target level of 5 mg/l. Results from the two sites during the summer of 1997 are found in Figures E-9 and E-10. During both deployments, D.O. concentrations below the target level were measured.

The low D.O. concentrations observed during the summer months are probably due to the lack of flow through the backwater complex. With the exception of high-water periods, there is little opportunity for mixing to occur with the oxygenated flows of the main channel. During June and July of 1997, several Upper Mississippi River researchers reported low D.O. concentrations in the main channel. It is speculated that zebra mussels may have been responsible for this and therefore contributed to the low backwater D.O. concentrations measured during the summer of 1997 in the Big Timber project. The addition of a water quality monitoring site (W-3) will allow for a better understanding in the future of water quality relationships between the project channels and ambient river conditions.

TABLE 5-5

D.O. Concentrations Below 5 mg/l

D.O. (mg/l)	Date	Location
4.71	6/19/96	W-1
2.57	6/19/97	W-2
3.40	7/2/97	W-1
1.63	7/2/97	W-2
4.17	7/17/97	W-1
4.57	7/17/97	W-2

(2) Conclusions. D.O. monitoring results were similar to those discussed in the initial Big Timber performance evaluation report. The project has been successful in attaining the target D.O. level (5 mg/l) at both sampling sites during the critical winter period. During the summer, D.O. concentrations below the target level were measured; however, the post-project minimum concentration at the surface (1.63 mg/l) is higher than the pre-project minimum (0.60 mg/l). Another indication of the project's success is that

since project completion, USFWS and IADNR personnel have not observed any fish kills caused by oxygen depletion. Apparently, post-project D.O. concentrations have not been at a level that is lethal to fish, or perhaps the dredged channels have allowed for fish passage from the area during periods of low D.O. The low D.O. concentrations observed during the summer months are probably due to the lack of flow through the backwater complex. Also, during June and July of 1997, zebra mussels may have been partially responsible for the low D.O. concentrations.

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. At year 6, an average of 565.7 square feet of year-round habitat access is available in Round Pond and Willow Chute. Timber Chute has 268.5 square feet of year-round habitat access at year 6 (see Table 5-6 and Appendix D, Table D-2). In general, depths range from 6 feet to 8 feet below flat pool; with depths in Round Pond between 6 feet and 7 feet, Timber Chute depths between 5 feet and 6 feet, and Willow Chute depths between 7 feet and 8 feet.

TABLE 5-6

Round Pond, Timber Chute, and Willow Chute Sedimentation Transects

Transect	Provide Year-Round Habitat Access (Cross-Sectional Area) (Deep Habitat - Square Feet)		
	As Built 1991	Year 3 1994	Year 6 1997
Round Pond			
A	911.4	814.9	605.6
B	749.0	796.8	618.7
Timber Chute			
C	485.4	283.2	268.5
D [1/]			440.7
Willow Chute			
E	671.4	612.0	460.6
F	746.5	681.9	554.0
G	699.2	714.4	591.4
H	592.9	518.4	505.0
I	619.4	557.9	624.8
Average [2/]	712.8	670.9	565.7
	Year 50 target: 348.0		

[1/] Cross section D is a new cross section (Feb. 97) and thus has no previous data.
[2/] Average area does not include Timber Chute.

It is evident from Table 5-6 that the cross-sectional area varies from transect to transect and monitoring event to monitoring event. This variation is primarily due to the absence of survey control in year 0 and year 3. Further stabilization of the channel side slopes also contributes to the variability in cross-sectional area. The Round Pond transects shown on plate 4 are trending toward shallower side slopes.

The Timber Chute transect, Section C, shown on plate 5, indicates the channel side slopes appear to have stabilized and that little additional sediment has accumulated since year 3 in this portion of the project. However, as previously discussed in the Deep Aquatic Habitat section, Timber Chute has experienced excessive erosion since project completion.

The transition from shallow to deep aquatic habitat along the Willow Chute transects (plates 6-8) has softened, trending toward a narrower shallow aquatic habitat bench.

