UPPER MISSISSIPPI RIVER SYSTEM
ENVIRONMENTAL MANAGEMENT PROGRAM

BIG TIMBER REFUGE HABITAT REHABILITATION AND ENHANCEMENT PROJECT

POST-CONSTRUCTION PERFORMANCE EVALUATION REPORT – YEAR 15 (2006)

JUNE 2007

US Army Corps
of Engineers
Rock Island District

POOL 17
MISSISSIPPI RIVER MILES 443.5 – 445.0
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

REPLY TO
ATTENTION OF

CEMVR-PM-M

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ACKNOWLEDGMENT

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

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EXECUTIVE SUMMARY

1. General. As stated in the Definite Project Report, the Big Timber Habitat Rehabilitation and Enhancement Project (HREP) was initiated in response to a rapid accumulation of sediment that had greatly reduced the quantity and quality of the wetland habitat in the low swales present on Big Timber Refuge and aquatic habitat in the deep areas of the interior channels. In the shallow areas of the interior channels, dissolved oxygen values had fallen to critical levels and fish species diversity had decreased.

2. Purpose. The purpose of this report is to provide a summary of the monitoring data and field observations, as well as project operation and maintenance, since completion of the last Performance Evaluation Report (PER) in June 2002.

3. Project Goals, Objectives, and Features. The three goals and associated objectives for the Big Timber HREP are as follows:

a. Enhance Aquatic Habitat

(1) Restore deep aquatic habitat (depth $\geq$ 6') through hydraulic dredging
(2) Restore shallow aquatic habitat (2' $\geq$ depth $\geq$ 3') through mechanical excavation
(3) Improve levels of dissolved oxygen during critical seasonal stress periods through hydraulic dredging and mechanical excavation
(4) Provide year-round habitat access through hydraulic dredging and mechanical excavation

b. Enhance Terrestrial Habitat

(1) Produce mast tree dominated areas through revegetation

c. Enhance Migratory Waterfowl Habitat

(1) Increase reliable resting and feeding water areas through pothole creation, hydraulic dredging, and mechanical excavation
(2) Provide isolated resting, feeding, and brooding pools through pothole creation

4. Observations and Conclusions. For the evaluation period of February 2003 to March 2006, the objectives to meet each goal had the following observations and conclusions.

a. Enhance Aquatic Habitat

(1) <u>Restore Deep Aquatic Habitat</u>
   (a) Year 50 Target is to maintain a flat pool depth greater than or equal to 6 feet of deep aquatic habitat.
   (b) Based on sediment transects, Year 11 (2002) reported a total volume of 49.9 acre-feet.
   (c) Based on water quality data, Year 11 (2002) reported an average water depth of 4.68 feet, transects according to the monitoring plan will more accurately assess sediment deposition. Year 14 (2005)depths at the water quality monitoring station dropped to an average of 4.31 feet.

(2) <u>Restore Shallow Aquatic Habitat</u>
   (a) Year 50 Target is to maintain a flat pool volume greater than or equal to 15.8 acre-feet of shallow aquatic habitat
   (b) Based on sedimentation transects, Year 11 (2002) reported a total volume of 84.9 acre-feet

(3) <u>Improve Levels of Dissolved Oxygen During Critical Seasonal Stress Periods</u>

        - (a) Year 50 Target is to maintain a DO concentration greater than or equal to 5 milligrams per Liter (mg/L)
        - (b) Based on water quality data, Year 14 (2005) reported minimum, maximum, and average DO concentrations of 3.03, 21.33, and 9.43 mg/L for Station W-M443.6G and 3.48, 17.49, and 7.98 mg/L for Station W-M444.4H, respectively
        - (c) During Year 15 (2006), the DO concentration fell below 5 mg/L once at Station W-M443.6G and twice at Station W-M44.4H out of twelve occasions for each station

    - (4) Provide Year-Round Habitat Access
        - (a) Year 50 Target is to maintain a flat pool cross-sectional area greater than or equal to 348 square feet of year-round habitat
        - (b) Based on sedimentation transects, Year 11 (2002) reported an average cross-sectional area of 534 square feet

- **b. Enhance Terrestrial Habitat**
    - (1) Produce Mast Tree Dominated Areas
        - (a) Year 50 Target is to maintain a mast tree dominated area greater than or equal to 204 acres
        - (b) Based on results from the 1998 PER, Year 6 (1997) reported 354 acres of mast tree dominated areas
        - (c) Based on visual observations of district staff in Year 15 (2002), it appears that the target acreage of mast tree dominated areas is met

- **c. Enhance Migratory Waterfowl Habitat.**
    - (1) Increase Reliable Resting and Feeding Water Areas
        - (a) Year 50 Target is to maintain a reliable resting and feeding water area greater than or equal to 21.0 acres
        - (b) Based on sedimentation transects, Year 11 (2002) reported 50.6 acres of reliable resting and feeding water areas

    - (2) Provide Isolated Resting, Feeding, and Brooding Pools
        - (a) Year 50 Target is to maintain a total number of 10 potholes
        - (b) Based on sedimentation transects, Year 15 (2006) reported 10 potholes
        - (c) The USFWS reports that waterfowl usage of the potholes is minimal due to the small size that encourages predation, and the shallow depths resulting from sedimentation. The USFWS staff recommends a minimum size of 2.0 acres.

5. Conclusions and Recommendations. Data and observations collected since the last PER suggest that all of the goals and objectives evaluated for the Big Timber HREP are being met (see Table 9-1). Further data collection will continue to define sedimentation rates, survival of mast trees, and project utilization by migratory waterfowl and other wildlife.

Monitoring efforts for the Big Timber HREP have been performed according to Table B-1 in Appendix B and Table C-2 in Appendix C. The next PER will be a detailed report completed in March of 2011 following collection of field data from April 1, 2006 through December 31, 2011. This report should include new sedimentation transects.

Project O&M has been conducted in accordance with the O&M Manual. There are no operational requirements attached to the Big Timber HREP. The maintenance of project features has been adequate. Annual project inspections by the USFWS have resulted in proper corrective maintenance actions.

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1. INTRODUCTION

The Big Timber Refuge Habitat Rehabilitation and Enhancement Project (HREP), hereafter referred to as "the Big Timber HREP," is a part of the Upper Mississippi River System (UMRS) Environmental Management Program (EMP). The Big Timber HREP is located in Pool 17 on the Iowa side of the Mississippi River navigation channel between River Miles (RM) 443.5 and 445.0. Plate 1 in Appendix J contains a general plan of the Big Timber HREP. The Big Timber HREP is a United States Fish and Wildlife Service (USFWS) management unit of the Port Louisa National Wildlife Refuge.

a. Purpose. The purposes of this Performance Evaluation Report (PER) are as follows:

(1) Supplement monitoring results and project operation and maintenance discussed in the March 2002 Post-Construction Supplemental PER;

(2) Summarize the performance of the Big Timber HREP, 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 HREPs.

b. Scope. This report summarizes available project monitoring data, inspection records, and field observations made by the United States Army Corps of Engineers (Corps), the USFWS, and the Iowa Department of Natural Resources (IADNR) for the period from 1991 through 2006, including new data collected during February 13 to
March 16, 2006.

2. PROJECT GOALS AND OBJECTIVES

a. General. As stated in the Definite Project Report (DPR), the Big Timber HREP was initiated in response to a rapid accumulation of sediment that had greatly reduced the quantity and quality of the wetland habitat in the low swales present on Big Timber Refuge and aquatic habitat in the deep areas of the interior channels. In the shallow areas of the interior channels, dissolved oxygen values had fallen to critical levels and fish species diversity had decreased.

b. Goals and Objectives. Goals and objectives, formulated during the project design phase, are summarized in Table 2.1.

TABLE 2.1. Project Goals and Objectives

Goals	Objectives	Project Features
Enhance Aquatic Habitat	Restore deep aquatic habitat (Depth $\geq$ 6’)	Hydraulic dredging
	Restore shallow aquatic habitat (2’ $\leq$ Depth $\leq$ 3’)	Mechanical excavation
	Improve levels of dissolved oxygen during critical seasonal stress periods	Dredging and excavation
	Provide year-round habitat access	Dredging and excavation
Enhance Terrestrial Habitat	Produce mast tree dominated areas	Revegetation
Enhance Migratory Waterfowl Habitat	Increase reliable resting and feeding water areas	Pothole creation, dredging, and excavation
	Provide isolated resting, feeding, and brooding pools	Pothole creation

3. PROJECT DESCRIPTION

a. Project Features. The Big Timber HREP consists of hydraulic dredging and mechanical excavation to enhance aquatic habitat; pothole creation, hydraulic dredging, and mechanical excavation to enhance migratory waterfowl habitat; and revegetation to enhance terrestrial habitat. Plate 2 in Appendix J displays the main features of the Big Timber HREP.

(1) Creation of Deep Channels. Hydraulic dredging of approximately 74,000 cubic yards to create a 50-foot-wide channel from the mouth of Round Pond to the mouth of Timber Chute (1,120 feet long), and the head end of Timber Chute to the mouth of Big Denny (3,950 feet long). Minimum dredge depth was to elevation 528 (8 feet below Pool 17 flat pool of elev. 536). Hydraulically dredged material was placed in a confined dredged material placement site (CPS) between the Mississippi River and Big and Little Denny. In addition, approximately 5,500 cubic yards were mechanically excavated from Timber Chute to provide a 35-foot -wide by 327-foot-long channel through Timber Chute. Timber Chute minimum excavated depth was to elevation 528 (8 feet below Pool 17 flat pool). Mechanically excavated material was sidecast on both banks of Timber Chute.

(2) Shallow Habitat Excavation. Mechanical excavation of approximately 63,500 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 excavated 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. In areas where mud flats were encroaching on existing ponds or channels, the material from mechanical excavation was placed along the bank of the mud flat. Check dams were constructed at 4 locations to an approximate elevation of 543 feet MSL where overland flood flows were depositing sediments at the project site.

(4) Potholes. Explosives were used to blast 10 holes in the mud flats where willows were encroaching. These holes have since filled with water and now provide secluded open water areas for wood duck broods to rest, feed, and breed. The potholes were constructed to have a surface area of approximately 40 feet by 70 feet with a depth of 8 feet.

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

(6) Mast Tree Planting. Revegetation was done 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. Project Construction. The first contract was awarded on May 22, 1990. This contract consisted of removal of stumps, dredging, mechanical excavation and seeding. Dredging began during late summer and was essentially completed in the fall of 1991. Final inspection of the vegetation at the confined dredged material placement site was accomplished following the first growing season. Prior to final inspection of the vegetation, some concerns were raised that additional seeding or earthwork may be needed in the sandy areas to induce sufficient vegetative growth. However, adequate vegetation established itself and additional work was not required. Final inspection of the Big Timber HREP was conducted in the summer of 1992. The second contract was awarded on June 2, 1993, just before the Great Flood of 1993. Mast trees were planted during the fall with all work completed in the spring of 1995. The Big Timber HREP was not turned over to the USFWS for operation and maintenance until after completion of mast tree plantings in 1995 even though the original O&M agreement was signed in 1989.

c. Project Operation and Maintenance. Operation and maintenance (O&M) of the Big Timber HREP is the responsibility of the USFWS in accordance with Section 107(b) of the Water Resources Development Act of 1992, Public Law 102-580. These functions are further defined in the O&M Manual. The following paragraphs outline the O&M instructions for the major project features. These features were designed and constructed to minimize the O&M requirements. For all project features, specific operation requirements shall be performed as determined by the USFWS Site Manager. The Site Manager has said that it costs roughly $1,000 per year to operate and maintain the site without major rehabilitations. The projection in 1989 in the DPR stated that USFWS would need to spend about $300 per year on both timber and areal surveys. With the 25% contingency provided, this makes for an O&M cost of roughly $750 per year in 1989 dollars. Considering inflation, the project should have an average cost of $999 per year and is thus being maintained in accordance with the DPR.

In general, the USFWS shall conduct annual project inspections of the confined dredged material placement site, channels (Round Pond, Timber Chute, Willow Chute, Little Denny, and Big Denny), check dams, and potholes to record the presence of undesirable debris, waste materials, and unauthorized structures. Appropriate maintenance actions shall then be determined as needed by the USFWS Site Manager. In addition, annual project inspections of the Little Denny entrance access control shall be accomplished to discover any necessary debris removal and placement.

The Corps shall monitor the mast trees through annual inspections of the planting sites. Remedial actions shall be accomplished by the USFWS Site Manager to ensure growth and survival. The USFWS Site Manager shall document any remedial actions, as well as herbicide and deer repellant application, in the project inspection report.

4. PROJECT MONITORING

a. General. Appendix B presents the Post-Construction Evaluation Plan (Table B-1), along with the Sedimentation Transect Project Objectives Evaluation (Table B-2). These references were developed during the design phase and serve as a guide for measuring and documenting project performance. The Post-Construction Evaluation Plan also outlines the monitoring responsibilities for each agency. Appendix C contains the Monitoring and Performance Evaluation Matrix (Table C-1) and Resource Monitoring and Data Collection Summary (Table C-2). The Monitoring and Performance Evaluation Matrix outlines the monitoring responsibilities for each agency. The Resource Monitoring and Data Collection Summary presents the types and frequency of data needed to meet the requirements of the Post-Construction Evaluation Plan. Plate 3 in Appendix J contains the monitoring plan for the Big Timber HREP.

b. U.S. Army Corps of Engineers. The success of the project relative to original project objectives shall be measured by the Corps, USFWS, and IADNR through data collection and field observations. The Corps has overall responsibility to evaluate and document project performance.

The Corps is responsible for collecting field data as outlined in the Post-Construction Evaluation Plan at the specified time intervals. The Corps shall also perform joint inspections with the USFWS and IADNR in accordance with ER 1130-2-339. The purpose of these inspections is to assure that adequate maintenance is being performed as presented in the DPR and O&M Manual. Joint inspections should also occur after any event that causes damage in excess of annual O&M costs.

c. U.S. Fish and Wildlife Service. 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. However, the USFWS is responsible for O&M, as well as monitoring the project through field observations during inspections. Project inspections should be performed on an annual basis following the guidance presented in the O&M Manual. It is recommended that the inspections be conducted in May or June, which is representative of conditions after spring floods. Joint inspections with the Corps and IADNR shall also be conducted as mentioned above. During all inspections, the USFWS should complete the checklist form as provided in the O&M Manual. This form should also include a brief summary of the overall condition of the project and any maintenance work completed since the last inspection. Once completed, a copy of the form shall be sent to the Corps.

d. Iowa Department of Natural Resources. The IADNR collected fish data at the Big Timber HREP in the 1980s and 1990s, which is not currently identified as a monitoring requirement. The survey is included in Appendix L. The IADNR is to be present at the joint inspections with the Corps and USFWS as described above.

5. EVALUATION OF AQUATIC HABITAT OBJECTIVES

a. Restore Deep Aquatic Habitat (Depth ≥ 6').

(1) Monitoring Results. One of the objectives for enhancing aquatic habitat is to restore deep aquatic habitat through hydraulic dredging. As shown in Appendix B, Table B-1, the Year 50 Target is to maintain a deep aquatic habitat volume greater than or equal to 42.4 acre-feet. It is also important to maintain a flat pool depth greater than or equal to 6 feet. Sedimentation transects for Round Pond, Timber Chute, and Willow Chute were performed in July 1991 to reflect as-built conditions of the deep aquatic habitat. Sedimentation transects were conducted again in January 1994 and January 1997. A discussion of this data was included in the February 1996 and August 1998 PERs, respectively. Additional transects were completed in September 2002. According to Table C-2 in Appendix C, sedimentation transects are required every five years.

The deep aquatic habitat volume was determined by multiplying the cross-sectional area of each transect by the channel length between transects. The cross-sectional area for deep aquatic habitat was based on the total area for Transects A through D, while for Transects E through I, it was based on the area below a flat pool channel depth of 3 feet since these latter transects are a combination of deep and shallow aquatic habitat. These calculations are illustrated in Appendix F, Table F-3. As seen in Table 5.1, the deep aquatic habitat volume was found to be 49.9 acre-feet at Year 11 (2002), which is greater than the Year 50 Target of 42.4 acre-feet. The average deep aquatic habitat depth was determined by dividing the volume of each transect by the surface area between transects. These calculations are presented in Appendix F, Table F-4. The average deep aquatic habitat depth was found to be 4.9 feet at Year 11 (2002), which is less than the ideal deep aquatic habitat depth of 6 feet. However, it should be noted that there are depths within the channel that are greater than 6 feet as shown on Plates 6 through 8 in Appendix J. The water quality measurement depth of 4.36 feet dropped to a measurement of 4.15 feet in 2005.

TABLE 5.1. Restore Deep Aquatic Habitat

Year	Volume (Acre-Feet)	Sediment Rate (Acre-Feet/Yr)	Average Depth (Feet)	Sediment Rate (Inch/Year)
0 (1991)	67.2		6.5	
0-3		1.2		2.1
3 (1994)	63.6		6.0	
3-6		1.9		3.5
6 (1997)	57.8		5.1	
6-11		1.6		0.9
11 (2002)	**49.9**		4.9	
0-11		1.6		1.9
15 (2006)	**-**		-	
0-15				3.98
50 (Target)	**42.4**		6.0	

Based on 1938 and 1988 data, the DPR estimated an average annual sedimentation rate of 0.51 inches per year throughout the Big Timber HREP. However, the DPR estimated an average annual sedimentation rate of 0.62 inches per year in channeled areas (Round Pond) since this area is more susceptible to sediment deposition. The DPR also stated that detailed historical records of sedimentation rates were practically nonexistent. In Year 11 (2002), the average deep aquatic habitat sedimentation rate was estimated at 1.9 inches per year, which is 3 times the DPR rate.

TABLE 5.2. Water Quality Monitoring Data

Year	W-M443.6G (Round Pond) Flat Pool Depth (Ft)	W-M443.6G (Round Pond) Sediment Rate (In/Yr)	W-M444.4H (Willow Chute) Flat Pool Depth (Ft)	W-M444.4H (Willow Chute) Sediment Rate (In/Yr)	Average Flat Pool Depth (Ft)
0 (1991)	8.79		--		8.79
0-1		7.08		--	
1 (1992)	8.20		--		8.20
1-2		4.80		--	
2 (1993)	7.80		--		7.80
2-3		8.52		--	
3 (1994)	7.09		--		7.09
3-4		5.64		--	
4 (1995)	6.62		--		6.62
4-5		6.24		--	
5 (1996)	6.10		6.04		6.07
5-6		4.68		5.16	
6 (1997)	5.71		5.61		5.66
6-7		3.24		1.20	
7 (1998)	5.44		5.51		5.48
7-8		5.40		2.16	
8 (1999)	4.99		5.33		5.16
8-9		0.24		1.32	
9 (2000)	4.97		5.22		5.10
9-10		0.60		-1.56	
10 (2001)	4.92		5.35		5.14
10-11		6.72		4.32	
11 (2002)	4.36		4.99		4.68
11-12		4.72		1.69	
12 (2003)	4.75		5.06		
12-13		5.04		-0.84	
13 (2004)	4.33		4.97		
13-14		2.16		1.08	
14 (2005)	4.15		4.49		
1-15		Avg = 3.71 in/yr		Avg = 1.86 in/yr	
50 (2041)	**6**		**6**		**6**

In addition, during water quality monitoring, channel depths at both stations were recorded. Station W-M443.6G is located in Round Pond between sedimentation transects “A” and “B”. This portion of the channel was designed to have an ideal flat pool depth greater than or equal to 6 feet at Year 50 and is labeled as deep aquatic habitat on the monitoring plan. Station W-M444.4H is located in Willow Chute between sedimentation transects “I” and “L”. This portion of the channel was designed to have an ideal flat pool depth greater than or equal to 6 feet or between 2 and 3 feet at Year 50 and is labeled as combination shallow/deep aquatic habitat on the monitoring plan.

As seen in Table 5.2, Station W-M443.6G has an average depth of 4.36 feet at Year 11, which is less than the ideal water depth of 6 feet. Station W-M444.4H has an average depth of 4.99 feet at Year 11, which is also less than the ideal water depth of 6 feet. The flat pool depths for both stations were determined by adjusting the water depths recorded during site visits from January to December 2002. Using historical water profiles, the pool elevation at the Big Timber HREP could be determined by interpolating between two stream gages on the Mississippi River. To view individual water depths for each site visit and the steps taken to adjust these values to depths relative to flat pool, refer to Tables F-1 and F-2 in Appendix F. Based on this data, annual sedimentation rates were also determined as illustrated in Table 5.2.

In general, deep aquatic habitat depths in 1991 averaged 9 feet after project completion. In 2002, deep aquatic habitat depths averaged 4.68 feet in Round Pond and Willow Chute. This equates to an average sedimentation rate of 4.72 inches per year for Station W-M443.6G and 1.69 inches per year for Station W-M444.4H. These rates were found by plotting the average annual water depths since project completion and determining the best-fit line, with the resulting slope being the sedimentation rate (see Figures F-1 and F-2 in Appendix F). For comparison, the average depths determined from the sedimentation transects versus the water quality data were very close at 4.9 and 4.68 feet, respectively. A similar comparison can be found between the sedimentation rates from the transects and water quality data (Station W-M444.4H) at 1.9 and 1.69 inches per year, respectively.

(2) Conclusions. The last set of cross sections was performed in 2002 with only water quality monitoring stations depths measured since then. Based on 2002 measurements, it appears that the Big Timber HREP is meeting the objective of restoring deep aquatic habitat by maintaining a volume greater than or equal to 42.4 acre-feet. However, if sedimentation continues at a similar rate, the next round of transects may show the volume of deep aquatic habitat approaching the Year 50 Target. On the other hand, it may be possible that the channel will become more stable, causing the sedimentation rates to decrease, and as a result the deep aquatic habitat volume would be maintained. The average flat pool depth was found to be 4.9 feet, where the ideal deep aquatic habitat depth is 6 feet. It is important to note that there are depths greater than 6 feet within the channel. It's the average that falls below this ideal depth. It is also important to note that water quality monitoring station depths continued to decline through the measurements taken in 2005.