(2) Conclusions. At present, the Big Timber project is meeting the objective of providing year-round habitat access. Although the cross-sectional area of Timber Chute is approaching the 50-year target shown in Appendix A, Table A-1, sufficient depth exists to permit fish access during the harshest of winters when ice cover would be expected to approach a 2-foot thickness. As the project was designed to provide 8 feet of deep water at year 0 and depths in Round Pond and Timber Chute are $\leq$ 6 feet at year 6, the remaining life of this project is cause for concern, and increased monitoring efforts are warranted. When aquatic habitat depth approaches 3 feet, it could be said that year-round fisheries habitat has been lost. Should this loss of depth occur in the migratory path (primarily Timber Chute), it would effectively isolate the project from flowing water, stranding fish during severe winter ice conditions. This point would represent the critical ending for the objective of providing year-round habitat access. Succession in the Big Timber project area has been set back for years to come and as siltation progresses, a natural transition from deep to shallower water will take place. Although year-round fisheries habitat may diminish, the shallower water habitat will continue to have significant long-term benefits for waterfowl, shorebirds, wading birds, and other wildlife, even though other portions of the project area may have depths greater than 3 feet.

Sediment transect monitoring intervals will be revised. Based on USFWS Annual Inspection Reports, the Corps will survey the sediment transects when depths in the migratory path reach 4 feet and then 3.5 feet below flat pool. Following analysis of the sediment transects when depths in the migratory path reach 3.5 feet below flat pool, the options of project rehabilitation or abandonment may be considered at this time. Table B-2 (Resource Monitoring and Data Collection Summary) has been revised to reflect this change to the sediment transect monitoring interval.

6. EVALUATION OF TERRESTRIAL HABITAT OBJECTIVES

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 6, 354 acres of mast trees exist. 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 dynamic 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. Therefore, a gradual reduction in mast-producing acreage is expected over the life of the project.

In addition to the 348 acres previously available, 11 species of mast-producing trees and shrubs were planted on the containment dike in November 1993, adding an additional 6 acres of mast-producing species to the project. 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 elevated 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.

Table 6-1 lists the relative survival and growth rates in 1995 and also summarizes the results of the inspection of a portion of the mast tree planting area on July 24, 1997. The Site Manager's project inspection report noted that seedling survival appears to be approximately 50% and that the surviving trees appear to be quite healthy.

Most of the trees that existed within the dredged material placement site prior to the project have died or will die due to dredged material placement and related stresses. The trees would have died without the Great Flood of 1993; however, the flood may have increased the rate of tree mortality. Approximately 4 to 6 inches of terrestrial sediment deposition was measured in the Big Timber area in 1994. The entire containment area appears to have naturally seeded to cottonwood, green ash, silver maple, and elm. The condition of the mature mast-producing trees within the containment area is unknown at this time. Pre-project, those trees were located on low elevation ridges paralleling the flow of the river. It was anticipated that the dredged material would fill the lower areas and that little deposition would occur on the ridges.

TABLE 6-1

Tree and Shrub Plantings
Relative Survival and Growth Rates

Species	Number Planted	95 Survival/ Growth Rate	97 Survival
northern red oak	82	Good/excellent	Good
pin oak	82	Good/good	None found
bur oak	50	Fair/fair	Good
swamp white oak	96	Excellent/good	Good
northern pecan	50	Fair/poor	None found
black walnut	50	Poor/poor	None found
butternut	150	Good/good	None found
sycamore	50	Good/excellent	Good
Serviceberry	75	Poor/fair	Poor
red osier dogwood	75	Fair/good	Fair
gray dogwood	75	Fair/good	Fair
highbush cranberry	75	Good/excellent	Fair

(2) Conclusions. Black walnut, butternut, and northern red oak are species not recommended for planting at similar sites. While northern red oak at this site appears to be doing well, an extended high water event during the growing season would probably be fatal. Continued monitoring may prove this to be a false expectation; however, the virtual absence of naturally occurring northern red oak stands at similar sites remains the overriding factor when considering this species as recommended planting stock. The usefulness of planting serviceberry, cranberry, and the dogwood species on HREPs is still questionable. The abundance of naturally seeded buttonbush is evidence of the suitability of this species at this site. Additional opportunities to plant buttonbush or other desirable vegetation on the check dams and side-cast dredged material sites exist.

Of note is the absence of pin oak from the site. It may be that pin oak was not planted at the area surveyed, as only half of the planting area was surveyed. Pin oak survival would be expected to be good.