The overall average annual sedimentation rates are approximately 3 times that estimated in the DPR. However, from 1997 to 2002, the rates were found to be rather close at 0.62 and 0.9 inches per year as estimated in the DPR and determined from the sedimentation transects, respectively. This decrease in the sedimentation rate over the last five years may substantiate the hypothesis that evaluating this parameter on a linear basis is not appropriate in the early years of a project when the channels are relatively new and have not yet stabilized. It is thought that the sedimentation rates would be high the first few years, then stabilize over time and remain constant as the Big Timber HREP ages.

b. Restore Shallow Aquatic Habitat (>2' Depth $\leq$ 3').

(1) Monitoring Results. Another objective for enhancing aquatic habitat is to restore shallow aquatic habitat through mechanical excavation. As shown in Appendix B, Table

B-1, the Year 50 Target is to maintain a shallow aquatic habitat volume greater than or equal to 15.8 acre-feet. It is also important to maintain a flat pool depth greater than or equal to 2 feet. Sedimentation transects for Willow Chute, Big Denny, and Little Denny were performed in July 1991 to reflect as-built conditions of the shallow aquatic habitat. Sedimentation transects were conducted again in January 1994 and January 1997. A discussion of this data was included in the February 1996 and August 1998 PERs. Additional transects were completed in September 2002. According to Table C-2 in Appendix C, sedimentation transects are required every five years.

The shallow aquatic habitat volume was determined by multiplying the cross-sectional area of each transect by the channel length between transects. The cross-sectional area for shallow aquatic habitat was based on the total area for Transects L through K, while for Transects E through I, it was based on the area above a flat pool channel depth of 3 feet since these latter transects are a combination of deep and shallow aquatic habitat. These calculations are illustrated in Appendix F, Table F-3. As seen in Table 5.3, the shallow aquatic habitat volume was found to be 92.4 acre-feet at Year 11 (2002), which is much greater than the Year 50 Target of 15.8 acre-feet. The average shallow aquatic habitat depth was determined by dividing the volume of each transect by the surface area between transects. These calculations are presented in Appendix F, Table F-4. The average shallow aquatic habitat depth was found to be 2.0 feet at Year 11 (2002).

TABLE 5.3. Restore Shallow Aquatic Habitat

Year	Volume (Acre-Feet)	Sediment Rate (Acre-Feet/Yr)	Average Depth (Feet)	Sediment Rate (Inches/Year)
0 (1991)	61.2		4.3	
0-3		-0.6		2.6
3 (1994)	63.1		3.6	
3-6		1.3		2.0
6 (1997)	59.3		3.1	
6-11		-6.6		2.6
11 (2002)	92.4		2.0	
0-11		-2.8		2.5
50 (Target)	**15.8**			

Based on 1938 and 1988 data, the DPR estimated an average annual sedimentation rate of 0.51 inches per year throughout the Big Timber HREP. However, the DPR estimated an average annual sedimentation rate of 0.62 inches per year in channeled areas (Round Pond) since this area is more susceptible to sediment deposition. The DPR also stated that detailed historical records of sedimentation rates were practically nonexistent. In Year 11 (2002), the average shallow aquatic habitat sedimentation rate was estimated at 2.5 inches per year, which is 4 times the DPR rate.

(2) Conclusions. It appears that the Big Timber HREP is meeting the objective of restoring shallow aquatic habitat by maintaining a volume greater than or equal to 15.8 acre-feet as of Year 11 (2002). Rather than showing a decrease, the volume increased greatly from 59.3 acre-feet in Year 6 (1997) to 84.9 acre-feet in Year 11 (2002). The reason for this substantial

increase in volume is due to a similar increase in channel width that can be seen on Plates 6 through 11 in Appendix L and Table F-5 in Appendix F. It would appear that the increase in channel width is due to natural erosion of the bankline as the chute bends back and forth. The average flat pool depth was found to be 2.0 feet, which was quite a bit less than that of 3.1 feet in 1997. Water quality data indicates that some areas of the project are not meeting the project goals and objectives. The amount of shallow aquatic habitat remaining will be verified by the next set of transects obtained at the project site. Trends as of 2001 do not appear to meet the goals but are inadequate to make a determination of success for project goals and objectives.

The overall average annual sedimentation rate is 4 times that estimated in the DPR. The sedimentation rate has varied over time over the length of the project and it is important to look at long term trends. More recently it has had relatively stable periods and the overall trend appears to have slowed to a state of quasi-equilibrium. When looking at the volume versus the sedimentation rate, it appears that even though the flat pool depth continues to decrease, the channel is widening at a faster rate allowing the volume to increase.

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

(1) Monitoring Results. The water quality objective of the Big Timber Refuge project is to improve levels of dissolved oxygen (DO) during critical seasonal stress periods. These periods would typically occur during the winter when snow-covered ice is present or during the summer when high temperatures persist. Fish kills are more likely to occur during the winter when ice formation prevents fish from escaping the low DO conditions. As shown in Appendix B, Table B-1, the goal of the project is to maintain a DO concentration greater than or equal to 5 mg/l. A pre-project baseline water quality monitoring program was initiated at site W-M443.6G on May 6, 1989. Post-project water quality monitoring commenced at site W-M443.6G on September 24, 1991 and at site W-M 444.4H on November 7, 1995. The locations of the water quality monitoring stations can be found on Plate 3 in Appendix J. The project's original fact sheet identified several resource problems. Severe summer and winter fish kills attributable to low DO levels and freeze outs, respectively, were reported. The purpose of the monitoring program was to determine baseline water quality conditions and then perform post-construction monitoring to determine the project's impact. Previous post-evaluation reports for this project covered the periods September 24, 1991 through June 13, 1995; June 19, 1996 through July 17, 1997; July 31, 1997 through September 19, 2000; and January 3 through September 18, 2001. Reported herein are water quality data collected from January 8 through March 16, 2006.

Data gathered during the current reporting period were obtained through a combination of periodic grab samples and the use of *in-situ* continuous monitors. Grab samples were collected just below the surface on 35 occasions. The two sites were visited approximately twice per month from June through September and three times (approximately every sixth week) from December through March each year. Sampling typically was not performed during April, May, October and November. The following variables were typically measured: water depth, velocity, wave height, air and water temperature, cloud cover, wind speed and direction, DO, pH, total alkalinity, specific conductance, Secchi disk depth, turbidity, suspended solids, chlorophyll (a, b and c) and pheophytin a. *In-situ* continuous water quality monitors (YSI model 6000UPG, 6600 or 6600EDS sondes) were deployed on each sampling trip to sites W-M443.6G and W-M444.4H. Sondes were positioned three feet off the bottom, thus placing them approximately two feet from the water surface during most deployments, which were typically for a period of two weeks during the summer months and about six weeks during the winter. The sondes were normally equipped to measure DO, temperature, pH, specific conductance, depth and turbidity. Data were recorded hourly during summer deployments and every two hours during winter deployments.

All water quality data tables and figures are found in Appendix E. The results from periodic grab samples collected at site W-M443.6G are found in Table E-1. The table includes the results from DO and ancillary parameters that are useful in the interpretation of DO data. DO concentrations ranged from 2.13 mg/L to 21.33 mg/L. Five of the 35 DO measurements were below the 5 mg/L target level, with three occurring during a winter sampling event and two during a summer sampling event. Supersaturated conditions were observed during seven winter and five summer sampling events. Table E-2 displays the results from periodic grab samples collected at site W-M444.4H. DO concentrations ranged from 0.42 mg/L – 18.32 mg/L. Eight of the 35 DO measurements were below the 5 mg/L target level, with three occurring during a winter sampling event and five during a summer event. Supersaturated conditions were observed during six winter and one summer sampling event. Supersaturated DO conditions at both sites were often accompanied by high chlorophyll *a* concentrations and pH values, indicating algal photosynthesis. The average DO concentration at sites W-M443.6G and W-M444.4H was 8.85 mg/L and 7.43 mg/L, respectively. DO measurements were also taken in the navigation channel near the project during summer sampling trips. All summer navigation channel DO measurements exceeded 5 mg/L.

Comparisons of post-project DO data from surface grab samples collected at site W-443.6G during the six performance evaluation periods are summarized in Table 5.4 below. The lowest percentage of DO concentrations < 5 mg/L occurred during the current evaluation period (14.3%); however, it was comparable to those observed during the preceding three evaluation periods (15.8% - 18.2%). A higher percentage of DO concentrations < 5 mg/L occurred during winter samplings (27.3%) and a lower percentage occurred during summer samplings (8.3%), relative to previous evaluation periods. The minimum (2.13 mg/L) and average (8.85 mg/L) DO concentrations for the present evaluation period were within the range of those observed previously, 1.74 – 3.86 mg/L and 7.82 – 9.18 mg/L, respectively. The maximum DO concentration (21.33 mg/L) was the highest ever observed at this site.

Table 5-4. Improve Levels of Dissolved Oxygen During Critical Seasonal Stress Periods

Site W-M443.6G	9/24/91-11/7/95	6/19/96-7/17/97	7/31/97-9/19/00	1/3/01-9/18/01	1/8/02-12/17/02	2/13/03-3/16/06
Number of Samplings	48	11	38	12	11	35
Winter Samplings	18	4	10	4	3	11
Summer Samplings	30	7	28	8	8	24
DO Conc. < 5 mg/l	8(16.7%)	3(27.3%)	6(15.8%)	2(16.7%)	2(18.2%)	5(14.3%)

Site W-M443.6G	9/24/91-11/7/95	6/19/96-7/17/97	7/31/97-9/19/00	1/3/01-9/18/01	1/8/02-12/17/02	2/13/03-3/16/06
DO Conc. < 5 mg/l Winter Samplings	0	0	1(10.0%)	1(25.0%)	0	3(27.3%)
DO Conc. < 5 mg/l Summer Samplings	8(26.7%)	3(42.9%)	5(17.9%)	1(12.5%)	2(25.0%)	2(8.3%)
Minimum DO Conc. (mg/l)	1.74	3.40	3.15	1.94	3.86	2.13
Maximum DO Conc. (mg/l)	16.61	17.64	19.66	17.47	18.95	21.33
Average DO Conc. (mg/l)	9.18	8.89	9.16	7.82	8.60	8.85

Table 5.5 summarizes comparisons of post-project DO data from surface grab samples collected at site W-M444.4H. The percentage of DO concentrations < 5 mg/L during the current evaluation period (22.9%) was within the range of that previously observed (9.1 – 42.1%). Like site W-M443.6G, a higher percentage of DO concentrations < 5 mg/L occurred during winter samplings (27.3%), relative to previous evaluation periods. The percentage of DO concentrations < 5 mg/L occurring during summer samplings (20.8%) was less than previously observed, with the exception of the 2002 evaluation period (12.5%). The minimum DO concentration (0.42 mg/L) was the lowest ever observed. The average (7.43 mg/L) and maximum (18.32 mg/L) DO concentrations for the present evaluation period were within the range of those observed previously, 6.29 – 8.56 mg/L and 10.46 – 19.43 mg/L, respectively.

Table 5-5. Improve Levels of Dissolved Oxygen During Critical Stress Periods

Site W-M444.4H	6/19/96-7/17/97	7/31/97-9/19/00	1/3/01-9/18/01	1/8/02-12/17/02	2/13/03-3/16/06
Number of Samplings	11	38	12	11	35
Winter Samplings	3	10	4	3	11
Summer Samplings	8	28	8	8	24
DO Conc. < 5 mg/l	3(27.3%)	16(42.1%)	4(33.3%)	1(9.1%)	8(22.9%)
DO Conc. < 5 mg/l Winter Samplings	0	1(10.0%)	1(25.0%)	0	3(27.3%)
DO Conc. < 5 mg/l Summer Samplings	3(37.5%)	15(53.6%)	3(37.5%)	1(12.5%)	5(20.8%)
Minimum DO Conc. (mg/l)	1.63	2.10	0.56	2.70	0.42
Maximum DO Conc. (mg/l)	10.46	18.84	19.43	16.51	18.32
Average DO Conc. (mg/l)	6.29	7.52	7.69	8.56	7.43

In-situ continuous water quality monitors (YSI model 6000UPG, 6600 or 6600EDS sondes) were deployed on each sampling trip to sites W-M443.6G and W-M444.4H. Sondes were positioned three feet off the bottom, thus placing them approximately two feet from the water surface during most deployments, which were typically for a period of two weeks during the summer months and about six weeks during the winter. The sondes were normally equipped to measure DO, temperature, pH, specific conductance, depth and turbidity. Data were recorded hourly during summer deployments and every two hours during winter deployments.

The results from *in-situ* continuous monitors deployed during the winter months indicate that occasionally DO concentrations fell below the target level of 5 mg/L, sometimes remaining below that level for several days. Low DO concentrations measured with a continuous monitor at both sites on February 12, 2004 and December 22, 2005 were validated by low field meter readings on these dates (see Figures E-1 and E-2). As shown in Figure E-1, the field meter readings on December 23, 2003 at both sites did not agree with the sonde measured values. It is possible that one of the instruments was improperly calibrated, or stratification was present and the field probe was not positioned at the same depth as the continuous monitors. DO concentrations that initially fell below 5 mg/L at both sites in January of 2004 (as shown in Figure E-1), remained below that level for approximately one month. This was the longest continuous stretch during the current reporting period that DO concentrations remained below the target level. Dead gizzard shad (a temperature sensitive species) and snow-covered ice were most likely responsible for the low DO concentrations at this time. No dead game fish were observed and according to Bernie Schonhoff, IADNR Fishery Biologist, except for the normal winter gizzard shad die-off, no fish kills were observed during the entire reporting period. Supersaturated DO concentrations were common during the winter at both sites, as displayed in the data from the February 22 through March 22, 2005 deployment (see Figure E-3).

The June 10-24, 2003 deployment, as shown in Figure E-4, is representative of most deployments during the summer months at sites W-M443.6G and W-M444.4H. DO concentrations measured by *in-situ* continuous monitors during the summer commonly fell below the 5 mg/L target level for a short time during the night and usually recovered the following day. In general, the DO concentrations at site W-M443.6G were higher than those at site W-M444.4H. As shown in Figure E-5, the worst-case summer condition occurred during the June 8-22, 2004 deployment. At both sites the DO concentration remained below 5 mg/L for the entire deployment. These low DO concentrations were confirmed by field meter readings taken at each site when the sondes were deployed and retrieved. This deployment was during a high water event when water depths were nearly three times the normal level. DO concentrations in the main channel at river mile 442.8 were also relatively low at this time: 6.11 mg/L on June 8, 2004 and 5.34 mg/L on June 22, 2004. The typical diel pattern of rising daytime DO concentrations followed by falling nighttime values was most evident in the July 19 – August 2, 2005 deployment (see Figure E-6). In this extreme case, daily DO fluctuations were typically in the 10–15 mg/L range. For most summer deployments, however, daily DO fluctuations were in the 5-10 mg/L range, with daytime highs commonly above saturation and nighttime lows typically below 5 mg/L. These diurnal fluctuations are due primarily to algal photosynthetic activity.

In addition to improving DO levels, restoring deep aquatic habitat is another objective of the Big Timber project. As shown in Appendix B, Table B-1, the Year 50 Target is to maintain a flat pool depth greater than or equal to 6 feet in selected areas (including sites W-M443.6G and W-M444.4H). Flat pool adjusted water depth was determined for both sampling sites according to the method described in U.S. Army Corps of Engineers (2001). Average annual sediment accumulation was calculated by subtracting average annual water depths from successive years. The loss of water depth and accumulation of sediment at the two sampling sites from 1991 through 2005 is shown in Figure E-7. Both sites do not currently meet their respective Year 50 Target depth. The average annual sediment accumulation rate is 3.98 in/yr for the 1991-2005 period at site W-M443.6G and 1.08 in/yr for the 1996-2005 period at site W-M444.4H. These rates are considerably higher than the 0.5 in/yr sedimentation rate estimated in U.S. Army Corps of Engineers (1989). Since monitoring at site W-M444.4H did not start until late 1995, the data do not include the high sediment accumulation years which would have occurred immediately after project completion and at the time of the Great Flood of 1993. This contributed to the difference in sediment accumulation rates at the two sites.

(2) Conclusions. The water quality objective of the Big Timber Refuge project is to improve DO levels during critical seasonal stress periods. The Year 50 Target is to maintain a DO concentration greater than or equal to 5 mg/L. During the current performance evaluation period (February 13, 2003 through March 16, 2006), there were occasions at both sampling sites when DO concentrations fell below 5 mg/L. These low DO excursions occurred during both the winter and summer months and occasionally lasted for several days. No game fish kills were reported during this performance evaluation period according to Bernie Schonhoff, IADNR Fishery Biologist. In fact, no fish kills besides the normal gizzard shad winter kill have been reported since project completion.

Restoring deep aquatic habitat is also an objective of the Big Timber Refuge project. The Year 50 Target is to maintain a flat pool depth greater than or equal to 6 feet in selected areas. Flat pool adjusted water depth values from sites W-M443.6G and W-M444.4H indicate that sediment accumulation is occurring at a considerably greater rate than estimated. Water depth levels at the two sampling sites have already fallen below the Year 50 Target of 6 feet. Accumulation of sediment in the dredged channels results in a decrease in the volume of DO, higher summer water temperatures, increased sediment resuspension and a decrease in water depth. As the channels continue to fill, these factors will likely result in an increase in the frequency and duration of below target level DO concentrations; therefore, increasing the potential for fish kills.

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

(1) Monitoring Results. The final objective for enhancing aquatic habitat is to provide year-round habitat access through hydraulic dredging and mechanical excavation. As shown in Appendix B, Table B-1, the Year 50 Target is to maintain a cross-sectional area greater than or equal to 348 square feet. It is also important to maintain a flat pool depth greater than or equal to 3.5 feet. Sedimentation transects for Round Pond, Timber Chute, and Willow Chute were performed in July 1991 to reflect as-built conditions of the year-round habitat access. Sedimentation transects were conducted again in January 1994 and January 1997. A discussion of this data was included in the February 1996, August 1998, and April 2002 PERs. Additional transects were completed in September 2002. According to Table C-2 in Appendix C, sedimentation transects are required every five years.

The cross-sectional area for year-round habitat access was based on the total area for Transects A through D, while for Transects E through I, it was based on the area below a flat pool channel depth of 3 feet since these latter transects are a combination of deep and shallow aquatic habitat. These calculations are illustrated in Appendix F, Table F-3. As seen in Table 5.6, the year-round habitat access cross-sectional area was found to be 534 square feet at Year 11 (2002), which is greater than the Year 50 Target of 348 square feet.

The IADNR fish survey conducted in the late 1980s and early 1990s shows that fish size increased for all species sampled with the exception of walleye. No further fish surveys have been done at Big Timber Refuge as it is not a required part of the monitoring plan. The survey has been attached in Appendix L.

TABLE 5.6. Provide Year-Round Habitat Access

Year	Cross-Sectional Area (SF)	Average Depth (Feet)	Sediment Rate (Inch/Year)
0 (1991)	567	6.5	
0-3			2.1
3 (1994)	542	6.0	
3-6			3.5
6 (1997)	476	5.1	
6-11			0.9
11 (2002)	**534**	4.9	
0-11			1.9
50 (Target)	**348**	3.5	

(2) Conclusions. It appears that the Big Timber HREP is meeting the objective of providing year-round habitat access by maintaining a cross-sectional area greater than or equal to 348 square feet. Rather than showing a decrease, the cross-sectional area actually increased from 476 square feet in Year 6 (1997) to 534 square feet in Year 11 (2002), which is close to that determined in Year 3 (1994) of 542 square feet. The reason for this increase in cross-sectional area is due to a similar increase in channel width that can be seen on Plates 6 through 8 in Appendix L and Table F-5 in Appendix F.

The average flat pool depth was found to be 4.9 feet. The ideal year-round habitat access depth is 3.5 feet, thus sufficient depth exists to permit fish access during the harshest of winters when ice cover would be anticipated to approach a 2-foot thickness. In Year 6 (1997), there was concern that the area within Timber Chute, or Transect D, was close to reaching this ideal depth, which would mean a loss in fisheries habitat. In Year 11 (2002), Transect D showed an increase in the average flat pool depth from 3.6 feet to 4.1 feet as seen on Table F-4 in Appendix F. While this is an improvement, this critical area within Timber Chute needs to be closely monitored in the future as water quality monitoring station depths have continued to decline. Similarly, as habitat has improved overall, fish size has improved; however, should the Timber Chute area not be maintained, fish lengths may decrease back to where they were in the early 1980s.

6. EVALUATION OF TERRESTRIAL HABITAT OBJECTIVES

a. Produce Mast Tree Dominated Areas.

(1) Monitoring Results. The objective for enhancing terrestrial habitat is to produce mast tree dominated areas through revegetation. As shown in Appendix B, Table B-1, the Year 50 Target is to maintain greater than or equal to 204 acres of mast trees. Prior to construction, a forest inventory delineated 348 acres with an over story dominated by mast-producing species. During construction, 11 species of mast-producing trees and shrubs were planted on the containment dike in November 1993, adding an additional 6 acres to the Big Timber HREP. More importantly, the tree plantings introduced a diverse mixture of mast species in a linear strip traversing a large portion of the project area. By planting the mast trees on the containment dike above the surrounding floodplain, they are protected during most flood events. As a result, these species are available as a seed source for the future. Buttonbush were not planted during the original construction phase. The USFWS has recommended that this species be added to the site. Silvicultural practices shall be performed throughout the project life to provide for the regeneration of mast-producing species in the project area. Through proper forest management, a minimum of 204 acres of mast trees should be available at Year 50.