Most of the shrub species and the oaks had been browsed back to the ground by deer. The sprouts from the stumps appeared to be healthy. It is unclear whether browse protection methods are cost effective. As long as the root system maintains enough reserves to produce a top that competes with other vegetation, the planting should be viewed as successful. While tree form may suffer, HREPs are not designed to be timber plantations.

Herbicide application is very much on a case-by-case and year-by-year situation. As much flexibility as possible should be allowed for the Site Manager/Contracting Officer's Representative to react to dynamic competing vegetation conditions. At the time of the July 24, 1997 survey, weed competition was not overtopping or overwhelming the tree and shrub plantings.

The higher elevation of the dredged material placement site may provide the geomorphic opportunity to establish mast-producing species (i.e., mast trees). However, dredged material composition can present different problems for revegetation. Fine material may not provide pore space for oxygen to reach plant roots. Sand, on the other hand, may have too much drainage, and may heat up too much to allow for woody material to establish. Lack of soil fertility is also an issue. In addition, without some form of drainage, a rise in elevation alone will not make the site suitable. As dredged material placement sites consolidate, they may become convex. Without some form of drainage, the sites become perched wetlands, unsuitable for mast trees except at the higher and drier perimeter. Successful planting of the site after placement is dependent on consolidation of the dredged material and suitable topography. Typical natural landforms supporting mast-producing trees are low, narrow ridges paralleling the flow of the river.

Annual deposition of fine materials from flood events may range from less than 1 centimeter to 10 centimeters depending on duration and timing. Light deposition is not generally harmful to the existing trees; however, increasing depth of deposition may increase the amount of mortality of trees, especially of first or second year seedlings. Larger trees fare better. Sand deposition in trees occurs in large flood events, such as the Flood of 1993, and from channel maintenance dredging.

Observations of channel maintenance dredged material placed in trees have shown survival to be very site specific. There are channel maintenance sites with live trees in greater than 10 feet of dredged material and dead trees in as little as 2 feet of dredged material. It is hypothesized that sand deposition would cause less mortality than silt deposition of the same depths. If placement of the material has not caused mortality of the pre-project mature mast trees, then the seed source is in place to potentially vegetate the site. Tree mortality within the dredged material placement site should be expected. If the parent mast trees are dead, however, replanting of the dredged material placement site should be considered. If the elevation of the placement area is approximately the same as the pre-project ridges, the assumption can be made that the containment area may be high enough in elevation to support future generations of mast-producing trees.

7. EVALUATION OF MIGRATORY WATERFOWL HABITAT OBJECTIVES

a. Increase Reliable Resting and Feeding Water Area.

(1) Monitoring Results. Currently, almost 26 acres of reliable resting and feeding water areas exist for waterfowl in the project area. The 50-year target is 21 acres (see Appendix A, Table A-1).

Recent observations by the USFWS and the Corps indicate that preferred waterfowl foods are available such as buttonbush, acorns, duckweed, and invertebrates. (See Appendix C.) The 1997 Site Manager's report noted that emergent vegetation is nearly nonexistent. Small areas of duckweed have been noted in Timber Chute and Big and Little Denny.

The USFWS staff inspecting the project area with Corps personnel in March 1996 observed approximately 1,500 waterfowl in the vicinity of the dredge cut, primarily lesser scaup and mallards. Two pelicans and several great blue herons also were observed using the area.

(2) Conclusions. Opening up silted-in backwaters has attracted waterfowl use. Submergent and emergent vegetation response has been slow since project construction. The reason for the lack of observed aquatic vegetation growth has not been determined. The occurrence of notable high water periods during the spring of the last three consecutive years may have increased water depths or turbidity to a degree sufficient to inhibit growth of aquatic vegetation.

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

(1) Monitoring Results. Pothole sedimentation transects are shown on plates 12 through 15. 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 6, the 10 potholes are little changed from the year 3 survey.

The USFWS staff visited one of the potholes during the site inspection in March 1996 and observed 10 wood ducks flushing from the periphery of the pothole. However, no waterfowl nesting or brooding activity has been documented. Evidence of beaver activity was also observed. Due to manpower constraints, the USFWS has not compiled waterfowl production data for 1996 and 1997.

TABLE 7-1

Big Timber Pothole Data

Dimension, Feet	1995	1997	Change, Percent
Depth			
Average	5.6	5.5	-2
Minimum	4.5	4.2	-7
Maximum	6.7	6.9	+3
Width			
Average	45	46	+2
Minimum	31	34	+10
Maximum	60	61	+2
Length			
Average	73	74	+1
Minimum	64	62	-3
Maximum	79	82	+4

(2) Conclusions. Pothole habitat is providing resting and feeding opportunity for waterfowl.

Detailed results of previous sampling efforts were included in the initial Performance Evaluation Report for this project, dated February 1996. Communications with refuge staff have indicated that the small size and steep slopes of the potholes may limit their value as nesting and brooding habitat.

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 USFWS Wapello District Manager of the Mark Twain National Wildlife Refuge (Site 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. The 1997 Site Manager's project inspection report noted no waste materials or unauthorized structures were found in the project area, and that Little Denny access controls remain in place. No maintenance is required at this time.

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 are being met (see Table 9-1). Further data collection will better define sedimentation rates, survival of mast trees in/on/near dredged material placement sites, and project utilization by migratory waterfowl and other wildlife.

TABLE 9-1

Project Goals and Objectives

Goals	Objectives	Project Features	Status	Year 6	50-Yr Target
Enhance Aquatic Habitat	Restore deep (>6 feet) aquatic habitat	Hydraulic Dredging	Met	68.3	42.4
	Restore shallow (2-3 feet aquatic habitat	Mechanical Excavation	Met	34.6	15.8
	Improve levels of dissolved oxygen during critical seasonal stress periods	Dredging & Excavation	Met	$\geq$ 5	5
	Provide year-round habitat access (cross-sectional area)	Dredging & Excavation	Met	Round Pond-Willow Chute 565.7 Timber Chute 268.5	Round Pond-Willow Chute 348 Timber Chute 258
Enhance Terrestrial Habitat	Produce mast tree dominated areas	Revegetation	Met	354	204
Enhance Migratory Waterfowl Habitat	Increase reliable resting and feeding water area	Pothole Creation and Dredging/Excavation	Met	29.4	21
	Provide isolated resting, feeding, and brooding areas	Pothole Creation	Met	10	10

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.

Sediment transect monitoring intervals will be revised. Based on USFWS Annual Inspection Reports, the Corps will survey the sediment transects when depths in the migratory path reach 4 feet and then 3.5 feet below flat pool. Table B-2 (Resource Monitoring and Data Collection Summary) will be revised to reflect this change to the sediment transect monitoring interval.

The next post-construction performance evaluation will be completed in early 2002 following collection of data for the second 5-year interval.

Design of HREPs and evaluation and measurement units of project features has evolved since inception of EMP HREP program. Measuring acre-feet of shallow habitat, or cross-sectional area of year-round habitat access, something easily calculated during design, has been somewhat objective during post-project construction evaluation. This is primarily due to repeatability (the ability to recover the original transects surveyed during the design phase) coupled with the fact that these transects may not have been part of the as-built surveys. For example, dredged or excavated channel side slopes may have softened, widening the channel and decreasing depth, but the cross-sectional area may not reflect this loss of depth. During design, acre-feet of deep aquatic habitat may be a useful tool, but does it make it a difference to the fish post-construction? Perhaps simpler measurements in tandem with increased biological monitoring are warranted. For aquatic habitat, this may simply be depth in combination with fish response. Biological response, or lack of, may also be a better indicator of project success than the physical parameters currently being monitored at the majority of the HREPs. Another measurement criteria to consider would be post-construction sediment analysis to determine the source of sedimentation (e.g., side slope sloughing, bedload deposition, etc.) if possible.

In light of the Big Timber project and its backwater location, aquatic habitat monitoring results are probably not applicable to the few remaining projects under design. However, lessons learned from planting mast trees at this project can be applied (i.e., species, stock, deer browse, and herbicide application) to the mast tree portion of the Gardner Division project.

A revised Post-Construction Evaluation Plan is shown below as Table 9-2.