In 1997, 354 acres of mast trees existed, the 348 acres delineated prior to construction in addition to the 6 acres planted during construction. A discussion of this data was included in the August 1998 PER. This acreage is not anticipated to remain constant, since the dominance of oak, pecan, and walnut is only a temporal stage in the dynamic life cycle of a bottomland forest. As the existing forest ages, natural succession should result in a gradual attrition of these species to be replaced by more shade tolerant species. Therefore, a reduction in mast tree acreage is expected over the life of the project.

Since then, additional mast tree surveys have not been completed. According to Table C-2 in Appendix C, vegetation transects are required every 5 years. However, the USFWS prepared land cover maps based on 2000 data for the Port Louisa National Wildlife Refuge. As seen in Figure 6-1, the land cover map for the Upper Big Timber Division delineates the refuge into two main vegetation types, wetlands and forest. The wetlands are further broke down into permanently, semi-permanently, and seasonally flooded. The forest is further separated into wet floodplain and mesic bottomland. Also delineated on the map is scrub/shrub, wet meadow, and developed.

(2) Conclusions. It appears that the Big Timber HREP is meeting the objective of providing mast tree dominated areas. The 2000 land cover map illustrated that the majority of the Upper Big Timber Division is wet floodplain forest, with mesic bottomland forest, or mast trees, next in abundance. These forest types are also illustrated in the aerial photos provided by the USFWS (see Figures 6-2 and 6-3). The areas of mesic bottomland forest within the Big Timber HREP are adjacent to Round Pond, near Willow Chute and Little Denny, and to either side of Big Denny. The largest area of mesic bottomland forest lies east of Big Denny and extends to the Mississippi River. The USFWS reports declining quality and composition of the stands but the next land cover map will not be produced for the area until 2010.

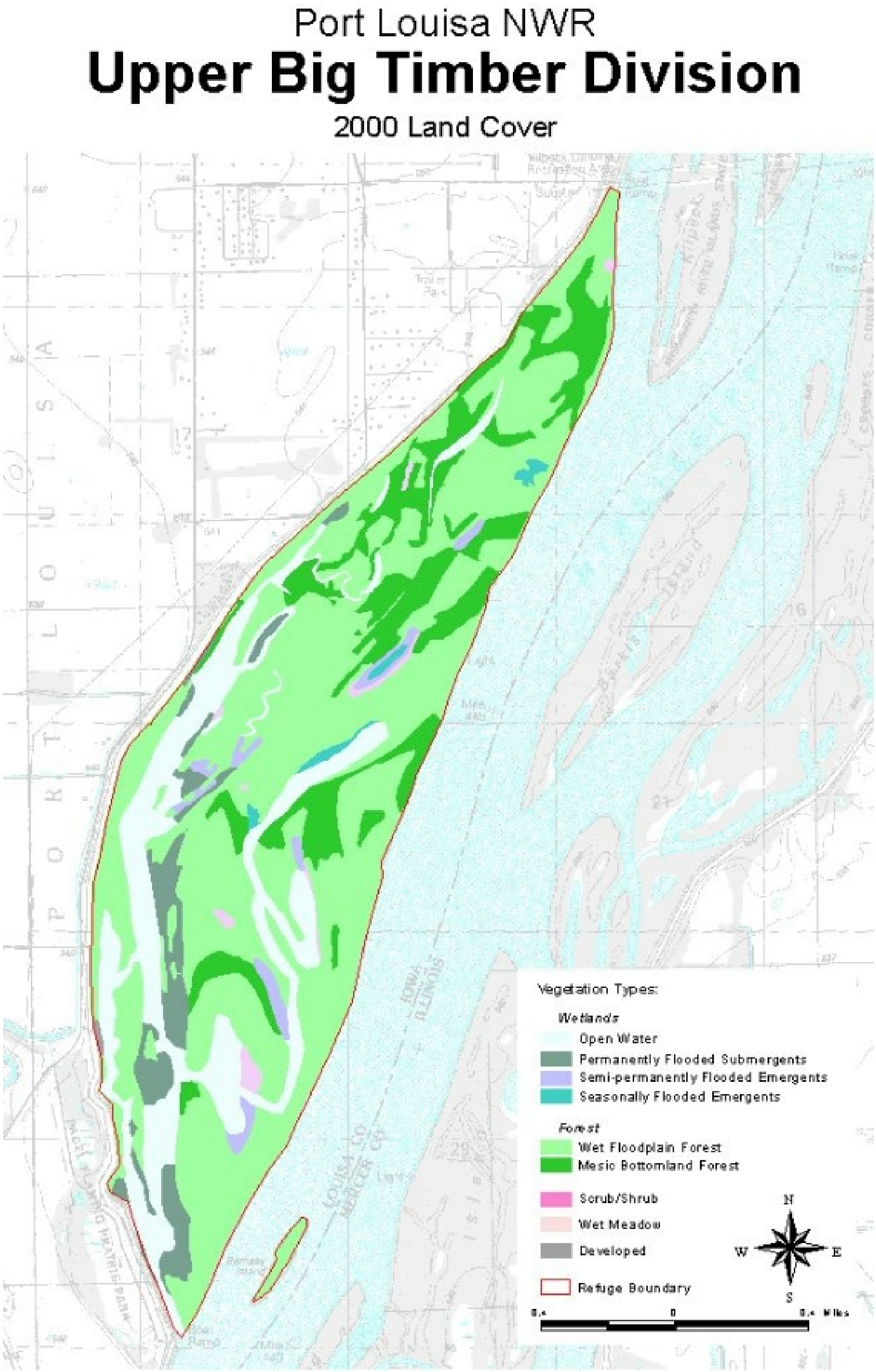

Port Louisa NWR
Upper Big Timber Division
2000 Land Cover
Vegetation Types:
Wetlands
Open Water
Permanently Flooded Submergents
Semi-permanently Flooded Emergents
Seasonally Flooded Emergents
Forest
Wet Floodplain Forest
Mesic Bottomland Forest
Scrub/Shrub
Wet Meadow
Developed
Refuge Boundary
N
W
E
S
0.4
0
0.4 Miles
PORT LOUISA
IOWA
ILLINOIS
LOUISA CO
MERCER CO
Ramsey Island

FIGURE 6-1

FIGURE 6-2
Big Timber Division Land Cover

FIGURE 6-3
Big Timber Division Forests

Note: Aerial photos courtesy of the US Fish & Wildlife Service

7. EVALUATION OF MIGRATORY WATERFOWL HABITAT OBJECTIVES

a. Increase Reliable Resting and Feeding Water Area.

(1) Monitoring Results. One of the objectives for enhancing migratory waterfowl habitat is to increase the reliable resting and feeding water area through aquatic habitat and pothole creation. As shown in Appendix B, Table B-1, the Year 50 Target is to maintain greater than or equal to 21 acres of water surface area within the Big Timber HREP. Sedimentation transects within the channels and potholes were performed in July 1991 to reflect as-built conditions of the reliable resting and feeding water area. Sedimentation transects were conducted again in January 1994, January 1997, and September 2002. A discussion of this data was included in the February 1996, August 1998, and April 2002 PERs, respectively. In the 1998 PER, nearly 26 acres of reliable resting and feeding water area existed based on current aerial photography at that time. Since then, additional mapping has not been completed. However, additional transects were completed in September 2002. According to Table C-2 in Appendix C, sedimentation transects and aerial photography are required every five years. The next transects have not been scheduled.

The channel water surface area was determined by multiplying the channel width at flat pool for each transect by the channel length between transects. The pothole water surface was found by multiplying the pothole long chord by the pothole short chord (refer to Plates 12 through 15). These calculations are illustrated in Appendix F, Tables F-5 and F-6. As seen in Table 7-1, the reliable resting and feeding water area at Year 11 (2002) was found to be 50.0 acres for the channel and 0.63 acres for the potholes, resulting in a total of 50.6 acres. The majority of the surface area lies in the channel, with only 1% of the acreage coming from the potholes.

TABLE 7.1. Increase Reliable Resting and Feeding Water Area

Year	Channel Water Surface Area (Acres)	Pothole Water Surface Area (Acres)	Total Water Surface Area (Acres)
0 (1991)	23.2	0.60	23.8
4 (1995)	25.8	0.77	26.6
6 (1997)	27.1	0.79	27.9
11 (2002)	50.0	0.63	**50.6**
50 (Target)			**21.0**

(2) Conclusions. It appears that the Big Timber HREP is meeting the objective of increasing reliable resting and feeding water area by maintaining a surface area greater than or equal to 21 acres. Rather than showing a decrease, the surface area actually increased from 27.9 acres in Year 6 (1997) to 50.6 acres in Year 11 (2002). The reason for this increase in surface area is due to a similar increase in channel width that can be seen on Plates 6 through 11 in Appendix L and Table F-5 in Appendix F. The pothole surface area has remained rather constant, only varying from 0.60 to 0.79 acres over the last 11 years.

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

(1) Monitoring Results. The other objective for enhancing migratory waterfowl habitat is to provide isolated resting, feeding, and brooding pools through pothole creation. As shown in Appendix B, Table B-1, the Year 50 Target is to maintain a total number of 10 potholes throughout the design life of the Big Timber HREP. Pothole sedimentation transects were conducted at project completion to reflect as-built conditions of the isolated resting, feeding, and brooding pools. Pothole sedimentation transects were conducted again in September 1995 and June 1997. A discussion of this data was included in the August 1998 PER. Additional transects were completed in September 2002. According to Table C-2 in Appendix C, sedimentation transects are required every five years.

Using the sedimentation transect data, the cross-sectional area and average depth was determined to evaluate each pothole. These parameters were based on a flat pool elevation of 536 feet. The calculations are illustrated in Appendix F, Table F-6. As seen in Table 7-2, the average long and short chord cross-sectional areas at Year 11 (2002) were found to be 77 and 38 square feet, respectively, while the average flat pool depth was estimated at 2.1 feet.

TABLE 7.2. Provide Isolated Resting, Feeding, and Brooding Pools

Year	Cross-Sectional Area (SF) Long Chord	Cross-Sectional Area (SF) Short Chord	Flat Pool Depth (FT)
0 (1991)	--	--	--
4 (1995)	151	68	3.5
6 (1997)	154	70	3.4
11 (2002)	**77**	**38**	**2.1**

(2) Conclusions. It appears that the Big Timber HREP is meeting the objective of providing isolated resting, feeding, and brooding pools by maintaining a total number of 10 potholes. When looking at the pothole water surface area (Table 7-1) and cross-sectional area / depth (Table 7-2), a similar comparison can be seen. From Year 4 (1995) to Year 6 (1997), there was little change in these three parameters. Then in Year 11 (2002), all three parameters decreased. The reason for this is more than likely due to the presence or absence of a flood. Between Years 4 (1995) and 6 (1997), there were no major floods, as the sedimentation transects were completed in January 1997. Between Years 6 (1997) and 11 (2002), there were two major events, the Floods of 1997 and 2001.

According to USFWS reports, the potholes are not being utilized by waterfowl. They report that they do provide excellent habitat for amphibians but the use by waterfowl is limited by inadequate size and depth. The pothole’s small size, steep slopes, and surrounding forest make for excellent opportunities for predators. The USFWS staff has recommended future potholes be a minimum of 2 acres and constructed using bulldozers to eliminate steep slopes.

8. OPERATION AND MAINTENANCE SUMMARY

a. Operation. The Big Timber HREP has no general operating requirements.

b. Maintenance.

(1) Inspections. The USFWS Site Manager performed an annual inspection of the Big Timber HREP on August 16, 2006. The USFWS Site Manager's project inspection and monitoring results can be found in Appendix D.

(2) Maintenance Based on Inspections. During the annual inspection in 2006, the USFWS Site Manager drove a boat through Timber Chute where sedimentation was a concern. The depth finder displayed readings around 6 feet in this area, which is equivalent to approximately 5 feet when adjusted to flat pool. As stated in the last PER, the channel depths recorded in 1999 ranged from 3.85 to 5.9 feet below flat pool. There were several people fishing, catching bluegills around the snags. Almost no wetland vegetation was found anywhere, except for the mud flats in Round Pond.

The USFWS Site Manager discovered that the check dam, which blocks Little Denny off from boat traffic, was still intact in 2006 but during a phone conversation in May of 2007 reported that the check dam is no longer functioning as the logs are no longer present. Beyond this point, the ground was just as muddy as the rest of the Big Timber HREP, but it was observed that the water was much clearer. This observation may be due to several factors, such as fewer carp inhabiting the area due to the shallow depths, the check dam blocking sediment, or the lack of boat traffic churning up the water. Potholes 8, 9, and 10 were found. The edges were mucky and no longer steep. Sediment deposition could not be determined from visual observation. The mast tree plantings were overgrown and difficult to walk in so tree survival was not evaluated.

The 2000 USFWS Site Manager's project inspection report noted that in aquatic habitat areas there was very little presence of emergent vegetation, which is consistent with the previous report. Considerable sloughing of the bank along Big Denny was documented, which may be partly due to boat traffic. The Big Timber HREP is designated as a no-wake zone at the entrance to Round Pond. The report also noted a considerable number of snags along Big and Little Denny. In addition, rapid sedimentation of areas along the channel with little or no vegetation was observed. The 1997 USFWS Site Manager's project inspection report noted that no waste materials or unauthorized structures were found in the project area, and that the Little Denny entrance access control remained in place. In addition, the 1997 report mentioned concerns about the sedimentation rate in Timber Chute. With depths already approaching the design life of the project prior to 1997, it was anticipated that the existing depths would only be worse or at best, the same. It was recommended that the Corps and USFWS continue to closely monitor the sedimentation rate to determine if corrective measures are required if sediment continues to accumulate at a rate greater than that estimated in the DPR.

Since the last PER, the Big Timber HREP has required little maintenance. Further maintenance, with respect to erosion and sediment deposition, shall be determined once the next round of sedimentation transects are conducted and analyzed.

9. CONCLUSIONS AND RECOMMENDATIONS

a. Project Goals, Objectives, and Management Plan. Data and observations collected since the last PER suggest that all of the goals and objectives evaluated for the Big Timber HREP are being met, as illustrated in Table 9-1. Further data collection will continue to define sedimentation rates, survival of mast trees, and project utilization by migratory waterfowl and other wildlife. The last sediment tracts were measured in Year 11 (2002).

TABLE 9.1. Project Goals and Objectives

Goals	Objectives	Project Features	Unit	Year 11 (2002)	Year 50 Target	Status
Enhance Aquatic Habitat	Restore deep aquatic habitat (Depth ≥ 6')	Hydraulic dredging	Acre Feet	49.9	42.4	Met
	Restore shallow aquatic habitat (2' ≤ Depth ≤ 3')	Mechanical excavation	Acre Feet	84.9	15.8	Met
	Improve levels of dissolved oxygen during critical seasonal stress periods	Dredging & excavation	mg/L		5	Met
		(Station W-M443.6G)	(min)	3.86		
			(max)	18.95		
			(ave)	8.60		
		(Station W-M444.4H)	(min)	2.70		
			(max)	16.51		
			(ave)	8.56		
	Provide year-round habitat access	Dredging & excavation	Square Feet	534	348	Met
Enhance Terrestrial Habitat	Produce mast tree dominated areas	Revegetation	Acres	[1/] 204+	204	Met
Enhance Migratory Waterfowl Habitat	Increase reliable resting & feeding water area	Pothole creation, dredging, & excavation	Acres	50.6	21	Met
	Provide isolated resting, feeding, & brooding pools	Pothole creation	Each	10	10	Met

[1/] Based on visual observations of USFWS data

b. Post-Construction Evaluation and Monitoring Schedules. Monitoring efforts for the Big Timber HREP have been performed according to the Post-Construction Performance Evaluation Plan in Appendix B and the Resource Monitoring and Data Collection Summary in Appendix C. The next PER will be a detailed report completed in March of 2013 following collection of field data from January 1, 2008 through December 31, 2012. This report should include new sedimentation transects.

(1) Restore Deep Aquatic Habitat. It is not only apparent for the Big Timber HREP but for other HREPs as well that the annual sedimentation rates are consistently underestimated. This may be due to the fact that many of the existing HREPs are still in the younger years of their design life and that sediment deposition is not linear, but rather

logarithmic. The result is higher sedimentation rates in the earlier years of the project until the channel becomes stabilized and sedimentation rates begin to level off. If this is indeed the case, then it seems practical to conduct sedimentation transects on a similar scale. Transects should be performed more frequently in the first ten years and less often in later years. This in turn would closely follow the implementation schedule for PERs. More importantly, a better relationship between sedimentation rates versus project life could be determined and used in the design of future HREPs.

(2) Provide Year-Round Habitat Access. Timber Chute has experienced excessive sedimentation since project completion. The flat pool depths in Timber Chute are approaching the critical point of 3.5 feet and no longer meet the criteria for deep aquatic habitat (Depth $\geq$ 6’). In regard to maintenance of a migratory path for fish, the remaining life of this objective 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 below flat pool. When project depths reach 3.5 feet, the options of rehabilitation or abandonment of this objective may be considered. Any decision would be carried forth only upon written mutual agreement of the USFWS and 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 Year 50 Target without additional dredging in the future.

c. Project Operation and Maintenance. Project O&M has been conducted in accordance with the O&M Manual. There are no operational requirements attached to the Big Timber HREP. The maintenance of project features has been adequate. Annual project inspections by the USFWS have resulted in proper corrective maintenance actions.

d. Project Design Enhancement. Discussions with those involved in operation, maintenance, and monitoring activities at the Big Timber HREP have resulted in the following general conclusions regarding project features that may affect future HREP design.

(1) Hydraulic Dredging / Check Dams. To reduce project sediment deposition in Timber Chute and the lower end of Willow Chute, two options could be evaluated. The first 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 raise the effective height of the excavated dredged material adjacent to Timber Chute to match the check dam. This option would maintain the expansion zone bordering Timber Chute but should prevent sediment from entering the channel provided the check dam is partially fortified.

APPENDIX A

ACRONYMS

ACRONYMS

CEMVR	Corps of Engineers, Mississippi Valley Division, Rock Island District
CPUE	Catch Per Unit Effort
CY	Cubic Yards
DO	Dissolved Oxygen
DPR	Definite Project Report
EMP	Environmental Management Program
ER	Engineer Regulation
HREP	Habitat Rehabilitation and Enhancement Project
IADNR	Iowa Department of Natural Resources
LTRMP	Long-Term Resource Monitoring Program
MSL	Mean Sea Level
O&M	Operation and Maintenance
PER	Performance Evaluation Report
RM	River Mile
UMRS	Upper Mississippi River System
USFWS	United States Fish and Wildlife Service

APPENDIX B

POST-CONSTRUCTION EVALUATION PLAN
AND
SEDIMENTATION TRANSECT PROJECT OBJECTIVES EVALUATION

TABLE B-1
Post-Construction Evaluation Plan

Goal	Objective	Enhancement Feature	Unit	Year 0 (1991) Without Project	Year 0 (1991) With Project	Year 11 (2001) With Project	Year 50 Target With Project	Feature Measurement	Annual Field Observations by USFWS Site Manager
Enhance Aquatic Habitat	Restore deep aquatic habitat (Depth ≥ 6’)	Hydraulic dredging	Acre Feet	0	67.2	49.9	42.4	Perform hydrographic soundings of transects	Development of emergent vegetation within deep dredged area
	Restore shallow aquatic habitat (2’ ≤ Depth ≤ 3’)	Mechanical excavation	Acre Feet	0	61.2	84.9	15.8	Perform hydrographic soundings of transects	Encroachment of bank or obvious shoaling in shallow dredged areas
	Improve levels of dissolved oxygen during critical seasonal stress periods	Dredging & excavation	mg/L	0	5		5	Perform water quality tests	Fish stress (at surface) or fish kills
		(Station W-M443.6G)	(min)			3.86			
			(max)			18.95			
			(ave)			8.60			
		(Station W-M444.4H)	(min)			2.70			
			(max)			16.51			
			(ave)			8.56			
	Provide year-round habitat access	Dredging & excavation	Feet^2	0	567	534	348	Perform hydrographic soundings of transects	Development of emergent vegetation within access area
Enhance Terrestrial Habitat	Produce mast tree Dominated areas	Revegetation	Acre	348	354	[1/] 204+	204	Perform vegetation transects in mast tree area	Seedling survival
Enhance Migratory Waterfowl Habitat	Increase reliable resting & feeding water areas	Pothole creation & dredging/excavation	Acre	0	23.8	50.6	21.0	Perform hydrographic soundings of transects	Waterfowl presence or absence
	Provide isolated resting, Feeding, & brooding pools	Pothole creation	Each	0	10	10	10	Perform areal survey of project area	

[1/] Based on visual observations of USFWS data

TABLE B-2
Sedimentation Transect Project Objectives Evaluation

Transect	Project Objectives to Be Evaluated			
	Restore Deep Aquatic Habitat	**Restore Shallow Aquatic Habitat**	**Provide Year-Round Habitat Access**	**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

APPENDIX C

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

TABLE C-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	USFWS	USFWS	LTRMP	--
	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	See Table C-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 C-2
Construction	Construction Monitoring	Assesses construction impacts; Assures permit conditions are met	Corps	Corps	HREP	See Section 401 Stipulations
Post-Construction	Performance Evaluation Monitoring	Determines success of project as related to objectives	Corps / USFWS	Corps / USFWS	HREP / USFWS	See Table C-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	Corps	HREP	--

TABLE C-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		2M	M								
Secchi Disk Depth	2W		2W		2M	M								
Suspended Solids	2W		2W		2M	M								
Dissolved Oxygen	2W		2W		2M	M								
Specific Conductance	2W		2W		2M	M								
Water Temperature	2W		2W		2M	M								
pH	2W		2W		2M	M								
Total Alkalinity	--		--		2M	M								
Chlorophyll (a,b,c,)	2W		2W		2M	M								
Velocity	--		--		2M	M								
Water Depth	2W		2W		2M	M								
Pheophytin (a)	2W		2W		2M	M								
Percent Ice Cover						M								
Ice Depth						M								
Percent Snow Cover						M								
Snow Depth						M								
Wind Direction					2M	M								
Wind Speed					2M	M								
Wave Height					2M	M								
Air Temperature					2M	M								
Percent Cloud Cover					2M	M								
Sediment Test Stations [3/]													Corps	
Elutriate			1											
Bulk Sediment			1											

TABLE C-2 (Continued)
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														
Column Settling Stations [4/]													Corps	
Column Settling Analysis								1						
Boring Stations [5/]													Corps	
Geotechnical Borings								1						
TRANSECT MEASUREMENTS														
Sedimentation Transects [6/]													Corps	
Hydrographic Soundings							1		5Y					
Vegetation Transects [7/]													Corps	
Mast Tree Survey												5Y		
AREA MEASUREMENTS														
Mapping [8/]													Corps	
Aerial Photos/Remote Sensing										1		5Y		

LEGEND:
W = Weekly
M = Monthly
Y = Yearly
nW = n-Weekly interval
nY = n-Yearly interval
1,2,3, --- = number of times data is collected within designated project phase

TABLE C-2 (Continued)
Resource Monitoring and Data Collection Summary [1/]

[1/] Resource Monitoring and Data Collection Summary - See Plate 3 for Monitoring Plan

[2/] Water Quality Stations

W-M443.6G
W-M444.4H
W-M442.8F (summer DO and temperature only)

[3/] Sediment Test Stations (Design Phase)

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

[4/] Column Settling Stations (Design Phase)

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

[5/] Boring Stations (Design Phase)

DPR-BT-88-1
DPR-BT-88-2
DPR-BT-88-3
DPR-BT-88-4
DPR-BT-88-5
DPR-BT-88-6
DPR-BT-88-7
DPR-BT-88-8
DPR-BT-88-9

[6/] Sedimentation Transects (Post-Construction Phase) – See Table B-2 for Sediment Transect Project Objectives Evaluation. Based on USFWS project inspection reports, the Corps shall adjust the monitoring interval as necessary to survey the sedimentation transects when depths in the migratory path reach 4 feet and then 3.5 feet below flat pool

[7/] Vegetation Transects (Post-Construction Phase) – Mast tree survey of hardwood trees planted in the confined dredged material placement site

[8/] Mapping (Post-Construction Phase) – aerial photography

APPENDIX D

COOPERATING AGENCY CORRESPONDENCE

BIG TIMBER HABITAT REHABILITATION AND ENHANCEMENT PROJECT

UPPER MISSISSIPPI ENVIRONMENTAL MANAGEMENT PROGRAM
POOL 16, RIVER MILE 443 THROUGH 445
LOUISA COUNTY, IOWA

JOINT INSPECTION- USFWS and USACE

Inspected by: Tom Cox, Refuge Manager — Date: August 16, 2006
Roger Perk, CEMVR Chief of EC-DN
Troy Hythecker, CEMVR EC-DN
Gary Swenson, CEMVR District Forester

1. PROJECT INSPECTION

   a. Confined Dredged Material Placement Site: The dredged material placement site was not observed during this visit.

   b. Hydraulic Dredging: There has been significant deposition of material in the hydraulically dredged channels. Refer to the sedimentation transects for accurate data.

   c. Mechanical Excavation: There has been significant deposition of material in the mechanically excavated channels. Refer to the sedimentation transects for accurate data.

   d. Check Dam: The check dam remains in good condition and is continuing to serve its function of reducing boat access to Little Denny Lake.

   e. Pothole Creation: The potholes have filled in with some sediment, and the slopes have flattened out to a stable slope. There has not been very much waterfowl use of the potholes, possibly because they are not large enough, are too close to trees, or do not have adequate depth of water during the appropriate waterfowl migration seasons.

Revegetation: It was difficult to see the mast trees planted along the high ridge because the areas were overgrown with other vegetation. Beavers and deer seem to have damaged some of the trees. Some of the tree species observed were: silver maple, green ash, elm, and Kentucky coffee trees. The Site Manager noted that it may have been beneficial to plant willow trees adjacent to the slough and plant the mast producing trees behind them to help protect the mast trees from beaver damage. It was also mentioned that if the berm was wider and the trees were planted in larger areas instead of a long narrow strip, the survival may have been better.

APPENDIX E

WATER QUALITY DATA

Table E-1. Post-project water quality monitoring results from surface samples collected at site W-M443.6G

- DATE	WATER DEPTH (M)	VELOCITY (CM/SEC)	WATER TEMP. (°C)	DISSOLVED OXYGEN (MG/L)	pH (SU)	CHLOROPHYLL a (MG/M^3)
05/06/89	0.5	--	12	12.4	8.8	160
05/20/89	0.82	--	22	13.1	8.9	125
06/03/89	0.69	--	25	11.6	8.7	76
06/17/89	0.51	--	25	17.3	9	130
07/01/89	0.62	--	31	19.7	9.2	195
07/15/89	0.62	--	21	7.1	7.9	60
07/29/89	0.46	--	29	9	8.1	26
08/12/89	0.59	--	29	11.7	8.6	46
08/26/89	0.49	--	27	7.9	8.4	28
09/09/89	0.87	--	22	12.2	8.6	160
09/23/89	0.69	--	16	9.4	8.3	33
10/14/89	0.46	--	20	10.9	8.6	15
10/28/89	0.61	--	16	10.4	8.1	21
04/14/90	0.6	--	9	11.5	8.6	35
05/08/90	0.6	<.250	22	0.6	9.2	26
05/26/90	1.2	<.250	17	7.7	7.6	17
06/09/90	0.69	<.113	22	3.8	7.6	6
06/30/90	1.02	<.113	27	8	7.7	34
07/20/90	0.46	<.113	30	13.9	8.3	84
08/04/90	0.61	<.113	27	8.8	7.9	81
08/18/90	0.67	<.113	32	12.6	8.2	129
09/01/90	--	--	30	9.3	8	13
09/15/90	1.44	<.113	25	10.1	8.1	69
09/29/90	1.38	<.113	19	11.9	8.5	49
09/24/91	3.048	0.163	16	10.3	8.94	23.8
10/10/91	2.774	0.102	14.7	9.18	8.64	20.2
10/22/91	2.682	0.108	15.2	13.95	8.6	48.5
11/05/91	3.078	0.058	2.7	11.5	8.18	12.2
11/26/91	3.658	0.073	2.9	12.6	--	6.1
12/13/91	3.703	0.073	2	11.72	7.64	3.1
02/03/92	2.682	0	3.3	13.72	7.52	21
04/07/92	3.52	--	14.2	15.82	8.8	40
05/12/92	3.048	0.093	19	16.61	4.53	54.4
06/04/92	2.743	0	22.5	--	8.6	34.5
06/16/92	2.59	0.202	25	3.06	7.85	29.6
07/10/92	2.768	0.133	--	7.82	8.27	69.3
07/22/92	3.2	0	24	7.51	7.7	42.1
07/27/92	2.926	0	27.5	8.01	8.7	76.7
08/12/92	2.819	0.113	24.5	7.83	8.32	58.4
08/25/92	2.59	0.08	28	8.66	8.4	19.6
08/31/92	1.86	0	25.5	9.75	9	24.6
09/15/92	2.896	0	24	7.95	8.49	95.9
09/28/92	3.23	0.28	17.5	9.44	8	33.3
10/13/92	2.865	0	13	8.88	8.12	11.8

Table E-1. Post-project water quality monitoring results from surface samples collected at site W-M443.6G

- DATE	WATER DEPTH (M)	VELOCITY (CM/SEC)	WATER TEMP. (°C)	DISSOLVED OXYGEN (MG/L)	pH (SU)	CHLOROPHYLL a (MG/M^3)
11/24/92	3.825	0.068	4.8	--	8	9.5
01/25/93	3.322	0	0.7	12.4	8.19	22
11/10/93	2.53	0.075	4.9	13.74	8.94	35.5
01/10/94	2.743	0	1.5	11.3	8.24	12.1
02/24/94	3.78	0.04	-0.3	11.62	7.78	6.1
03/09/94	3.581	0	2.6	9.92	7.91	--
04/19/94	2.743	0.088	15.8	8.29	8.31	67
05/10/94	3.871	0.125	16	14.72	8.7	60
05/24/94	2.758	0.037	22.8	2.91	7.47	21
06/14/94	2.545	0.14	26.7	3.84	7.64	26
07/07/94	2.606	0	28.4	6.67	7.98	40
07/19/94	2.438	0.202	27.3	4.95	7.97	32
08/09/94	2.286	--	25	4.88	8.28	46
08/30/94	2.347	0.041	23.3	7.17	8.4	27
09/13/94	2.134	0.107	24	6.83	8.51	57
10/04/94	2.53	0.042	16.9	7.86	8.34	36
10/25/94	2.377	0.119	12	10.22	9.23	39
12/06/94	2.438	0.072	4.2	11.8	8.57	9.2
02/14/95	2.566	0.07	2.9	12.3	8.15	20
03/14/95	2.179	0	9.6	16.44	8.88	57
04/11/95	3.048	0.081	7.9	12.75	9.47	140
06/13/95	2.957	0.044	22.2	--	7.95	58
06/27/95	2.484	0	26.3	1.74	7.72	43
07/11/95	1.951	0.07	28.2	3.82	7.97	100
07/25/95	2.377	0	28.2	5.2	8.29	82
08/29/95	2.499	0	29.2	4.71	8.15	33
09/12/95	2.286	0	20.4	6.02	7.89	32
09/27/95	2.103	0.021	15.9	6.92	--	23
10/10/95	2.682	0	15.7	8.39	8.17	--
10/24/95	2.332	--	9.2	8.89	8.4	27
11/07/95	2.819	0.223	4.2	10.01	7.8	58
06/19/96	2.743	0.131	23.1	4.71	7.71	--
07/10/96	2.85	0	25.3	13.99	8.64	75
08/13/96	2.164	0.26	--	--	--	65
08/27/96	0.914	0.05	26.9	7.45	--	45
09/19/96	1.92	0.19	18.7	7.62	8.39	42
12/23/96	2.179	0	2.9	12.89	8.1	8.1
01/07/97	2.103	0	3.9	17.64	--	44
02/11/97	2.073	0	1.3	6.21	--	15
02/25/97	3.993	0	1.1	10.15	--	6.5
06/18/97	2.256	0.112	25.2	9.51	8.54	76
07/02/97	2.042	--	29	3.4	7.89	100
07/17/97	2.103	0.078	27.6	4.17	7.94	92

Table E-1. Post-project water quality monitoring results from surface samples collected at site W-M443.6G

- DATE	WATER DEPTH (M)	VELOCITY (CM/SEC)	WATER TEMP. (°C)	DISSOLVED OXYGEN (MG/L)	pH (SU)	CHLOROPHYLL a (MG/M^3)
07/31/97	2.286	0	25.5	6.9	8.3	120
08/19/97	2.073	0.074	23.2	4.68	7.67	44
09/03/97	2.042	0.131	23.1	5.6	7.88	44
09/25/97	1.981	0	18.9	8.39	8.29	50
12/23/97	1.859	0	1.9	16.75	--	17
01/27/98	1.676	0	2.4	14.69	8.34	4.9
02/24/98	2.073	--	6.5	12.73	8.53	11
03/24/98	2.408	0	6	17.81	8.07	69
06/03/98	2.042	0.258	21.8	3.83	7.54	59
07/02/98	3.444	0.191	27.1	3.15	7.26	9.8
07/14/98	3.109	0	27.2	6.19	7.48	12
07/28/98	1.966	0	27.7	5.8	7.92	72
08/13/98	1.92	0	26.7	8.33	8.44	70
08/25/98	1.829	0.068	26.5	4.5	7.9	52
09/10/98	1.753	0.064	21.6	7.35	8.22	54
09/29/98	1.875	0	26	13.54	8.56	65
12/29/98	1.829	0	3.2	19.66	8.7	17
01/28/99	1.829	0	1.7	4.66	7.7	8.3
02/25/99	1.829	0	3.5	19.1	9	25
03/23/99	1.981	0	8	15	9	34
05/27/99	4.542	0	18.6	5.8	6.73	<1
06/22/99	2.682	0.054	24.5	11.1	8.2	49
07/08/99	1.829	0.053	28.2	7.46	8.2	80
07/27/99	2.896	0.127	29.5	7.09	8.1	34
08/10/99	1.92	0.145	24.6	5.76	7.7	68
08/24/99	1.768	0.095	22.9	6.57	8.2	64
09/08/99	1.676	0	23.3	5.24	8.2	42
09/21/99	1.81	0	15	7.74	8.5	32
02/08/00	1.3	0	1.6	12.13	7.9	11
03/07/00	2.1	0	11.7	18.82	8.9	94
05/31/00	1.97	--	19.9	6.32	7.8	40
06/15/00	4.12	--	22.9	5.04	7.5	5.6
07/06/00	2.871	--	24.9	4.6	7.5	10
07/25/00	1.831	--	24.7	12.45	8.3	54
08/08/00	1.79	--	28.6	13.42	8.8	19
08/22/00	1.965	--	24.2	6.84	8.3	60
09/05/00	1.71	--	21.2	6	7.9	59
09/19/00	1.76	--	20.4	7.17	8.5	71
01/03/01	1.7	--	0.4	1.94	7.5	4
02/13/01	1.98	--	0.8	10.92	7.7	3.2
03/06/01	1.785	0	1.9	15.7	8.3	39
03/20/01	1.97	0	3.6	17.47	8.9	21
06/05/01	3.37	0.028	17.1	9.93	7.9	24

Table E-1. Post-project water quality monitoring results from surface samples collected at site W-M443.6G

-	WATER	VELOCITY	WATER	DISSOLVED	pH	CHLOROPHYLL a
DATE	DEPTH (M)	(CM/SEC)	TEMP. (°C)	OXYGEN (MG/L)	(SU)	(MG/M^3)
06/19/01	2.96	0	24.1	5.75	7.6	47
07/03/01	3.04	--	24.8	5.07	7.5	6.3
07/18/01	1.62	--	27.5	5.22	7.9	50
07/31/01	1.8	--	29.2	5.04	8.1	54
08/14/01	1.55	0	26.3	4.03	7.9	70
08/28/01	1.59	--	25.4	5.9	8.2	44
09/18/01	1.64	0	19.3	6.83	8.2	--
01/08/02	1.715	0	2.5	18.95	8.1	9.5
02/28/02	1.85	0	1.8	17.3	8.3	36
06/18/02	2.35	--	21.5	5.22	7.4	19
07/02/02	2.39	--	28.5	5.86	7.7	62
07/18/02	1.6	--	28	4.13	7.7	99
08/01/02	1.55	--	28.6	3.86	7.7	56
08/14/02	1.72	0	23.3	5.62	7.8	70
08/29/02	1.48	--	26	6.84	8.1	37
09/10/02	1.5	0.061	26.7	5.42	8.1	54
09/24/02	1.5	--	16.2	6.94	8.2	49
12/17/02	1.52	--	2.6	14.44	8.66	--
02/13/03	1.460	0.30	1.9	14.83	8.36	-
04/10/03	1.570	1.89	7.0	18.45	9.20	-
06/10/03	1.620	-	21.1	8.45	8.20	88.0
06/24/03	1.520	-	25.8	6.17	7.70	91.0
07/08/03	2.710	1.69	29.2	5.77	8.10	77.0
07/22/03	1.750	-	25.3	5.43	8.20	80.0
08/05/03	1.310	0.70	25.5	5.28	8.50	85.0
08/19/03	1.490	-	26.7	4.89	8.40	52.0
09/02/03	1.320	0.59	20.5	9.02	8.30	155.0
09/16/03	1.280	3.58	20.8	9.75	8.60	120.0
12/23/03	1.420	1.14	1.4	3.95	7.78	-
02/12/04	1.360	0.43	0.4	2.13	7.60	-
03/23/04	1.390	-	6.5	21.18	9.40	-
06/08/04	3.940	-	23.2	5.72	7.20	2.6
06/22/04	4.350	8.33	22.1	4.91	7.20	<1
07/07/04	1.630	2.99	22.9	10.26	8.10	89.0
07/20/04	1.700	2.25	27.1	5.78	7.90	65.0
08/03/04	1.420	3.59	25.5	5.60	7.90	73.0
08/17/04	1.420	1.43	22.1	5.66	8.10	81.0
08/31/04	1.440	2.14	23.1	6.02	7.90	50.0
09/14/04	1.450	-	23.2	7.84	8.60	44.0
01/04/05	1.425	0.59	3.6	21.33	8.70	32.0
02/22/05	1.640	-	2.4	15.59	8.20	13.0
03/22/05	1.430	-	5.7	16.12	9.10	100.0
06/08/05	1.840	-	26.4	7.04	8.30	94.0

Table E-1. Post-project water quality monitoring results from surface samples collected at site W-M443.6G

- DATE	WATER DEPTH (M)	VELOCITY (CM/SEC)	WATER TEMP. (°C)	DISSOLVED OXYGEN (MG/L)	pH (SU)	CHLOROPHYLL a (MG/M^3)
06/21/05	1.645	0.41	26.5	8.98	8.40	130.0
07/06/05	1.550	0.78	26.3	8.79	8.60	92.0
07/19/05	1.380	0.45	28.2	7.36	8.40	74.0
08/02/05	1.310	0.35	26.9	5.28	8.20	64.0
08/17/05	1.330	1.75	25.5	7.46	8.40	50.0
08/30/05	1.385	1.09	25.7	5.97	8.40	48.0
09/13/05	1.320	3.50	24.9	6.26	8.50	62.0
12/22/05	1.480	0.40	0.8	3.03	7.30	46.0
01/25/06	1.400	-	-0.1	17.79	8.90	110.0
03/16/06	1.510	-	9.2	11.72	8.10	26.0
MIN.	0.460	0.00	-0.3	0.60	4.53	2.6
MAX.	4.542	8.33	32.0	21.33	9.47	195.0
AVG.	2.036	0.38	18.2	9.14	8.18	50.9

Table E-2. Post-project water quality monitoring results from surface samples collected at site W-M444.4H

- DATE	WATER DEPTH (M)	VELOCITY (CM/SEC)	WATER TEMP. (°C)	DISSOLVED OXYGEN (MG/L)	pH (SU)	CHLOROPHYLL a (MG/M^3)
11/07/95	1.65	0.18	4.5	10.66	8.3	23
06/19/96	2.26	0	23.2	2.57	7.57	28
07/10/96	2.62	0	26.3	6.72	7.93	100
08/13/96	2.13	0.21	--	--	--	52
08/27/96	1.28	0.08	26.5	6.35	--	195
09/19/96	0.62	--	21	7.1	7.9	49
12/23/96	2.18	0	3.3	8.27	--	16
01/07/97	2.09	0	4	10.46	--	52
02/11/97	2.13	0	1	6.59	--	67
02/25/97	3.95	0	1.6	9.57	--	<1
06/18/97	2.13	0.09	25.5	5.4	7.95	130
07/02/97	2.13	0.09	29.6	1.63	7.89	69
07/17/97	2.13	0.15	28.7	4.57	7.9	140
07/31/97	2.32	0	25.8	5.68	7.93	80
08/19/97	2.1	0.08	24.3	2.1	7.47	36
09/03/97	2.04	0.14	24.5	2.66	7.61	24
09/25/97	2.07	0.15	19	4.98	7.77	22
12/23/97	1.83	0	3.5	11.84	--	24
01/27/98	1.89	0	3.1	12.43	7.72	32
02/24/98	2.13	--	6.8	9.35	7.78	12

Table E-2. Post-project water quality monitoring results from surface samples collected at site W-M444.4H

-	WATER DEPTH	VELOCITY	WATER	DISSOLVED	pH	CHLOROPHYLL a
DATE	(M)	(CM/SEC)	TEMP. (°C)	OXYGEN (MG/L)	(SU)	(MG/M^3)
03/24/98	2.21	0.03	6.6	18.84	8.38	95
06/03/98	1.98	0.11	22.2	6.84	7.47	35
07/02/98	3.73	0	27.2	3.26	7.28	10
07/14/98	3.19	0.05	28.1	5.22	7.4	13
07/28/98	1.98	0	28.1	6.36	7.86	51
08/13/98	2.01	0	26.8	3.71	7.73	64
08/25/98	1.92	0	27.8	2.99	7.67	62
09/10/98	1.78	0.08	22.9	4.73	7.68	82
09/29/98	1.87	0.05	24.7	11.25	8.3	78
12/29/98	1.94	0	3.9	16.9	8.8	28
01/28/99	2.04	0	0.4	3.72	7.6	6.7
02/25/99	1.91	0	3	13.83	8.5	31
03/23/99	2.13	0	9.3	13.55	8.9	48
05/27/99	4.51	0.12	18.1	5.51	7.23	2.7
06/22/99	2.74	0.08	24.5	11.2	8.2	33
07/08/99	2.13	--	28.2	4.61	8.1	56
07/27/99	3.02	0	29.9	6.37	8.1	28
08/10/99	2.07	0.16	26.2	6.87	7.7	67
08/24/99	2.07	--	23.8	4.48	7.8	65
09/08/99	1.8	0	25.1	4.96	8	77
09/21/99	1.98	0	17.5	4.72	8	36
02/08/00	1.86	0	1.3	6.1	7.5	8.5
03/07/00	2.15	0.12	11.8	16.13	8.7	100
05/31/00	2.05	--	20.4	7.08	8	48
06/15/00	4.22	--	23.1	2.55	7.4	5.7
07/06/00	3.02	--	24.6	4.91	7.5	20
07/25/00	1.91	--	25.1	10.84	7.9	80
08/08/00	1.78	--	29.6	13.58	8.5	19
08/22/00	2.01	--	24.7	4.9	7.7	36
09/05/00	1.74	--	23.8	3.31	7.8	45
09/19/00	1.8	--	21.4	7.25	8.5	70
01/03/01	1.84	--	0.7	0.56	7.5	4.3
02/13/01	2.1	--	0.6	11.46	7.7	36
03/06/01	1.89	--	1.9	19.43	8.5	37
03/20/01	2.04	0	3.8	16.82	9	18
06/05/01	3.75	0	17.2	10.69	8.1	27
06/19/01	3.05	0.05	24.4	5.8	7.6	47
07/03/01	3.51	0	25.9	6.11	7.6	7.9
07/18/01	1.85	--	27.7	3.35	7.6	<1
07/31/01	1.87	0	29.6	5.08	8	68
08/14/01	1.69	0	24.9	2.36	7.8	78
08/28/01	1.67	0	25.8	7.16	8.2	--
09/18/01	1.76	0	19.4	3.43	7.9	--