TABLE 9-2

Project Goals and Objectives (revised May 1998)

Goals	Objectives	Project Features	50-Yr Target
Enhance Aquatic Habitat	Restore deep (>6 feet) aquatic habitat	Hydraulic Dredging	6 Feet
	Restore shallow (2-3 feet aquatic habitat	Mechanical Excavation	2 Feet
	Improve levels of dissolved oxygen during critical seasonal stress periods	Dredging & Excavation	$\geq$5 mg/l
	Provide year-round habitat access	Dredging & Excavation	3.5 Feet
Enhance Terrestrial Habitat	Produce mast tree dominated areas	Revegetation	204 Acres
Enhance Migratory Waterfowl Habitat	Increase reliable resting and feeding water area	Pothole Creation and Dredging/Excavation	21 Acres
	Provide isolated resting, feeding, and brooding areas	Pothole Creation	10 Ea

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 and USFWS personnel have resulted in the following general conclusion regarding project features that may affect future project design:

(1) General. The primary dredging project design and evaluation criteria in apparent need of review is project feature life expectancy. For this project, a 50-year life does not appear to be a realistic restoration goal. A programmatic review of engineering performance criteria and constructed HREP O&M requirements should be accomplished. Additionally, future PERs should consider O&M expenditures versus estimated costs. Program reauthorization might consider the ability to return to a project post-construction and fund additional work to simplify or correct O&M difficulties. The benefits of restoring habitat through maintenance activities and the habitat disruptions that may accompany such activities need to be assessed on a project-by-project basis.

(2) Restore Deep (>6 Feet) Aquatic Habitat. To reduce project sediment deposition in Timber Chute and the lower end of Willow Chute, two options should be evaluated. One option would be to extend the Willow Chute check dam downstream, which would move the expansion zone and associated sediment deposition downstream. The second option would be to raising the effective height of the excavated sidecast

material adjacent to Timber Chute to match the check dam. This would maintain the expansion zone bordering Timber Chute but should prevent sediment from entering Timber Chute provided the check dam is fortified somewhat. Hydraulic modeling of the expansion zone would identify the benefits of these options, and should be scheduled for inclusion in the next Supplemental Performance Evaluation Report. This analysis should be done in an approximate fashion, using existing data.

(3) Restore Shallow (2-3 feet) Aquatic Habitat. Projects which introduce uncontrolled flow to areas previously subjected to drying or freeze-out during normal or low water stages should anticipate higher than average sediment deposition rates if the sediment will no longer be subject to consolidation due to drying.

(4) Provide Year-Round Habitat Access (Cross-Sectional Area). Timber Chute has experienced excessive erosion since project completion. The cross-sectional area of Timber Chute is approaching the 50-year target, and depths no longer meet the criteria for deep aquatic habitat ($D \geq 6$ feet). In regard to maintenance of a migratory path for fish, the remaining life of this project is cause for concern. Sediment transect monitoring intervals have been revised to collect data when projects depths in the migratory path reach 4 feet and 3.5 feet. When project depths reach 3.5 feet, the options of rehabilitation or abandonment may be considered. Any decision would be carried forth only upon written mutual agreement of the USFWS and the Corps. Included within this agreement would be a description of the agreed-upon course of action and funding responsibilities, if any. At this point, year-round fisheries habitat access seems unlikely to meet the 50-year target without additional dredging in the future.

(5) Produce Mast Tree Dominated Area. If the elevation of the placement area is approximately the same as the pre-project ridges, the assumption can be made that the containment area may be high enough in elevation to support future generations of mast producing trees. Long-range (20 years +/-) plans for this site should consider mast tree plantings. These plantings would be most likely to succeed after a new cottonwood/silver maple canopy has been established and competition from the herbaceous growth that immediately follows such a dredging action has been set back. Two years after the mast trees have been planted, the canopy closure could be reduced to 40% to provide increased light availability for enhanced growth. Additional opportunities to plant buttonbush or other desirable vegetation on the check dams and side-cast dredged material sites exist.

(6) Provide Isolated Feeding, Resting, and Brooding Pools. Pothole construction by blasting is particularly suited to projects like Big Timber, which are located in remote areas of the floodplain. Although pothole size may be suitable for open, prairie conditions, potholes less than 0.1 acre appear to be too small for floodplain forest areas such as the Big Timber HREP (potholes range from 0.03 acre to 0.08 acre in size). Coupled with the steep side slopes, the Big Timber potholes are better suited to hiding predators than providing isolated pools for rearing duck broods. Consequently, this information was utilized in setting the charges for the blasted potholes at the Potters Marsh, IL, (Pool 13) HREP, which also included mechanically excavated potholes. The Potters blasted potholes are larger (approximately 1/3 acre), and have shallow side slopes. The Bellevue LTRM has studied waterfowl and wading bird use of the potholes at the Potters

Marsh HREP, and study results indicate a positive response to pothole construction. The results of the Potters Marsh pothole study are discussed in more detail in the Potters Marsh IPER.