Table E-2. Post-project water quality monitoring results from surface samples collected at site W-M444.4H

- DATE	WATER DEPTH (M)	VELOCITY (CM/SEC)	WATER TEMP. (°C)	DISSOLVED OXYGEN (MG/L)	pH (SU)	CHLOROPHYLL a (MG/M^3)
01/08/02	1.85	0	3.8	15.86	8.1	15
02/28/02	1.93	--	3.5	16.51	8.2	33
06/18/02	2.69	--	22.3	10.41	7.8	104
07/02/02	2.6	--	29	6.02	7.7	45
07/18/02	1.85	0.104	28.5	6.48	7.9	167
08/01/02	1.85	--	29.8	6.41	8	125
08/14/02	1.98	--	24.6	2.7	7.4	35
08/29/02	1.99	--	26	6.49	7.9	59
09/10/02	1.75	0	26.9	5.93	7.9	91
09/24/02	1.65	--	17.3	6.94	8.2	56
12/17/02	1.65	--	3.6	10.4	8.22	--
02/13/03	1.700	0.390	2.0	13.47	8.08	-
04/10/03	1.840	1.620	7.3	13.26	8.50	-
06/10/03	1.780	-	21.7	7.87	7.90	111.0
06/24/03	1.720	-	27.5	7.52	7.90	123.0
07/08/03	2.120	2.140	30.3	8.04	8.40	168.0
07/22/03	1.950	-	26.2	2.69	7.20	118.0
08/05/03	1.530	1.350	26.3	5.79	8.30	185.0
08/19/03	1.640	-	28.0	2.96	8.10	208.0
09/02/03	1.410	1.650	21.5	5.48	7.70	230.0
09/16/03	1.470	1.060	21.0	8.72	8.40	223.0
12/23/03	1.580	0.220	1.5	3.18	7.75	-
02/12/04	1.525	0.140	0.6	0.42	7.40	-
03/23/04	1.650	-	8.8	18.32	9.20	-
06/08/04	4.330	-	23.2	4.69	7.00	<1
06/22/04	4.760	2.790	21.8	5.00	7.10	<1
07/07/04	1.740	1.140	23.5	6.33	7.30	81.0
07/20/04	1.750	1.290	28.1	6.05	7.80	76.0
08/03/04	1.570	1.140	25.9	4.81	7.70	58.0
08/17/04	1.730	0.190	22.8	7.58	8.10	127.0
08/31/04	1.450	1.010	22.7	6.20	7.90	70.0
09/14/04	1.750	-	24.3	5.64	7.90	56.0
01/04/05	1.720	0.750	3.5	17.49	8.50	13.0
02/22/05	1.840	-	3.2	15.02	8.20	18.0
03/22/05	1.690	-	7.3	13.63	8.90	56.0
06/08/05	1.820	-	27.5	5.40	8.10	91.0
06/21/05	1.840	1.04	26.9	5.42	8.30	110.0
07/06/05	1.720	1.28	25.6	7.71	8.10	110.0
07/19/05	1.500	0.82	28.3	3.48	7.90	72.0
08/02/05	1.490	1.20	27.8	5.49	8.20	95.0
08/17/05	1.460	0.18	25.8	7.29	8.30	110.0
08/30/05	1.555	1.89	25.5	6.22	8.20	94.0
09/13/05	1.530	3.97	26.5	6.73	8.50	94.0
12/22/05	1.540	0.29	1.3	1.86	7.30	25.0

Table E-2. Post-project water quality monitoring results from surface samples collected at site W-M444.4H

- DATE	WATER DEPTH (M)	VELOCITY (CM/SEC)	WATER TEMP. (°C)	DISSOLVED OXYGEN (MG/L)	pH (SU)	CHLOROPHYLL a (MG/M^3)
01/25/06	1.350	-	1.1	14.93	8.20	56.0
03/16/06	1.700	-	9.2	5.35	7.30	29.0
MIN.	0.620	0.00	0.4	0.42	7.00	2.7
MAX.	4.760	3.97	30.3	19.43	9.20	230.0
AVG.	2.071	0.41	18.6	7.52	7.94	66.1

FIGURE E-1. POST-PROJECT DISSOLVED OXYGEN CONCENTRATIONS COLLECTED WITH A CONTINUOUS MONITOR NEAR THE SURFACE AT SITES W-M443.6G AND W-M444.4H

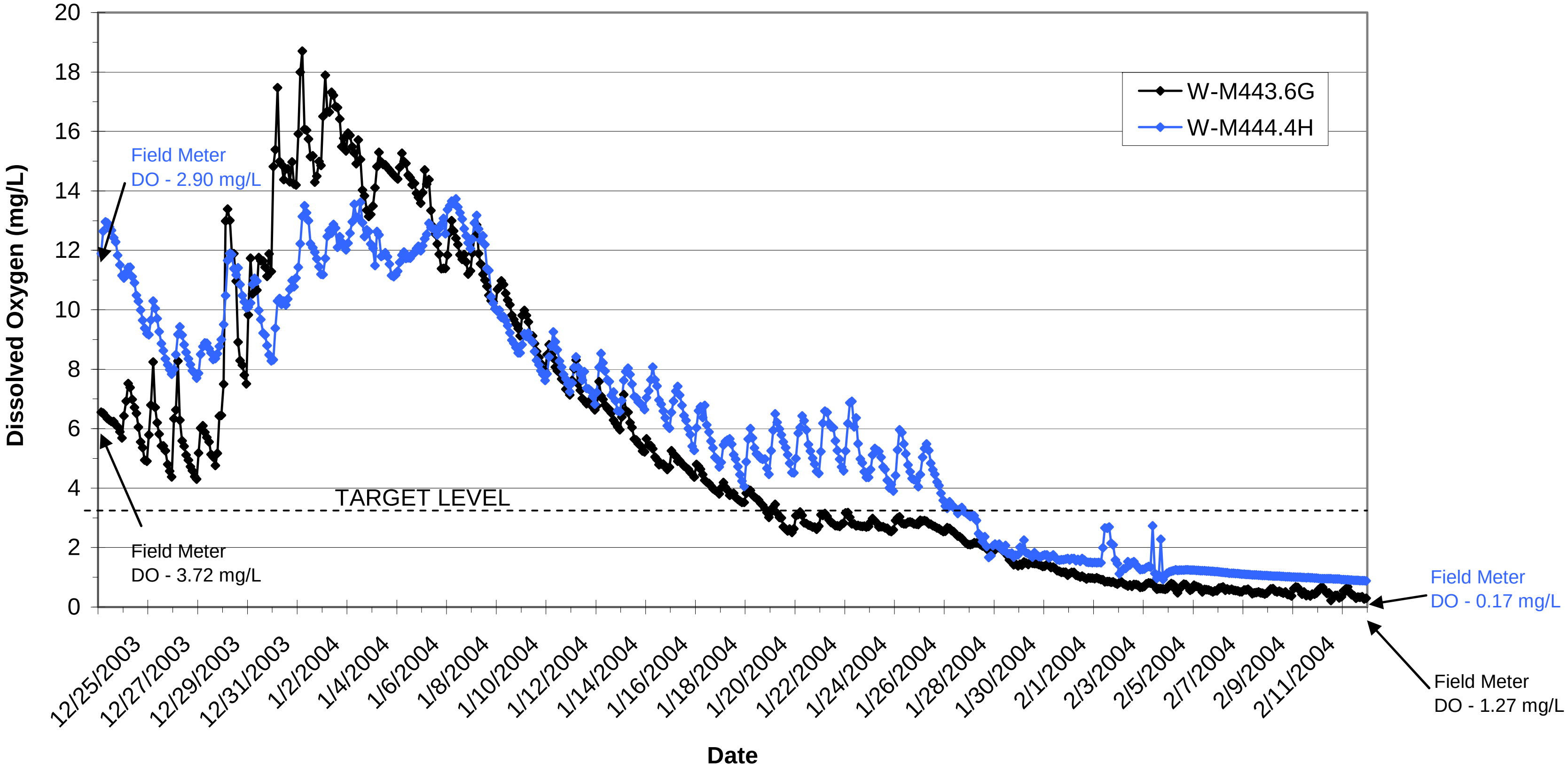


FIGURE E-2. POST-PROJECT DISSOLVED OXYGEN CONCENTRATIONS COLLECTED WITH A CONTINUOUS MONITOR NEAR THE SURFACE AT SITES W-M443.6G AND W-M444.4H

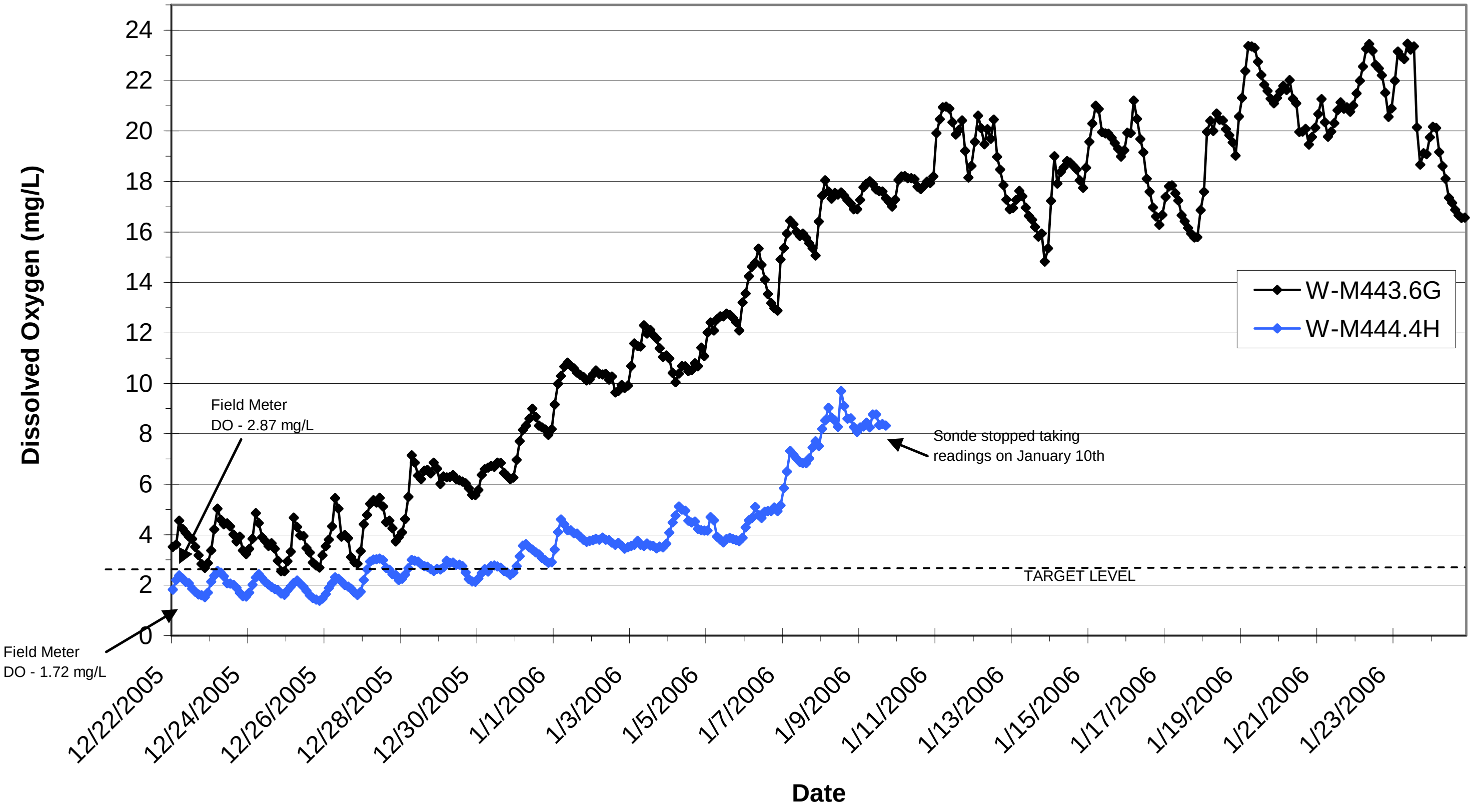


FIGURE E-3. POST-PROJECT DISSOLVED OXYGEN CONCENTRATIONS COLLECTED WITH A CONTINUOUS MONITOR NEAR THE SURFACE AT SITES W-M443.6G AND W-M444.4H

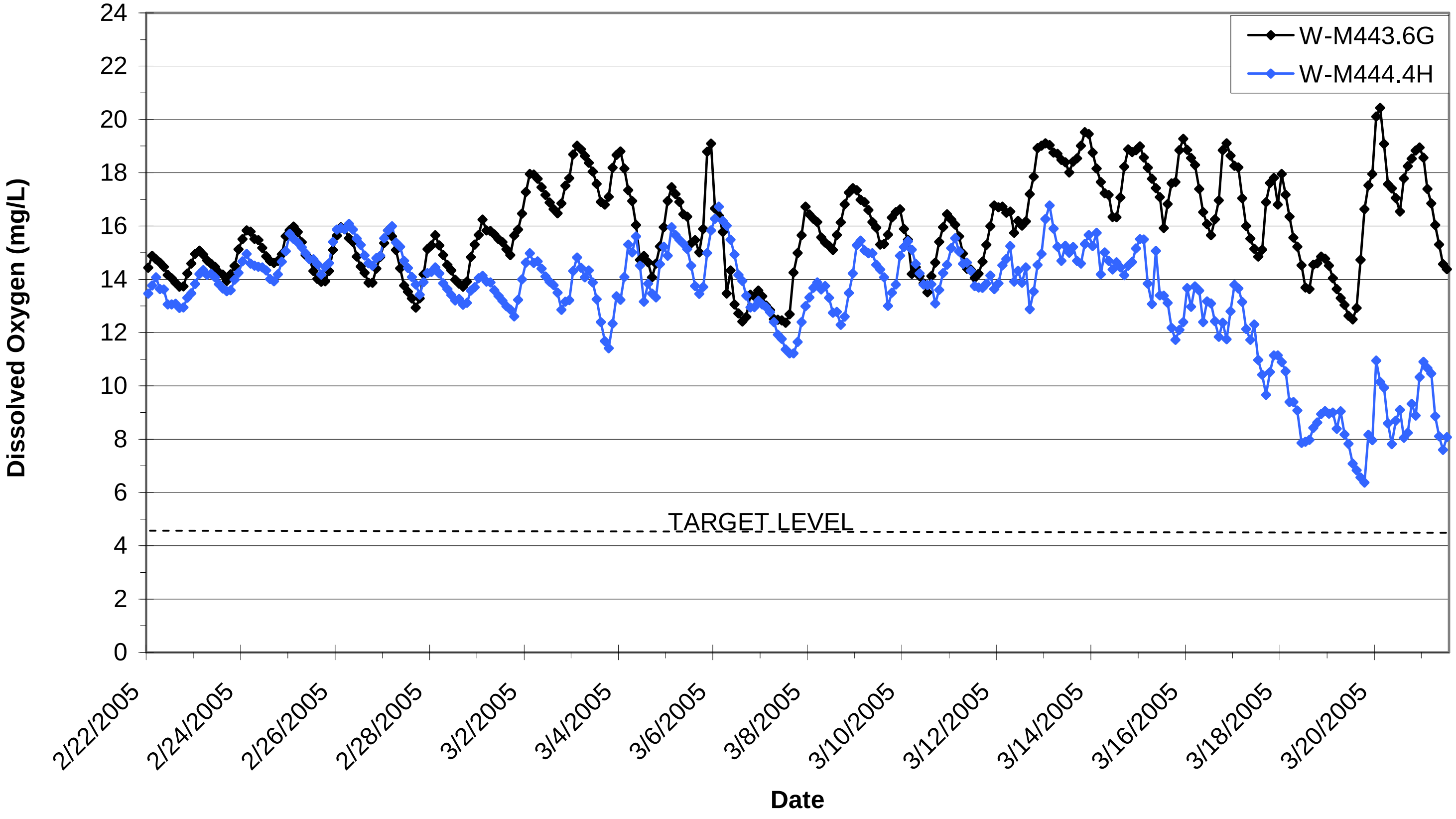


FIGURE E-4. POST-PROJECT DISSOLVED OXYGEN CONCENTRATIONS COLLECTED WITH A CONTINUOUS MONITOR NEAR THE SURFACE AT SITES W-M443.6G AND W-M444.4H

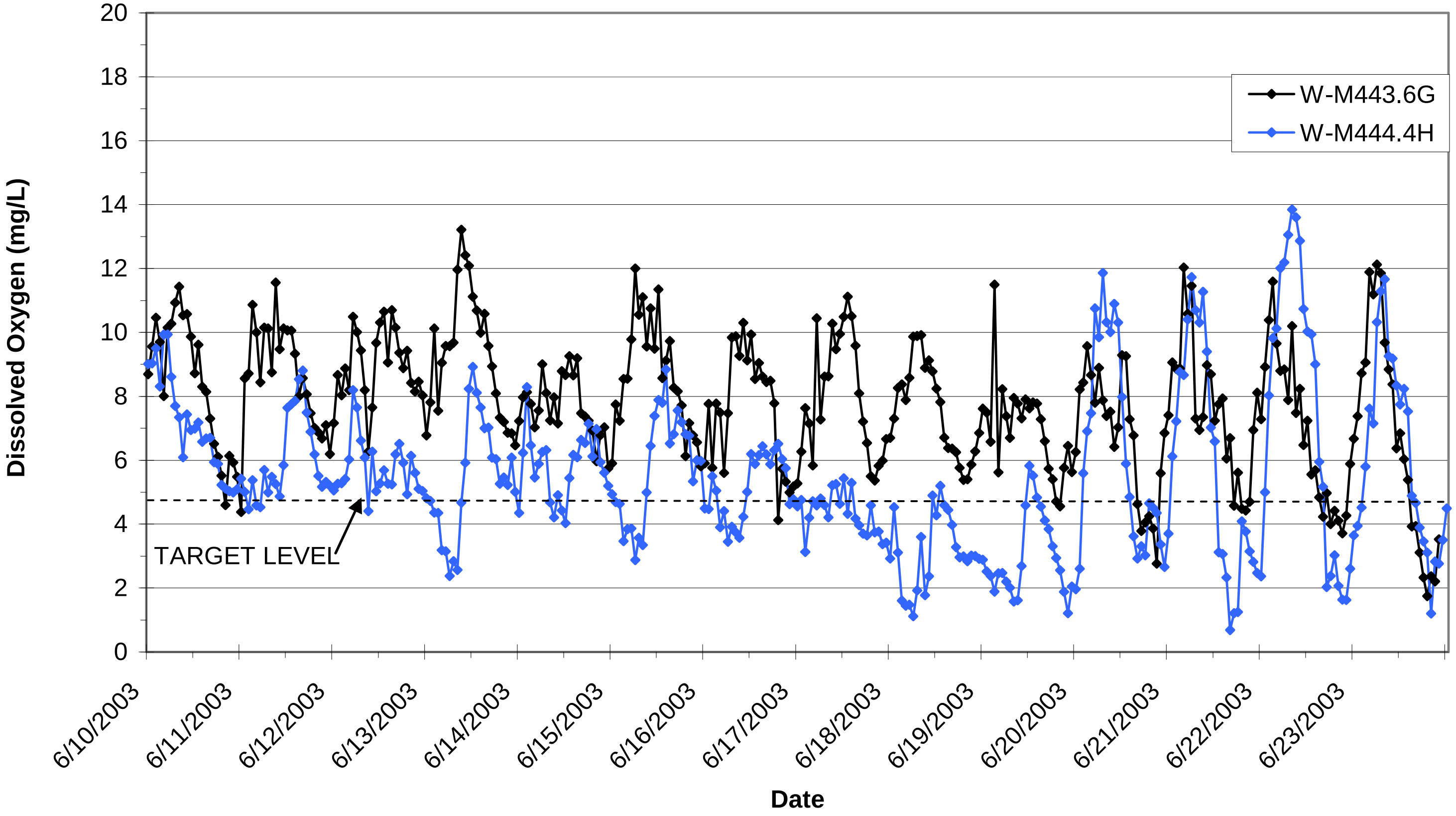


FIGURE E-5. POST-PROJECT DISSOLVED OXYGEN CONCENTRATIONS COLLECTED WITH A CONTINUOUS MONITOR NEAR THE SURFACE AT SITES W-M443.6G AND W-M444.4H

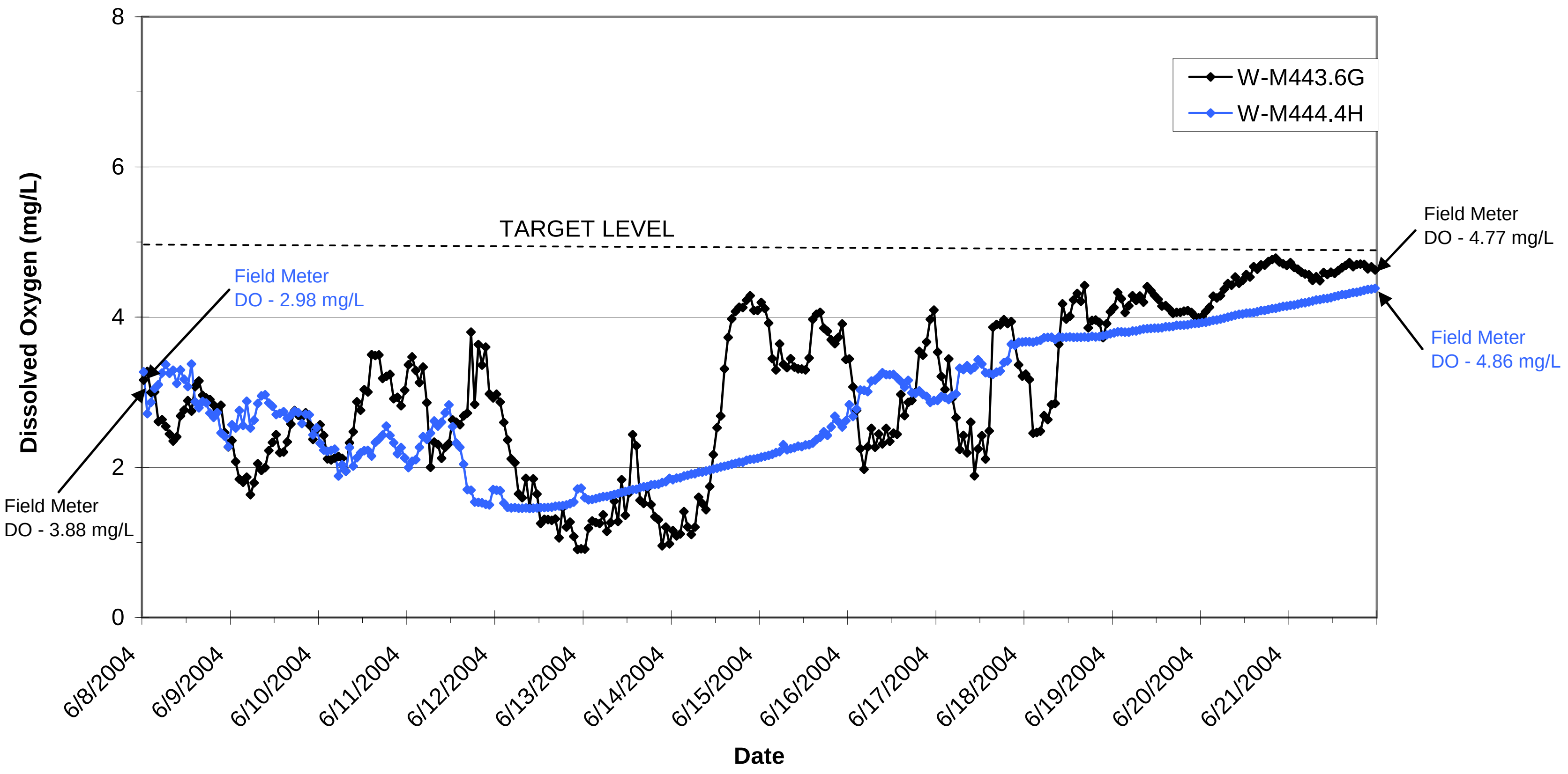
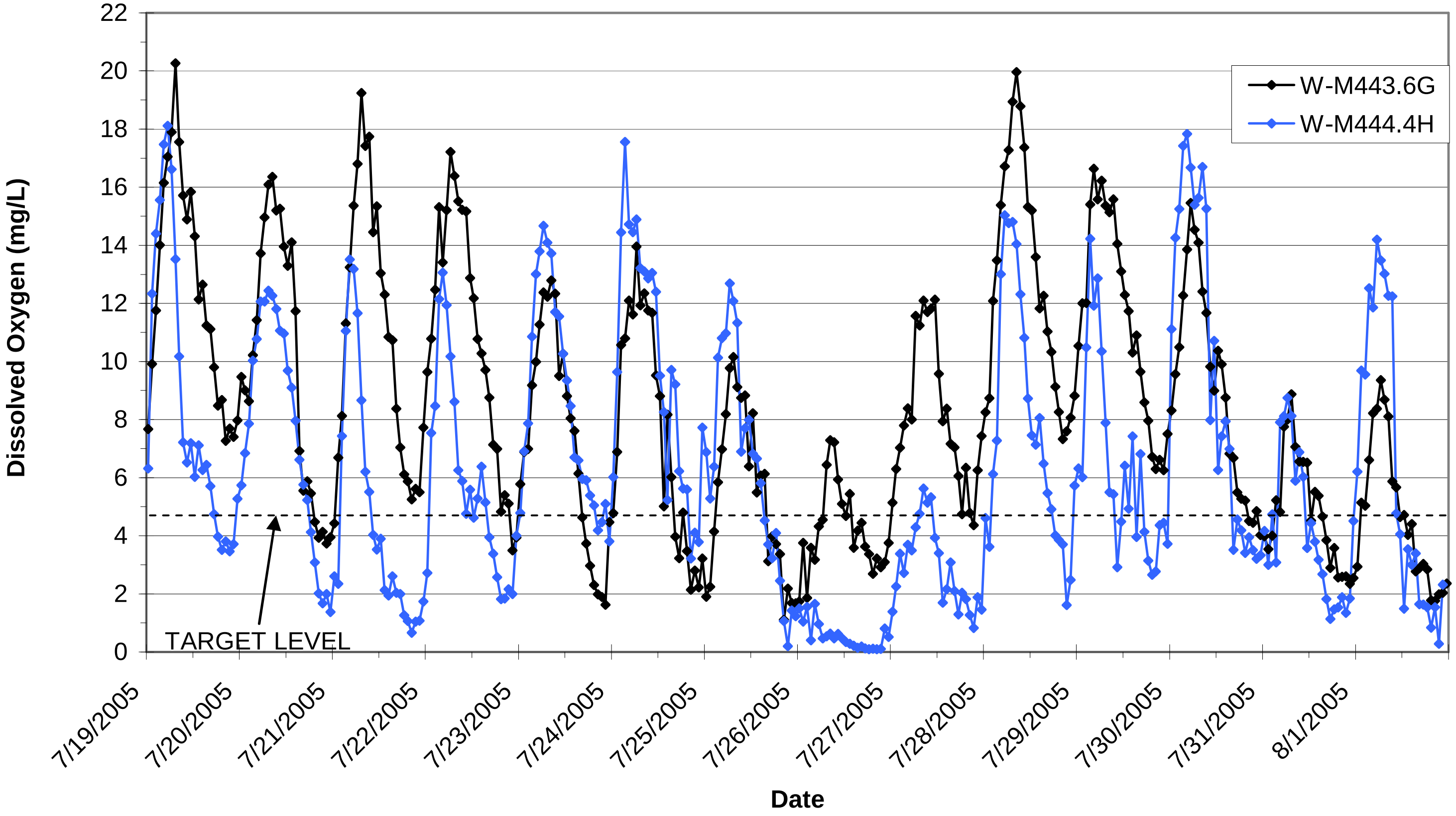


FIGURE E-6. POST-PROJECT DISSOLVED OXYGEN CONCENTRATIONS COLLECTED WITH A CONTINUOUS MONITOR NEAR THE SURFACE AT SITES W-M443.6G AND W-M444.4H



APPENDIX F

TECHNICAL COMPUTATIONS

FIGURE F-1. AVERAGE ANNUAL WATER DEPTH AND SEDIMENT ACCUMULATION AT SITES W-M443.6G AND W-M444.4H FROM 1991 THROUGH 2005*

YEAR	W-M443.6G WATER DEPTH (FT)	W-M443.6G SEDIMENT ACCUMULATION (IN)	W-M444.4H WATER DEPTH (FT)	W-M444.4H SEDIMENT ACCUMULATION (IN)
1991	8.79		-	
		7.08		-
1992	8.20		-	
		4.80		-
1993	7.80		-	
		8.52		-
1994	7.09		-	
		5.64		-
1995	6.62		-	
		12.96		-
1996	5.54		5.30	
		-2.04		-3.72
1997	5.71		5.61	
		3.24		1.20
1998	5.44		5.51	
		5.40		2.16
1999	4.99		5.33	
		0.24		1.32
2000	4.97		5.22	
		0.60		-1.56
2001	4.92		5.35	
		6.72		4.32
2002	4.36		4.99	
		-4.68		-0.84
2003	4.75		5.06	
		5.04		1.08
2004	4.33		4.97	
		2.16		5.76
2005	4.15		4.49	
		Average = 3.98 in/yr		**Average = 1.08 in/yr**

* Water depth is the average value, adjusted to flat pool, for all visits to a sampling site during a given year.
*Sediment accumulation was calculated by subtracting average annual water depths from successive years and converting to inches.

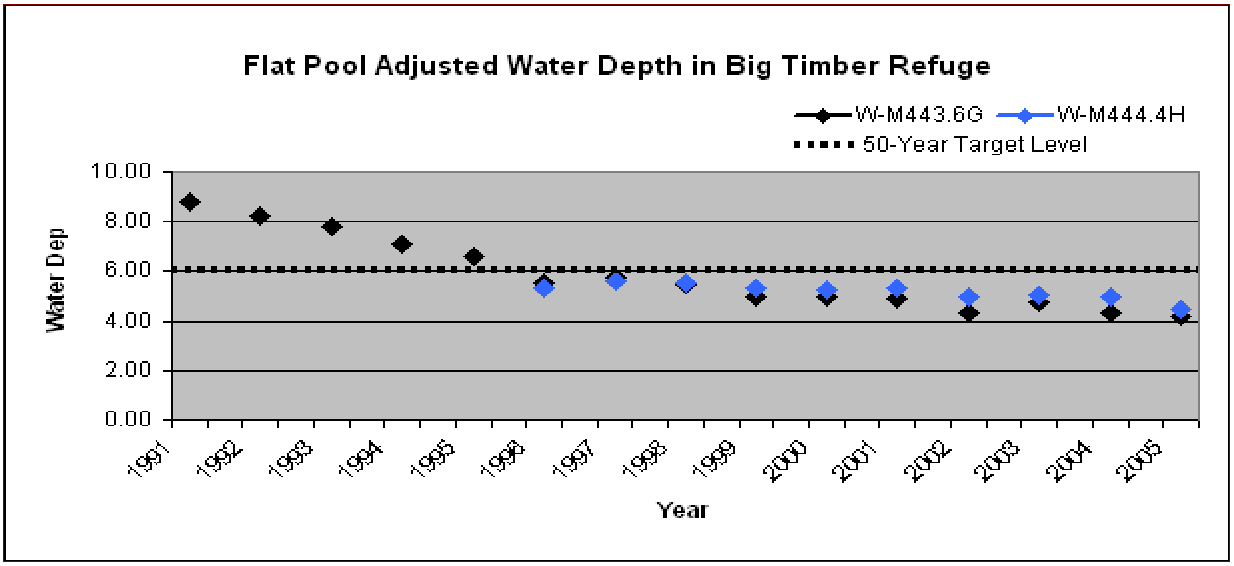


TABLE F-1
Summary of Channel Depths at Station W-M443.6G

Date	MUS14 453.0 Pool Elevation (feet) 1/	MUS14 453.0 Gage Reading (feet)	W-M 443.6G Flat Pool Depth (feet) 4/	W-M 443.6G Channel Depth (feet)	W-M 443.6G Pool Elevation (feet)	W-M 443.6G Bottom Elevation (feet) 3/	MI17 437.1 Pool Elevation (feet) 2/	MI17 437.1 Gage Reading (feet)
05/06/89	537.92	7.18	1.06	1.64	536.58	534.94	535.66	9.09
05/20/89	537.59	6.85	2.18	2.69	536.51	533.82	535.76	9.19
06/03/89	539.01	8.27	0.86	2.26	537.40	535.14	536.29	9.72
06/17/89	536.45	5.71	1.65	1.67	536.02	534.35	535.73	9.16
07/01/89	537.03	6.29	1.47	2.03	536.56	534.53	536.24	9.67
07/15/89	536.43	5.69	1.86	2.03	536.17	534.14	535.99	9.42
07/29/89	536.26	5.52	1.51	1.51	536.00	534.49	535.82	9.25
08/12/89	535.99	5.25	2.12	1.94	535.81	533.88	535.69	9.12
08/26/89	536.38	5.64	1.53	1.61	536.07	534.47	535.86	9.29
09/09/89	537.52	6.78	2.06	2.85	536.79	533.94	536.29	9.72
09/23/89	536.79	6.05	1.79	2.26	536.47	534.21	536.25	9.68
10/14/89	536.15	5.41	1.64	1.51	535.87	534.36	535.68	9.11
10/28/89	536.44	5.70	1.79	2.00	536.22	534.21	536.06	9.49
04/14/90	537.84	7.10	1.10	1.97	536.87	534.90	536.20	9.63
05/08/90	539.00	8.26	1.03	1.97	536.94	534.97	535.51	8.94
05/26/90	541.29	10.55	0.86	3.94	539.08	535.14	537.55	10.98
06/09/90	538.66	7.92	1.26	2.26	537.00	534.74	535.85	9.28
07/20/90	537.40	6.66	1.11	1.51	536.40	534.89	535.71	9.14
08/04/90	538.89	8.15	0.71	2.00	537.29	535.29	536.19	9.62
08/18/90	537.71	6.97	1.29	2.20	536.91	534.71	536.36	9.79
Dredging Construction Substantially Complete								
09/24/91	539.23	8.49	8.68	10.00	537.31	527.32	535.99	9.42
10/10/91	537.37	6.63	8.73	9.10	536.37	527.27	535.68	9.11
10/22/91	537.08	6.34	8.37	8.80	536.42	527.63	535.97	9.40
11/05/91	537.75	7.01	9.29	10.10	536.81	526.71	536.16	9.59
11/26/91	541.90	11.16	8.59	12.00	539.41	527.41	537.68	11.11
12/13/91	541.53	10.79	9.08	12.15	539.06	526.92	537.36	10.79
02/03/92	537.95	7.21	8.29	8.80	536.51	527.71	535.51	8.94
04/07/92	541.80	11.06	8.38	11.55	539.16	527.62	537.34	10.77
05/12/92	541.25	10.51	7.31	10.00	538.68	528.69	536.91	10.34
06/04/92	537.72	6.98	8.46	9.00	536.54	527.54	535.72	9.15
06/16/92	537.36	6.62	7.92	8.50	536.58	528.08	536.04	9.47
07/10/92	538.41	7.67	8.18	9.08	536.90	527.82	535.86	9.29
07/22/92	540.01	9.27	8.70	10.50	537.79	527.30	536.26	9.69
07/27/92	539.16	8.42	8.55	9.60	537.04	527.45	535.58	9.01
08/12/92	537.66	6.92	8.48	9.25	536.77	527.52	536.15	9.58
08/25/92	536.42	5.68	8.55	8.50	535.95	527.45	535.62	9.05
08/31/92	536.49	5.75	6.13	6.10	535.97	529.87	535.61	9.04
09/15/92	537.77	7.03	8.81	9.50	536.69	527.19	535.94	9.37

Date	**MUS14 453.0 Pool Elevation (feet) 1/**	**MUS14 453.0 Gage Reading (feet)**	**W-M 443.6G Flat Pool Depth (feet) 4/**	**W-M 443.6G Channel Depth (feet)**	**W-M 443.6G Pool Elevation (feet)**	**W-M 443.6G Bottom Elevation (feet) 3/**	**MI17 437.1 Pool Elevation (feet) 2/**	**MI17 437.1 Gage Reading (feet)**
09/28/92	540.48	9.74	8.47	10.59	538.12	527.53	536.49	9.92
10/13/92	538.15	7.41	8.45	9.40	536.95	527.55	536.12	9.55
11/24/92	542.18	11.44	8.36	12.55	540.19	527.64	538.81	12.24
01/25/93	540.54	9.80	8.11	10.90	538.79	527.89	537.58	11.01
11/10/93	538.27	7.53	7.50	8.30	536.80	528.50	535.78	9.21
01/10/94	539.04	8.30	7.88	9.00	537.12	528.12	535.79	9.22
02/24/94	543.46	12.72	7.36	12.40	541.04	528.64	539.36	12.79
03/09/94	542.23	11.49	7.82	11.75	539.92	528.18	538.33	11.76
04/19/94	540.20	9.46	7.40	9.00	537.60	528.60	535.80	9.23
05/10/94	545.33	14.59	6.20	12.70	542.49	529.80	540.53	13.96
05/24/94	540.32	9.58	7.20	9.05	537.84	528.80	536.13	9.56
06/14/94	538.37	7.63	7.31	8.35	537.03	528.69	536.11	9.54
07/07/94	539.52	8.78	7.07	8.55	537.48	528.93	536.07	9.50
07/19/94	539.84	9.10	6.48	8.00	537.52	529.52	535.92	9.35
08/09/94	537.58	6.84	7.01	7.50	536.49	528.99	535.73	9.16
08/30/94	537.68	6.94	7.03	7.70	536.66	528.97	535.96	9.39
09/13/94	536.91	6.17	6.86	7.00	536.14	529.14	535.61	9.04
10/04/94	539.63	8.89	6.81	8.30	537.48	529.19	536.00	9.43
10/25/94	538.58	7.84	6.83	7.80	536.97	529.17	535.86	9.29
12/06/94	538.35	7.61	7.12	8.00	536.88	528.88	535.86	9.29
02/14/95	537.14	6.40	8.18	8.42	536.24	527.82	535.61	9.04
03/14/95	538.58	7.84	5.87	7.15	537.27	530.13	536.37	9.80
04/11/95	542.94	12.20	5.66	10.00	540.33	530.34	538.53	11.96
06/13/95	540.85	10.11	7.05	9.70	538.64	528.95	537.12	10.55
06/27/95	538.66	7.92	7.06	8.15	537.09	528.94	536.00	9.43
07/11/95	538.17	7.43	5.71	6.40	536.69	530.29	535.66	9.09
07/25/95	538.49	7.75	6.74	7.80	537.05	529.26	536.06	9.49
08/29/95	540.20	9.46	6.46	8.20	537.73	529.54	536.03	9.46
09/12/95	538.57	7.83	6.57	7.50	536.93	529.43	535.80	9.23
09/27/95	537.77	7.03	6.15	6.90	536.75	529.85	536.04	9.47
10/10/95	539.26	8.52	7.08	8.80	537.72	528.92	536.65	10.08
10/24/95	538.55	7.81	6.68	7.65	536.97	529.32	535.88	9.31
11/07/95	541.13	10.39	6.78	9.25	538.47	529.22	536.63	10.06
06/19/96	542.39	11.65	5.17	9.00	539.83	530.83	538.06	11.49
07/10/96	541.25	10.51	6.72	9.35	538.63	529.28	536.82	10.25
08/13/96	537.99	7.25	6.49	7.10	536.61	529.51	535.66	9.09
09/19/96	536.99	6.25	5.91	6.30	536.39	530.09	535.97	9.40
12/23/96	538.17	7.43	6.20	7.15	536.95	529.80	536.10	9.53
01/07/97	538.13	7.39	6.15	6.90	536.75	529.85	535.80	9.23
02/11/97	538.22	7.48	6.03	6.80	536.77	529.97	535.76	9.19
02/25/97	545.47	14.73	5.73	13.10	543.37	530.27	541.92	15.35

Date	MUS14 453.0 Pool Elevation (feet) 1/	MUS14 453.0 Gage Reading (feet)		W-M 443.6G Flat Pool Depth (feet) 4/	W-M 443.6G Channel Depth (feet)	W-M 443.6G Pool Elevation (feet)	W-M 443.6G Bottom Elevation (feet) 3/		MI17 437.1 Pool Elevation (feet) 2/	MI17 437.1 Gage Reading (feet)
06/18/97	538.89	8.15		6.01	7.40	537.39	529.99		536.35	9.78
07/02/97	539.08	8.34		5.37	6.70	537.33	530.63		536.12	9.55
07/17/97	539.74	9.00		5.43	6.90	537.46	530.57		535.89	9.32
07/31/97	540.20	9.46		5.77	7.50	537.73	530.23		536.02	9.45
08/19/97	538.70	7.96		5.64	6.80	537.16	530.36		536.10	9.53
09/03/97	538.41	7.67		5.79	6.70	536.91	530.21		535.87	9.30
09/25/97	538.69	7.95		5.31	6.50	537.19	530.69		536.15	9.58
12/23/97	537.40	6.66		5.63	6.10	536.47	530.37		535.82	9.25
01/27/98	537.87	7.13		4.87	5.50	536.63	531.13		535.77	9.20
02/24/98	539.17	8.43		5.39	6.80	537.41	530.61		536.19	9.62
03/24/98	539.73	8.99		6.31	7.90	537.58	529.69		536.10	9.53
06/03/98	538.61	7.87		5.71	6.70	536.98	530.29		535.86	9.29
07/02/98	544.58	13.84		4.77	11.30	542.52	531.23		541.10	14.53
07/14/98	543.29	12.55		5.17	10.20	541.03	530.83		539.47	12.90
07/28/98	538.18	7.44		5.52	6.45	536.93	530.48		536.06	9.49
08/13/98	538.37	7.63		5.23	6.30	537.06	530.77		536.16	9.59
08/25/98	537.75	7.01		5.38	6.00	536.61	530.62		535.83	9.26
09/10/98	536.99	6.25		5.49	5.75	536.26	530.51		535.76	9.19
09/29/98	536.96	6.22		5.80	6.15	536.35	530.20		535.93	9.36
12/29/98	537.01	6.27		5.59	6.00	536.41	530.41		535.99	9.42
01/28/99	538.70	7.96		4.98	6.00	537.02	531.02		535.86	9.29
02/25/99	538.16	7.42		5.32	6.00	536.68	530.68		535.66	9.09
03/23/99	539.53	8.79		4.97	6.50	537.53	531.03		536.15	9.58
05/27/99	547.59	16.85		5.64	14.90	545.26	530.36		543.65	17.08
06/22/99	541.80	11.06		5.24	8.80	539.55	530.76		538.00	11.43
07/08/99	540.02	9.28		4.05	6.00	537.94	531.95		536.51	9.94
07/27/99	542.49	11.75		5.31	9.50	540.18	530.69		538.59	12.02
08/10/99	539.59	8.85		4.97	6.30	537.33	531.03		535.76	9.19
08/24/99	538.91	8.17		4.43	5.80	537.37	531.57		536.31	9.74
09/08/99	537.96	7.22		4.84	5.50	536.66	531.16		535.76	9.19
09/21/99	537.86	7.12		5.16	5.94	536.77	530.84		536.02	9.45
02/08/00	537.43	6.69		3.73	4.26	536.53	532.27		535.91	9.34
03/07/00	540.58	9.84		5.05	6.89	537.84	530.95		535.95	9.38
05/31/00	539.40	8.66		4.92	6.46	537.54	531.08		536.25	9.68
06/15/00	546.79	16.05		5.39	13.51	544.12	530.61		542.28	15.71
07/06/00	542.58	11.84		5.11	9.42	540.31	530.89		538.74	12.17
07/25/00	539.19	8.45		4.84	6.01	537.16	531.16		535.76	9.19
08/08/00	537.84	7.10		5.10	5.87	536.78	530.90		536.04	9.47
08/22/00	538.02	7.28		5.45	6.45	537.00	530.55		536.29	9.72
09/19/00	537.85	7.11		5.15	5.77	536.62	530.85		535.77	9.20
01/03/01	537.61	6.87		5.01	5.58	536.57	530.99		535.85	9.28