A P P E N D I X 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 0 With Alternative (As-Built)	Year 6 With Alternative	Year 50 Target With Alternative	Feature Measurement	Annual Field Observatio by Site Manager
ance atic itat	Restore deep (≥6 feet) aquatic habitat	Big Timber dredging	Hydraulic dredging	AC-FT	0	70.3	68.3	42.4	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	42.3	34.6	15.8	Perform hydrographic soundings of transects [3/]	Encroachment of bank or obvious shoaling in shallo dredged areas
	Improve levels of dissolved oxygen during critical seasonal stress periods	Big Timber dredging/ excavation	Dredging/ excavation	Mg/L	0	≥ 5	≥ 5	5	Perform water quality tests [2/]	Fish stress (at surface) or kills
	Provide year-round habitat access (cross-sectional area) [4/]	Big Timber dredging/ excavation	Dredging/ excavation	Sq. Ft.	0	Round Pond - Willow Chute: 712.8 Timber Chute: 485.4	Round Pond - Willow Chute: 565.7 Timber Chute: 268.5	Round Pond - Willow Chute: 348 Timber Chute: 258	Perform hydrographic soundings of transects [3/]	Development of emergent vegetation within access a
ance restrial itat [7/]	Produce mast tree dominated areas	Mast tree plantings on dredged material placement site	Revegetation	Acres of mast trees	348 [5/]	354	354	204	Perform vegetation transects in mast tree area [6/]	Seedling survival
ance ratory terfowl itat	Increase reliable resting and feeding water areas	Blasting of potholes and dredging/ excavation with constructed access limitation	Pothole creation and dredging/ excavation	AC	0	23.8	29.4	21	Perform hydrographic soundings of transects [3/]	Waterfowl presence or absence
	Provide isolated testing feeding and brooding pools	Blasting of potholes	Pothole creation	EA	0	10	10	10	Perform areal survey of project area [8/]	

TABLE A-1 (Continued)

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

[2/] Water Quality Stations

W-1
W-2
W-3 (summer D.O. and temperature only)

[3/] Sedimentation Transects (see Table A-2)

[4/] Average Cross-Sectional Area

[5/] Pre-project forest inventory

[6/] Mast tree survey of hardwood trees planted in the dredged material confined placement facility

[7/] For terrestrial habitat enhancement, year 0 is 1993 and the with-alternative is year 4.

[8/] Mapping

April 17, 1994, Color Aerial Photography
November 21, 1995, Black and White Aerial Photography
September 26, 1996, Color Oblique Aerial Photograph

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

	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				
(A)	X		X	X
(B)	X		X	X
(C)	X		X	X
(D)	X		X	X
(E)	X	X	X	X
(F)	X	X	X	X
(G)	X	X	X	X
(H)	X	X	X	X
(I)	X	X	X	X
(L)		X		X
(M)		X		X
(N)		X		X
Little Denny				
(J)		X		X
(K)		X		X
Potholes				
1				X
2				X
3				X
4				X
5				X
6				X
7				X
8				X
9				X
10				X

A P P E N D I X 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	Funding Source	Implementation Instructions
Pre-Project	Sedimentation Problem Analysis	System-wide problem definition. Evaluates planning assumptions.	USGS	USGS (EMTC)	LTRMP [1/]	--
	Pre-Project Monitoring	Identifies and defines problems at HREP site. Establishes need of proposed project features.	USFWS	USFWS	USFWS	--
	Baseline Monitoring	Establishes baselines for performance evaluation.	Corps	Corps	HREP [2/]	See Table B-2
Design	Data Collection for Design	Includes quantification of project objectives, design of project, and development of performance evaluation plan.	Corps	Corps	HREP	See Table B-2
Construction	Construction Monitoring	Assesses construction impacts; assures permit conditions are met.	Corps	Corps	HREP	See State Section 401 Stipulations
Post-Construction	Performance Evaluation Monitoring	Determines success of project as related to objectives.	Corps (quantitative) Sponsor (field observation)	Corps USFWS	HREP	See Table B-2
	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	USGS (EMTC)	HREP	--