Date	MUS14 453.0 Pool Elevatio n (feet) 1/	MUS14 453.0 Gage Reading (feet)	W-M 443.6G Flat Pool Depth (feet) 4/	W-M 443.6G Channel Depth (feet)	W-M 443.6G Pool Elevatio n (feet)	W-M 443.6G Bottom Elevatio n (feet) 3/	MI17 437.1 Pool Elevation (feet) 2/	MI17 437.1 Gage Reading (feet)
02/13/01	538.99	8.25	5.15	6.49	537.35	530.85	536.21	9.64
03/06/01	538.10	7.36	5.12	5.85	536.73	530.88	535.79	9.22
03/20/01	539.13	8.39	5.18	6.46	537.29	530.82	536.01	9.44
06/05/01	544.80	14.06	4.57	11.05	542.49	531.43	540.89	14.32
06/19/01	542.75	12.01	5.17	9.71	540.54	530.83	539.01	12.44
07/03/01	544.63	13.89	3.90	9.97	542.08	532.10	540.31	13.74
07/18/01	537.49	6.75	4.79	5.31	536.53	531.21	535.86	9.29
07/31/01	537.82	7.08	5.14	5.90	536.76	530.86	536.03	9.46
08/14/01	536.55	5.81	5.08	5.08	536.00	530.92	535.62	9.05
08/28/01	537.02	6.28	4.96	5.22	536.25	531.04	535.72	9.15
09/18/01	537.06	6.32	5.02	5.38	536.36	530.98	535.87	9.30
01/08/02	537.64	6.90	5.01	5.63	536.62	530.99	535.91	9.34
02/28/02	538.43	7.69	5.04	6.07	537.03	530.96	536.06	9.49
06/18/02	541.78	11.04	4.24	7.71	539.47	531.76	537.87	11.30
07/02/02	541.81	11.07	4.61	7.84	539.23	531.39	537.45	10.88
07/18/02	538.92	8.18	4.25	5.25	537.00	531.75	535.67	9.10
08/01/02	538.55	7.81	4.08	5.09	537.01	531.92	535.94	9.37
08/14/02	538.66	7.92	4.52	5.64	537.12	531.48	536.06	9.49
08/29/02	539.98	9.24	3.29	4.86	537.56	532.71	535.89	9.32
09/10/02	538.68	7.94	3.86	4.92	537.07	532.14	535.95	9.38
09/24/02	537.49	6.75	4.53	4.92	536.39	531.47	535.63	9.06
12/17/02	537.54	6.80	4.49	4.99	536.50	531.51	535.78	9.21
2/13/03			4.48	4.79	536.31	531.52		
4/10/03			4.54	5.15	536.61	531.46		
6/10/03			4.55	5.32	536.76	531.45		
6/24/03			4.48	4.99	536.51	531.52		
7/8/03			7.23	8.89	537.66	528.77		
7/22/03			4.63	5.74	537.11	531.37		
8/5/03			4.26	4.30	536.04	531.74		
8/19/03			5.01	4.89	535.87	530.99		
9/2/03			4.58	4.33	535.75	531.42		
9/16/03			4.27	4.20	535.93	531.73		
12/23/03			4.25	4.66	536.41	531.75		
2/12/04			4.41	4.56	536.15	531.59		
3/23/04								
6/8/04			5.65	14.27	544.62	530.35		
6/22/04								
7/7/04			4.67	5.58	536.91	531.33		
7/20/04			3.62	4.66	537.03	532.38		
8/3/04			4.42	4.66	536.24	531.58		
8/17/04			4.59	4.72	536.13	531.41		

Date	MUS14 453.0 Pool Elevation (feet) 1/	MUS14 453.0 Gage Reading (feet)	W-M 443.6G Flat Pool Depth (feet) 4/	W-M 443.6G Channel Depth (feet)	W-M 443.6G Pool Elevation (feet)	W-M 443.6G Bottom Elevation (feet) 3/	MI17 437.1 Pool Elevation (feet) 2/	MI17 437.1 Gage Reading (feet)
8/31/04			4.31	4.76	536.45	531.69		
9/14/04			4.20	4.68	536.47	531.80		
1/4/05			4.05	4.69	536.64	531.95		
2/22/05			4.74	6.04	537.30	531.26		
3/22/05			4.71	5.40	537.70	531.29		
6/8/05			3.92	5.09	538.89	532.08		
6/21/05			3.26	4.53	539.50	532.74		
7/6/05			3.23	4.30	538.75	532.77		
7/19/05			4.15	4.36	536.88	531.85		
8/2/05			4.42	4.54	536.70	531.58		
8/17/05			4.26	4.33	536.40	531.74		
8/30/05			4.54	4.86	536.75	531.46		
9/13/05			4.47	4.59	536.56	531.53		
12/22/05			4.05	4.95	538.26	531.95		
89 MIN	535.99	5.25	0.86	1.51	535.81	534.30	535.66	9.09
89 MAX	539.01	8.27	2.18	2.85	537.40	534.55	536.29	9.72
89 AVG	536.92	6.18	1.66	2.00	536.35	534.34	535.95	9.38
90 MIN	537.40	6.66	0.71	1.51	536.40	534.89	535.51	8.94
90 MAX	541.29	10.55	1.29	3.94	539.08	535.14	537.55	10.98
90 AVG	538.68	7.94	1.05	2.26	537.21	534.95	536.20	9.63
91 MIN	537.08	6.34	8.37	8.80	536.37	527.57	535.68	9.11
91 MAX	541.90	11.16	9.29	12.15	539.41	527.26	537.68	11.11
91 AVG	539.14	8.40	8.79	10.36	537.56	527.21	536.47	9.90
92 MIN	536.42	5.68	6.13	6.10	535.95	529.85	535.51	8.94
92 MAX	542.18	11.44	8.81	12.55	540.19	527.64	538.81	12.24
92 AVG	538.85	8.11	8.20	9.53	537.32	527.80	536.26	9.69
93 MIN	538.27	7.53	7.50	8.30	536.80	528.50	535.78	9.21
93 MAX	540.54	9.80	8.11	10.90	538.79	527.89	537.58	11.01
93 AVG	539.41	8.67	7.80	9.60	537.79	528.20	536.68	10.11
94 MIN	536.91	6.17	6.20	7.00	536.14	529.14	535.61	9.04
94 MAX	545.33	14.59	7.88	12.70	542.49	529.80	540.53	13.96
94 AVG	539.80	9.06	7.09	9.00	537.91	528.91	536.60	10.03
95 MIN	537.14	6.40	5.66	6.40	536.24	529.84	535.61	9.04
95 MAX	542.94	12.20	8.18	10.00	540.33	530.34	538.53	11.96
95 AVG	539.25	8.51	6.62	8.15	537.53	529.38	536.34	9.77
96 MIN	536.99	6.25	5.17	6.30	536.39	530.09	535.66	9.09
96 MAX	542.39	11.65	6.72	9.35	539.83	530.48	538.06	11.49
96 AVG	539.36	8.62	6.10	7.78	537.68	529.90	536.52	9.95
97 MIN	537.40	6.66	5.31	6.10	536.47	530.37	535.76	9.19
97 MAX	545.47	14.73	6.15	13.10	543.37	530.27	541.92	15.35

Date	MUS14 453.0 Pool Elevation (feet) 1/	MUS14 453.0 Gage Reading (feet)	W-M 443.6G Flat Pool Depth (feet) 4/	W-M 443.6G Channel Depth (feet)	W-M 443.6G Pool Elevation (feet)	W-M 443.6G Bottom Elevation (feet) 3/	MI17 437.1 Pool Elevation (feet) 2/	MI17 437.1 Gage Reading (feet)
97 AVG	539.36	8.62	5.71	7.40	537.68	530.29	536.53	9.96
98 MIN	536.96	6.22	4.77	5.50	536.26	530.76	535.76	9.19
98 MAX	544.58	13.84	6.31	11.30	542.52	531.23	541.10	14.53
98 AVG	539.04	8.30	5.44	7.09	537.65	530.56	536.69	10.12
99 MIN	537.86	7.12	4.05	5.50	536.66	531.16	535.66	9.09
99 MAX	547.59	16.85	5.64	14.90	545.26	530.36	543.65	17.08
99 AVG	540.24	9.50	4.99	7.38	538.39	531.01	537.12	10.55
00 MIN	537.43	6.69	3.73	4.26	536.53	530.55	535.76	9.19
00 MAX	546.79	16.05	5.45	13.51	544.12	532.27	542.28	15.71
00 AVG	539.96	9.22	4.96	7.69	538.73	531.04	537.42	10.85
01 MIN	536.55	5.81	3.90	5.08	536.00	530.82	535.62	9.05
01 MAX	544.80	14.06	5.18	11.05	542.49	532.10	540.89	14.32
01 AVG	539.33	8.59	4.92	6.83	537.91	531.08	536.93	10.36
02 MIN	537.49	6.75	3.29	4.86	536.39	530.96	535.63	9.06
02 MAX	541.81	11.07	5.04	7.84	539.47	532.71	537.87	11.30
02 AVG	539.04	8.30	4.36	5.72	537.36	531.64	536.20	9.63
03 MIN			4.25	4.20	535.75	528.77		
03 MAX			7.23	8.89	537.66	531.75		
03 AVG			4.75	5.21	536.45	531.25		
04 MIN			3.62	4.56	536.13	530.35		
04 MAX			5.65	14.27	544.62	532.38		
04 AVG			4.48	5.99	537.50	531.52		
05 MIN			3.23	4.30	536.40	531.26		
05 MAX			4.74	6.04	539.50	532.77		
05 AVG			4.15	4.81	537.53	531.85		
89-05 MIN	535.99	5.25	0.71	1.51	535.75	526.71	535.51	8.94
89-05 MAX	547.59	16.85	9.29	14.90	545.26	535.29	543.65	17.08
89-05 AVG	539.13	8.39	5.29	6.74	537.51	530.71	536.52	9.95

[1/] MUS14 453.0 Pool Elevation = MUS14 453.0 Gage Reading + Gage Zero
where Gage Zero = 530.74 feet MSL

[2/] MI17 437.1 Pool Elevation = MI17 437.1 Gage Reading + Gage Zero
where Gage Zero = 526.57 feet MSL (1912)

[3/] W-M443.6G Bottom Elevation = W-M443.6G Pool Elevation - W-M443.6G Channel Depth

[4/] W-M443.6G Flat Pool Depth = Flat Pool - W-M443.6G Bottom Elevation
where Flat Pool = 536 feet MSL

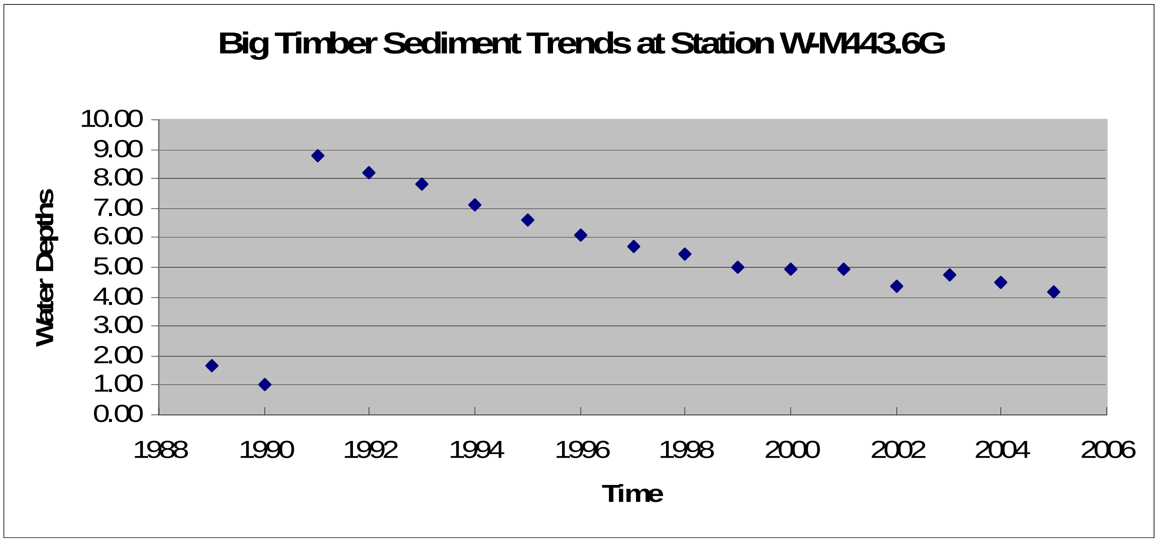


Figure F-2. Sedimentation Rates at Station W-M443.6G

TABLE F-2
Summary of Channel Depths at Station W-M444.4H

Date	MUS14 453.0 Pool Elevation (feet) 1/	MUS14 453.0 Gage Reading (feet)		W-M 444.4H Flat Pool Depth (feet) 4/	W-M 444.4H Channel Depth (feet)	W-M 444.4H Pool Elevation (feet)	W-M 444.4H Bottom Elevation (feet) 3/		MI17 437.1 Pool Elevation (feet) 2/	MI17 437.1 Gage Reading (feet)
07/10/96	541.25	10.51		5.74	8.60	538.85	530.26		536.82	10.25
08/13/96	537.99	7.25		6.27	7.00	536.73	529.73		535.66	9.09
12/23/96	538.17	7.43		6.10	7.15	537.05	529.90		536.10	9.53
01/07/97	538.13	7.39		5.98	6.85	536.87	530.02		535.80	9.23
02/11/97	538.22	7.48		6.11	7.00	536.89	529.89		535.76	9.19
02/25/97	545.47	14.73		5.40	12.95	543.55	530.60		541.92	15.35
06/18/97	538.89	8.15		5.48	7.00	537.52	530.52		536.35	9.78
07/02/97	539.08	8.34		5.52	7.00	537.48	530.48		536.12	9.55
07/17/97	539.74	9.00		5.34	7.00	537.66	530.66		535.89	9.32
07/31/97	540.20	9.46		5.66	7.60	537.94	530.34		536.02	9.45
08/19/97	538.70	7.96		5.60	6.90	537.29	530.40		536.10	9.53
09/03/97	538.41	7.67		5.66	6.70	537.04	530.34		535.87	9.30
09/25/97	538.69	7.95		5.48	6.80	537.32	530.52		536.15	9.58
12/23/97	537.40	6.66		5.45	6.00	536.55	530.55		535.82	9.25
01/27/98	537.87	7.13		5.46	6.20	536.73	530.54		535.77	9.20
02/24/98	539.17	8.43		5.44	7.00	537.56	530.56		536.19	9.62
03/24/98	539.73	8.99		5.48	7.25	537.77	530.52		536.10	9.53
06/03/98	538.61	7.87		5.38	6.50	537.12	530.62		535.86	9.29
07/02/98	544.58	13.84		5.55	12.25	542.70	530.45		541.10	14.53
07/14/98	543.29	12.55		5.22	10.45	541.22	530.78		539.47	12.90
07/28/98	538.18	7.44		5.47	6.50	537.03	530.53		536.06	9.49
08/13/98	538.37	7.63		5.42	6.60	537.17	530.58		536.16	9.59
08/25/98	537.75	7.01		5.59	6.30	536.71	530.41		535.83	9.26
09/10/98	536.99	6.25		5.52	5.85	536.32	530.48		535.76	9.19
09/29/98	536.96	6.22		5.75	6.15	536.40	530.25		535.93	9.36
12/29/98	537.01	6.27		5.89	6.35	536.46	530.11		535.99	9.42
01/28/99	538.70	7.96		5.53	6.70	537.16	530.47		535.86	9.29
02/25/99	538.16	7.42		5.44	6.25	536.81	530.56		535.66	9.09
03/23/99	539.53	8.79		5.30	7.00	537.70	530.70		536.15	9.58
05/27/99	547.59	16.85		5.34	14.80	545.46	530.66		543.65	17.08
06/22/99	541.80	11.06		5.25	9.00	539.74	530.75		538.00	11.43
07/08/99	540.02	9.28		4.88	7.00	538.12	531.12		536.51	9.94
07/27/99	542.49	11.75		5.52	9.90	540.38	530.48		538.59	12.02
08/10/99	539.59	8.85		5.28	6.80	537.52	530.72		535.76	9.19
08/24/99	538.91	8.17		5.29	6.80	537.50	530.71		536.31	9.74
09/08/99	537.96	7.22		5.13	5.90	536.77	530.87		535.76	9.19
09/21/99	537.86	7.12		5.63	6.49	536.86	530.37		536.02	9.45
02/08/00	537.43	6.69		5.49	6.10	536.61	530.51		535.91	9.34
03/07/00	540.58	9.84		4.98	7.05	538.08	531.02		535.95	9.38
05/31/00	539.40	8.66		5.03	6.72	537.70	530.97		536.25	9.68
06/15/00	546.79	16.05		5.49	13.84	544.35	530.51		542.28	15.71
07/06/00	542.58	11.84		5.40	9.91	540.50	530.60		538.74	12.17
07/25/00	539.19	8.45		4.93	6.27	537.33	531.07		535.76	9.19
08/08/00	537.84	7.10		4.97	5.84	536.87	531.03		536.04	9.47
08/22/00	538.02	7.28		5.51	6.59	537.08	530.49		536.29	9.72

09/19/00	537.85	7.11		5.18	5.90	536.72	530.82		535.77	9.20
01/03/01	537.61	6.87		5.38	6.04	536.66	530.62		535.85	9.28
02/13/01	538.99	8.25		5.40	6.89	537.49	530.60		536.21	9.64
03/06/01	538.10	7.36		5.35	6.20	536.85	530.65		535.79	9.22
03/20/01	539.13	8.39		5.25	6.69	537.44	530.75		536.01	9.44
06/05/01	544.80	14.06		5.61	12.30	542.69	530.39		540.89	14.32
06/19/01	542.75	12.01		5.28	10.00	540.73	530.72		539.01	12.44
07/03/01	544.63	13.89		5.22	11.51	542.29	530.78		540.31	13.74
07/18/01	537.49	6.75		5.46	6.07	536.61	530.54		535.86	9.29
07/31/01	537.82	7.08		5.28	6.13	536.85	530.72		536.03	9.46
08/14/01	536.55	5.81		5.50	5.54	536.05	530.50		535.62	9.05
08/28/01	537.02	6.28		5.16	5.48	536.32	530.84		535.72	9.15
09/18/01	537.06	6.32		5.36	5.77	536.42	530.64		535.87	9.30
01/08/02	537.64	6.90		5.37	6.07	536.70	530.63		535.91	9.34
02/28/02	538.43	7.69		5.18	6.33	537.15	530.82		536.06	9.49
06/18/02	541.78	11.04		5.16	8.83	539.67	530.84		537.87	11.30
07/02/02	541.81	11.07		5.08	8.53	539.45	530.92		537.45	10.88
07/18/02	538.92	8.18		4.91	6.07	537.16	531.09		535.67	9.10
08/01/02	538.55	7.81		4.93	6.07	537.14	531.07		535.94	9.37
08/14/02	538.66	7.92		5.24	6.50	537.25	530.76		536.06	9.49
08/29/02	539.98	9.24		4.76	6.53	537.77	531.24		535.89	9.32
09/10/02	538.68	7.94		4.54	5.74	537.20	531.46		535.95	9.38
09/24/02	537.49	6.75		4.93	5.41	536.48	531.07		535.63	9.06
12/17/2002	537.54	6.80		4.83	5.41	536.59	531.17		535.78	9.21
2/13/2003				5.21	5.58	536.37	530.79			
4/10/2003				5.33	6.04	536.71	530.67			
6/10/2003				4.95	5.84	536.89	531.05			
6/24/2003				5.04	5.64	536.61	530.96			
7/8/2003				5.10	6.96	537.85	530.90			
7/22/2003				5.15	6.40	537.25	530.85			
8/5/2003				4.94	5.02	536.08	531.06			
8/19/2003				5.49	5.38	535.89	530.51			
9/2/2003				4.87	4.63	535.76	531.13			
9/16/2003				4.85	4.82	535.97	531.15			
12/23/2003				4.74	5.18	536.45	531.26			
2/12/2004				5.22	5.41	536.20	530.78			
3/23/2004										
6/8/2004				6.82	15.62	544.80	529.18			
6/22/2004										
7/7/2004				4.68	5.74	537.06	531.32			
7/20/2004				3.95	5.15	537.20	532.05			
8/3/2004				5.38	5.68	536.30	530.62			
8/17/2004				4.57	4.76	536.19	531.43			
8/31/2004				5.23	5.74	536.51	530.77			
9/14/2004				5.12	5.64	536.52	530.88			
1/4/2005				4.82	5.54	536.73	531.18			
2/22/2005				4.49	5.97	537.48	531.51			
3/22/2005				5.27	6.04	536.77	530.73			
6/8/2005				4.33	5.64	537.32	531.67			
6/21/2005				3.46	4.92	537.46	532.54			
7/6/2005				3.67	4.89	537.21	532.33			
7/19/2005				4.52	4.79	536.27	531.48			
8/2/2005				4.93	5.10	536.17	531.07			
8/17/2005				4.92	5.02	536.10	531.08			