[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	Jun-Sep	Dec-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								
Ice Depth						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	Remar
	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	Jun-Sep	Dec-Mar								
<u>POINT MEASUREMENTS</u> (Cont'd)														
Sediment Test Stations													Corps	
Elutriate			1											
Bulk Sediment			1											
Column Settling Stations													Corps	
Column Settling Analysis								1						
Boring Stations													Corps	
Geotechnical Borings								1						
<u>TRANSECT MEASUREMENTS</u>														
Sedimentation Transects 3/													Corps	
Hydrographic Soundings							1		5Y					See 3
Vegetation Transects 4/													Corps	
Mast Tree Survey												Y	Corps	
<u>AREA MEASUREMENTS</u>														
Mapping 5/														
Aerial Photography										1		5Y	Corps	

<u>Legend</u>

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

W-1
W-2
W-3 (summer D.O. and temperature only)

[3/] Sedimentation Transects

See Table B-3. Based on USFWS Annual Inspection Reports, the Corps will adjust the monitoring interval as necessary to survey the sediment transects when depths in the migratory path reach 4 feet and then 3.5 feet below flat pool.

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

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

[5/] 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-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[1/]**	**Increase Reliable Resting and Feeding Water Areas**
Round Pond -Timber Chute - Willow Chute - Big Denny				
(A)	X		X	X
(B)	X		X	X
(C)	X		X	X
(D)	X		X	X
(E)	X	X	X	X
(F)	X	X	X	X
(G)	X	X	X	X
(H)	X	X	X	X
(I)	X	X	X	X
(L)		X		X
(M)		X		X
(N)		X		X
Little Denny				
(J)		X		X
(K)		X		X
Potholes				
1				X
2				X
3				X
4				X
5				X
6				X
7				X
8				X
9				X
10				X

A P P E N D I X C

COOPERATING AGENCY CORRESPONDENCE

A P P E N D I X D

TECHNICAL COMPUTATION SHEETS

A P P E N D I X E

WATER QUALITY DATA

Sent new files to replace deleted tables.

A P P E N D I X F

REFERENCES

A P P E N D I X G

DISTRIBUTION LIST

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) Site Manager's Project Inspection and Monitoring Results, dated 16 June 1995.

(7) 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.

(8) Letter from Mr. William F. Hartwig, USFWS, to Colonel Charles S. Cox, Corps, September 1995, accepting the transfer of the Big Timber project from the Corps to the USFWS.

(9) Memorandum from U.S. Department of the Interior, Fish and Wildlife Refuge, Wapello District, dated 21 November 1995, subject: Big Timber Pothole Sampling.

(10) Big Timber Refuge Rehabilitation and Enhancement Performance Evaluation Report, February 1996.

(11) Letter from Ross Adams, covering subject material pertaining to the March 1997 site visit, dated April 1996.

(12) *Creel Surveys in the Big Timber Area of the Mississippi River, Pool 17, April-October 1989 and 1994*, by Bernard Schonhoff and Mark Cornish. Published in 1995 Fisheries Management Investigations, Iowa Department of Natural Resources, Des Moines, Iowa.

(13) *Evaluation of Largemouth Bass Length Limits in Big Timber Area of the Mississippi River, Pool 17*, 1989 and 1994, by Bernard Schonhoff and Mark Cornish. Published in 1996 Fisheries Management Investigations, Iowa Department of Natural Resources, Des Moines, Iowa.

(14) *Bluegill Dynamics of a Rehabilitated Mississippi River Backwater After Ice-Out*, by Mark Allen Cornish. Master's thesis submitted to the School of Graduate Studies of Western Illinois University, Macomb, Illinois. 1996.

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P L A T E S

ng towards the Big Denny pond access channel from Round Pond.

Boater access to a portion of the project area was limited by the placement of large diameter trees across the excavated channel.

f several project potholes created by blasting.

CEMVR Foresters examining swamp white oak planted as part of the mast tree planting component of the project.