8/30/2005				4.70	5.05	536.36	531.30			
9/13/2005				4.27	4.43	536.16	531.73			
12/22/2005				4.56	5.58	537.02	531.44			
96 MIN	537.99	7.25		5.74	7.00	536.73	529.73		535.66	9.09
96 MAX	541.25	10.51		6.27	8.60	538.85	530.26		536.82	10.25
96 AVG	539.14	8.40		6.04	7.58	537.54	529.96		536.19	9.62
97 MIN	537.40	6.66		5.34	6.00	536.55	529.89		535.76	9.19
97 MAX	545.47	14.73		6.11	12.95	543.55	530.66		541.92	15.35
97 AVG	539.36	8.62		5.61	7.43	537.83	530.39		536.53	9.96
98 MIN	536.96	6.22		5.22	5.85	536.32	530.11		535.76	9.19
98 MAX	544.58	13.84		5.89	12.25	542.70	530.78		541.10	14.53
98 AVG	539.04	8.30		5.51	7.28	537.77	530.49		536.69	10.12
99 MIN	537.86	7.12		4.88	5.90	536.77	530.37		535.66	9.09
99 MAX	547.59	16.85		5.63	14.80	545.46	531.12		543.65	17.08
99 AVG	540.24	9.50		5.33	7.87	538.55	530.67		537.12	10.55
00 MIN	537.43	6.69		4.93	5.84	536.61	530.49		535.76	9.19
00 MAX	546.79	16.05		5.51	13.84	544.35	531.07		542.28	15.71
00 AVG	539.96	9.22		5.22	7.58	538.36	530.78		537.00	10.43
01 MIN	536.55	5.81		5.16	5.48	536.05	530.39		535.62	9.05
01 MAX	544.80	14.06		5.61	12.30	542.69	530.84		540.89	14.32
01 AVG	539.33	8.59		5.35	7.39	538.03	530.65		536.93	10.36
02 MIN	537.49	6.75		4.54	5.41	536.48	530.63		535.63	9.06
02 MAX	541.81	11.07		5.37	8.83	539.67	531.46		537.87	11.30
02 AVG	539.04	8.30		4.99	6.50	537.51	531.01		536.20	9.63
03 MIN				4.74	4.63	535.76	530.51			
03 MAX				5.49	6.96	537.85	531.26			
03 AVG				5.06	5.58	536.50	530.93			
04 MIN				3.95	4.76	536.19	529.18			
04 MAX				6.82	15.62	544.80	532.05			
04 AVG				5.09	6.73	537.66	530.93			
05 MIN				3.46	4.43	536.10	530.73			
05 MAX				5.27	6.04	537.48	532.54			
05 AVG				4.47	5.22	536.76	531.53			
95-02 MIN	536.55	5.81		3.46	4.43	535.76	529.18		535.62	9.05
95-02 MAX	547.59	16.85		6.82	15.62	545.46	532.54		543.65	17.08
95-02 AVG	539.46	8.72		5.21	6.85	537.64	530.79		536.71	10.14

[1/] MUS14 453.0 Pool Elevation = MUS14 453.0 Gage Reading + Gage Zero
where Gage Zero = 530.74 feet MSL

[2/] MI17 437.1 Pool Elevation = MI17 437.1 Gage Reading + Gage Zero
where Gage Zero = 526.57 feet MSL

[3/] W-M444.4H Bottom Elevation = W-M444.4H Pool Elevation - W-M444.4H Channel Depth

[4/] W-M444.4H Flat Pool Depth = Flat Pool - W-M444.4H Bottom Elevation
where Flat Pool = 536 feet MSL

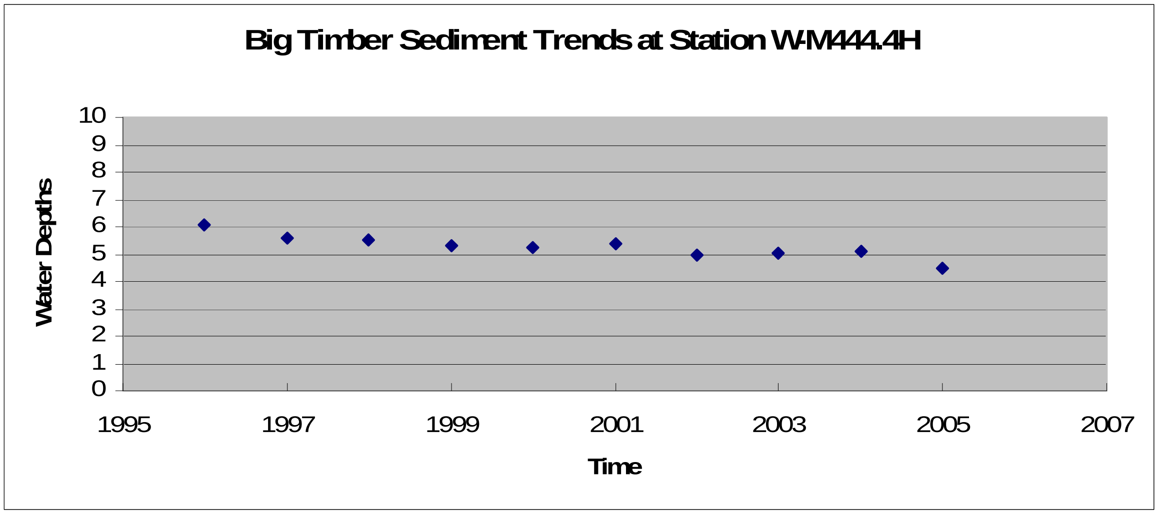


Figure F-3. Sedimentation Rates at Station W-M444.4H

TABLE F-3. Enhance Aquatic Habitat

		Provide Year-Round Habitat Access (Cross-Sectional Area)								Restore Deep Aquatic Habitat (≥ 6 Feet)				Restore Shallow Aquatic Habitat (2 to 3 Feet)			
	Length Feet	Deep Aquatic Habitat Square Feet [4/]				Shallow Aquatic Habitat Square Feet				Deep Aquatic Habitat Volume, Acre-Feet				Shallow Aquatic Habitat Volume, Acre-Feet			
Sedimentation Transects	Year 0 1991	Year 0 1991	Year 3 1994	Year 6 1997	Year 11 2002	Year 0 1991	Year 3 1994	Year 6 1997	Year 11 2002	Year 0 1991	Year 3 1994	Year 6 1997	Year 11 2002	Year 0 1991	Year 3 1994	Year 6 1997	Year 11 2002
Dredge Cut Begin		914	849	608	337	304	311	251	314								
Round Pond	184									3.9	3.6	2.6					
(A)		914	849	608													
	431									8.2	9.1	7.8					
(B)		748	995	962													
Timber Chute	427									6.1	6.3	6.0					
(C) [1/]		493	284	269													
	334									3.8	2.8	2.7					
(D) [2/]				443													
Willow Chute	332									3.7	2.8	2.8	2.6	2.3	2.4	1.9	2.4
(E)		491	445	287	337	304	311	251	314								
	428									5.2	4.7	3.3	3.9	3.2	3.2	2.8	3.4
(F)		577	516	391	455	340	349	320	375								
	864									10.8	10.3	8.1	10.9	7.0	7.2	6.9	9.0
(G)		510	527	423	640	370	373	373	530								
	850									9.4	9.0	8.1	11.5	6.7	6.9	7.3	9.8
(H)		456	399	410	540	320	330	373	475								
	594									6.2	5.7	6.1	7.9	4.4	4.7	5.2	6.2
(I)		458	433	483	617	331	353	383	438								
Big Denny	932									9.8	9.3	10.3	13.2	5.9	5.7	5.8	7.8
(L)						225	182	157	293								
	1595													11.1	9.6	9.7	17.8
(M)						383	345	372	677								
	659													4.8	5.8	5.4	10.6
(N)						257	419	348	729								
	1070													6.3	10.3	8.5	17.9
Dredge Cut End		458	433	483	617	257	419	348	729								
Little Denny																	
(J)						203	174	110	202								
	1850													9.3	7.4	5.9	7.5
(K)						236	175	167	153								
Average [3/]		567	542	476	**534**	293	312	291	447								
		(Year 50 Target = 348.0 SF)															
Total	10550									67.2	63.6	57.8	**49.9**	61.2	63.1	59.4	**92.4**
										(Year 50 Target = 42.4 AC-FT)				(Year 50 Target = 15.8 AC-FT)			

[1/] Timber Chute = Transect C

[2/] Transect D was a new cross section in 1997 and transitions from deep habitat to a combination of deep and shallow habitat.

[3/] Average deep aquatic habitat cross-sectional area includes Timber Chute or Transect C.

[4/] Cross-sectional area where flat pool depth ≥ 3 feet (I.e. average of cross-sectional area at flat pool elevation 536 and 530) for Transects E through I.

TABLE F-4. Average Annual Sedimentation Rates

Sedimentation Transects	Total Aquatic Habitat Volume, Acre-Feet				Total Aquatic Habitat Surface Area, Acres				Total Aquatic Habitat Average Depth, Feet				Total Aquatic Habitat Sedimentation Rate, Inches per Year			
	As Built 1991	Year 3 1994	Year 6 1997	Year 11 2002	As Built 1991	Year 3 1994	Year 6 1997	Year 11 2002	As Built 1991	Year 3 1994	Year 6 1997	Year 11 2002	Year 0-3 91-94	Year 3-6 94-97	Year 6-11 97-02	Year 0-11 91-02
Dredge Cut Begin																
Round Pond	3.9	3.6	2.6		0.5	0.5	0.5	0.5	7.0	7.1	4.7		-0.2	9.6		
(A)																
	8.2	9.1	7.8		1.2	1.3	1.4	1.3	6.7	7.1	5.4		-1.7	6.7		
(B)																
Timber Chute	6.1	6.3	6.0		0.9	1.0	1.1	1.0	6.5	6.1	5.4		1.6	2.7		
(C) [1/]																
	3.8	2.8	2.7		0.8	0.8	0.7	0.7	5.0	3.6	4.1		5.8	-2.1		
(D) [2/]																
Willow Chute	6.1	5.1	4.7	5.0	0.8	0.8	0.8	0.9	8.1	6.6	5.5	5.5	6.0	4.3	0.1	2.8
(E)																
	8.4	8.0	6.1	7.3	1.3	1.4	1.3	1.5	6.6	5.8	4.8	5.0	2.9	4.3	-0.5	1.7
(F)																
	17.8	17.5	14.9	19.8	2.9	2.9	2.9	4.9	6.2	6.1	5.1	4.0	0.4	4.0	2.5	2.3
(G)																
	16.2	15.9	15.4	21.3	2.8	2.8	2.9	5.7	5.7	5.7	5.3	3.7	-0.1	1.6	3.8	2.1
(H)																
	10.7	10.3	11.2	14.1	1.8	1.9	2.2	3.2	6.0	5.5	5.1	4.4	2.0	1.5	1.7	1.7
(I)																
Big Denny	15.7	15.0	16.1	21.0	2.1	2.3	2.7	3.1	7.5	6.4	5.9	6.8	4.5	2.1	-2.1	0.8
(L)																
	11.1	9.6	9.7	17.8	2.4	3.0	3.0	7.0	4.7	3.2	3.2	2.5	6.0	-0.1	1.6	2.3
(M)																
	4.8	5.8	5.4	10.6	0.9	1.3	1.4	5.1	5.3	4.4	4.0	2.1	3.7	1.8	4.5	3.5
(N)																
	6.3	10.3	8.5	17.9	1.5	2.1	2.4	9.1	4.3	4.8	3.6	2.0	-2.1	4.8	4.0	2.5
Dredge Cut End																
Little Denny																
(J)																
	9.3	7.4	5.9	7.5	3.4	3.7	3.7	6.1	2.7	2.0	1.6	1.2	3.0	1.7	0.8	1.6
(K)																
Average									5.9	5.3	4.6	3.7	2.3	3.0	1.6	2.2
Average (deep)									6.5	6.0	5.1	4.9	2.1	3.5	0.9	1.9
Average (shallow)									4.3	3.6	3.1	2.0	2.6	2.0	2.7	2.5

[1/] Timber Chute = Transect C

[2/] Transect D was a new cross section in 1997 and transitions from deep habitat to a combination of deep and shallow habitat.

TABLE F-5. Enhance Migratory Waterfowl Habitiat through Channel Dredging and Excavation

														Increase Reliable Resting and Feeding Water Areas			
	Length Feet	Deep Aquatic Habitat Channel Width, Feet				Shallow Aquatic Habitat Channel Width, Feet				Total Aquatic Habitat Channel Width, Feet				Total Aquatic Habitat Surface Area, Acres			
Sedimentation Transects	Year 0 1991	Year 0 1991	Year 3 1994	Year 6 1997	Year 11 2002	Year 0 1991	Year 3 1994	Year 6 1997	Year 11 2002	Year 0 1991	Year 3 1994	Year 6 1997	Year 11 2002	Year 0 1991	Year 3 1994	Year 6 1997	Year 11 2002
Dredge Cut Begin		130	120	130	100	40	50	30	30	130	120	130	127				
Round Pond	184													0.5	0.5	0.5	0.5
(A)		130	120	130						130	120	130	127				
	431													1.2	1.3	1.4	1.3
(B)		119	140	160						119	140	160	140				
Timber Chute	427													0.9	1.0	1.1	1.0
(C) [1/]		72	70	67						72	70	67	70				
	334													0.8	0.8	0.7	0.7
(D) [2/]				107								107	107				
Willow Chute	332													0.8	0.8	0.8	0.9
(E)		85	85	86	100	40	50	30	30	125	135	116	130				
	428													1.3	1.4	1.3	1.5
(F)		90	93	100	115	46	50	46	52	136	143	146	167				
	864													2.9	2.9	2.9	4.9
(G)		100	100	100	125	55	47	50	203	155	147	150	328				
	850													2.8	2.8	2.9	5.7
(H)		80	90	96	125	55	47	50	131	135	137	146	256				
	594													1.8	1.9	2.2	3.2
(I)		80	90	135	120	45	48	40	90	125	138	175	210				
Big Denny	932													2.1	2.3	2.7	3.1
(L)						70	80	80	80	70	80	80	80				
	1595													2.4	3.0	3.0	7.0
(M)						60	86	85	302	60	86	85	302				
	659													0.9	1.3	1.4	5.1
(N)						60	87	96	370	60	87	96	370				
	1070													1.5	2.1	2.4	9.1
Dredge Cut End		80	90	135	120	60	87	96	370	60	87	96	370				
Little Denny																	
(J)						80	87	84	170	80	87	84	170				
	1850													3.4	3.7	3.7	6.1
(K)						80	88	92	115	80	88	92	115				
Average		93	98	112	118	59	69	68	174	101	110	115	196	1.7	1.8	1.9	3.6
Total	10550													23.2	25.8	27.1	**50.0**
														(Year 50 Target = 21.0 AC)			

[1/] Timber Chute = Transect C

[2/] Transect D was a new cross section in 1997 and transitions from deep habitat to a combination of deep and shallow habitat.

Note: Since no data was collected in Year 11 for Transects A through D, these values were determined by taking the average of Years 0, 3, and 6,

TABLE F-6. Enhance Migratory Waterfowl Habitat through Pothole Creation

Pothole Number									Increase Reliable Resting and Feeding Water Areas			
	Long Chord Length, Feet				Short Chord Length, Feet				Surface Area, Acres [1]			
	Year 0	Year 3	Year 6	Year 11	Year 0	Year 3	Year 6	Year 11	Year 0	Year 3	Year 6	Year 11
	1991 [2]	1995	1997	2002	1991 [2]	1995	1997	2002	1991	1995	1997	2002
1	70	75	76	66	27	31	34	26	0.04	0.05	0.06	0.04
2	72	77	77	70	24	36	39	29	0.04	0.06	0.07	0.05
3	65	75	76	61	26	40	43	24	0.04	0.07	0.08	0.03
4	67	73	74	55	28	43	44	30	0.04	0.07	0.07	0.04
5	55	64	62	63	42	47	42	46	0.05	0.07	0.06	0.07
6	60	67	68	61	50	45	48	42	0.07	0.07	0.07	0.06
7	75	75	74	73	50	47	47	44	0.09	0.08	0.08	0.07
8	65	75	74	71	48	49	49	47	0.07	0.08	0.08	0.08
9	60	79	82	85	45	60	61	57	0.06	0.11	0.11	0.11
10	80	78	80	70	50	54	55	56	0.09	0.10	0.10	0.09
Average	67	74	74	68	39	45	46	40	0.06	0.08	0.08	0.06
Total									0.60	0.77	0.79	**0.63**
									(Year 50 Target = 21.0 AC)			

Pothole Number	Long Chord X-Section Area, SF				Short Chord X-Section Area, SF				Average Depth, Feet [3]			
	Year 0	Year 3	Year 6	Year 11	Year 0	Year 3	Year 6	Year 11	Year 0	Year 3	Year 6	Year 11
	1991	1995	1997	2002	1991	1995	1997	2002	1991	1995	1997	2002
1		134	132	30		30	29	9		3.3	3.1	1.0
2		106	100	40		54	53	20		3.7	3.1	1.4
3		122	100	18		29	31	6		2.4	2.1	0.7
4		120	108	42		49	55	18		3.1	2.9	1.6
5		133	151	119		56	60	52		3.2	3.3	3.0
6		147	155	102		65	76	57		3.6	3.6	2.7
7		222	227	174		105	107	92		4.6	4.8	3.9
8		164	175			84	92			3.6	3.6	2.7
9		191	197	91		117	111	52		3.9	3.7	1.9
10		173	195	75		90	89	34		3.4	3.3	1.6
Average		151	154	77		68	70	38		3.5	3.4	2.1

[1] Assume surface area = long chord x short chord.

[2] 1991 data was collected by the USFWS.

[3] Flat pool elevation (536 feet) was used as the reference to determine depths.

APPENDIX G

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APPENDIX H

REFERENCES

REFERENCES

Published reports relating to the Big Timber HREP 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, Upper Mississippi River System Environmental Management Program, Pool 17, Upper Mississippi River, Louisa County, Iowa, July 1989*. 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 444 - 445, Big Timber,* Solicitation No. DACW25-90-B-0031. These documents were prepared to provide sufficient detail of project features to allow construction of a confined dredged material placement site, hydraulically dredged channels, mechanically excavated channels, potholes, and check dams.

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

(4) *Operation and Maintenance Manual, Big Timber Refuge Rehabilitation and Enhancement, Upper Mississippi River Environmental Management Program, Pool 17, River Mile 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 HREP. Operation and maintenance instructions for major features of the project are presented.

(5) *Post-Construction Performance Evaluation Report (PER5F), Big Timber Refuge Rehabilitation and Enhancement, Upper Mississippi River System Environmental Management Program, Pool 17, Upper Mississippi River Mile 443 – 445, Louisa County, Iowa, February 1996.*

(6) *Post-Construction Supplemental Performance Evaluation Report (SPER501F), Big Timber Refuge Rehabilitation and Enhancement, Upper Mississippi River System Environmental Management Program, Pool 17, Mississippi River Miles 443.5 – 445, Louisa County, Iowa, August 1998.*

(7) *Post-Construction Performance Evaluation Report – Year 9 (2000), Big Timber Refuge Habitat Rehabilitation and Enhancement, Upper Mississippi River System Environmental Management Program, Pool 17, Mississippi River Miles 443.5 – 445, Louisa County, Iowa, June 2001.*

(7) *Post-Construction Performance Evaluation Report – Year 9 (2000), Big Timber Refuge Habitat Rehabilitation and Enhancement, Upper Mississippi River System Environmental*

Management Program, Pool 17, Mississippi River Miles 443.5 – 445, Louisa County, Iowa, March 2002.

(8) *Site Manager's Project Inspection and Monitoring Results, Big Timber Refuge Rehabilitation and Enhancement, Operation and Maintenance Manual, Upper Mississippi River Environmental Management Program, Pool 17, River Miles 443 through 445, Louisa County, Illinois,* July 1997, February 2001, July 2001.

APPENDIX I

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APPENDIX J

PLATES

APPENDIX K

August 2006 Site Photos

Photo 1 Coolegar Slough

Photo 2 Coolegar Slough

Photo 3 Coolegar Entrance to Round Pond

Photo 4 Round Pond Entrance

Photo 5 Entrance to Timber Chute

Photo 6 Timber Chute

Photo 7 Timber Chute

Photo 10 NE Bend in Big Denny

Photo 8 Mouth of Little Denny

Photo 11 Facing NE in Big Denny

Photo 9 Near Little Denny Facing NW

Photo 12 Big Denny

Photo 13 NE End of Big Denny

Photo 14 NE End of Big Denny

Photo 15 NE End of Big Denny

Photo 16 Big Denny

Photo 17 Pothole NE End of Big Denny

Photo 18 Pothole NE End of Big Denny

Photo 19 Pothole NE End of Big Denny

Photo 20 Pothole NE End of Big Denny

APPENDIX L

IADNR Fish Survey