UPPER MISSISSIPPI RIVER RESTORATION

ENVIRONMENTAL MANAGEMENT PROGRAM

POST-CONSTRUCTION

INITIAL PERFORMANCE EVALUATION REPORT

2012

FOR

COTTONWOOD ISLAND

HABITAT REHABILITATION AND ENHANCEMENT PROJECT

US Army Corps of Engineers
St. Louis District

Pool 21

River Mile 328.5 – 331.0

Lewis and Marion County, Missouri

ACKNOWLEDGEMENTS
&
POINTS OF CONTACT

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EXECUTIVE SUMMARY

General. The design goal of the Cottonwood Island HREP was to provide the physical conditions necessary to improve and enhance wetland habitat quality. As stated in the Definite Project Report, the Cottonwood Island Habitat Rehabilitation and Enhancement Project (HREP) was undertaken to address the following primary problems: sedimentation, side channel loss, backwater loss, wetland loss, and forest degradation. These problems were contributing to the direct loss of fish habitat, wildlife habitat, wetland biodiversity, and forest biodiversity.

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

1. Document the pre- and post-construction monitoring activities for the Cottonwood Island HREP
2. Summarize and evaluate project performance on the basis of project goals and objectives as stated in the Definite Project Report (DPR)
3. Summarize project operation and maintenance efforts, to date
4. Provide recommendations concerning future project performance evaluation
5. Share lessons learned and provide recommendations concerning the planning and design of future HREP projects

Project Goals and Objectives. The specific goals and objectives as stated in the DPR were to:

1. Restore aquatic overwintering habitat
    a. Improve water quality for fish
    b. Provide overwintering habitat for fish
2. Restore main channel border habitat
    a. Improve water quality for fish
    b. Provide flowing water habitat for fish
    c. Provide additional habitat and substrate for benthic and aquatic organisms
3. Restore wetland habitat
    a. Increase food, shelter, and breeding habitat for wildlife
    b. Increase bottomland hardwood diversity and quality

Project Performance Monitoring. Pre- and post-project monitoring, both qualitative and quantitative, was performed in accordance with the project evaluation from the original DPR. Monitoring and performance evaluation was conducted by the U.S. Army Corps of Engineers, US Fish and Wildlife Service, and Missouri Department of Conservation. The period of data collection covered in this report includes the pre-project monitoring (1992 - 1995), quantitative and qualitative post-project monitoring through 2012, and anecdotal information through 2012.

Evaluation of Project Objectives. For the evaluation period of 1997 to 2012, observations were made with regard to the efficacy of the objectives in meeting project goals. In addition, general conclusions were drawn regarding project measures that may affect future project design.

1. Restore aquatic overwintering habitat
    a. Improve water quality for fish
        i. Evaluation Criteria: Dissolved oxygen >5mg/l
        ii. General Observation: Sedimentation greatly reduced the quantity and quality of these habitat areas, especially in the chute's upper end. In the chute's shallow areas, low dissolved oxygen (DO) values reached critical levels and fish species diversity decreased.
        iii. Results: Dissolved oxygen has increased and thermal stratification occurs in deep areas.
        iv. Success: Dissolved oxygen objectives were met.
        v. Conclusion: DO values showed a slight increase during both the critical winter season (4% increase) and the summer season (8% increase). The minimal decrease since project completion has little potential for negative impacts to aquatic biota.
        vi. Lessons Learned & Recommendations: High sedimentation rates in deep holes (see below) may limit project effectiveness.
    b. Provide overwintering habitat for fish
        i. Evaluation Criteria: Acres between 6 – 10 feet
        ii. General Observation: High rates of historic sedimentation reduced depths and aquatic habitat quality in Cottonwood Chute. Fish community composition represented a degraded condition.
        iii. Results: The steady decline in water depths at both stations is indicative of sedimentation in the dredge channel. The average annual sedimentation rate from 1997 to 2005, the previous monitoring period, was 8.04 in/yr at site W-M328.7B and 6.72 in/yr at site W-M329.3B. During the most recent sampling period, the estimated average sedimentation rate dropped to 6.19 in/yr for site W-M328.7B and 5.84 in/yr at site W-M329.3B.
        iv. Success: Partial success was achieved, but high sedimentation rates may reduce expected duration of project benefits
        v. Conclusion: Although the sedimentation rate has decreased over the past two years, these rates are still considerably higher than the estimated sedimentation rates from the 1996 US Army Corps of Engineers DPR of 0.11 in/yr at W-M328.7B and 0.16 in/yr at site W-M329.3B.
        vi. Lessons Learned & Recommendations: Dredged hole will need to be self scouring, which would reduce habitat value, or maintenance dredging may need to be included in project O&M.
2. Restore main channel border habitat
    a. Provide flowing water habitat for fish
        i. Evaluation Criteria: Current velocity at notch 0.5ft./sec.
        ii. General Observation: Wing dams in channel border habitat can create shallow, uniform aquatic habitat. Wing dam alterations can alter flow fields and increase depth diversity within a local area.

iii. Results: The average velocity 100 feet upstream from Wing Dam No. 6 was 1.13 feet per second. This value increased to 1.37 feet per second at the notch and then rose to 1.50 feet per second 100 feet downstream from the notch. At Wing Dam No. 15, the average velocity 100 feet upstream was 0.96 feet per second. This value increased to 1.24 feet per second at the notch and 1.26 feet per second 100 feet downstream from the notch.
iv. Success: Current velocities are higher than anticipated, but the scour holes and bathymetric diversity were achieved.
v. Conclusion: Although the velocity measurements observed do not support the FastTABS modeling results, the refuge manager has been very pleased with the results of the notches over the years.
vi. Lessons Learned & Recommendations: Potential for damaging scouring and excessive velocities as stated in the DPR appear to not be of concern.

b. Provide flowing water habitat for fish
    i. There is currently no quantitative data that can be used to measure the success of this project goal.

c. Provide additional habitat and substrate for benthic and aquatic organisms
    i. Evaluation Criteria: Organisms present
    ii. General Observation: Benthic and aquatic organism density and diversity can be low in uniform, fine substrate. Adding hard substrate and flow diversity increases microhabitat diversity and abundance.
    iii. Results: The average flat pool channel depth for Year 0 was used as the base line in determining scour depth. The average scour depth 100 feet downstream from Wing Dam No. 6 was 3.88 feet. At Wing Dam No. 15, the average scour depth 100 feet downstream was 1.71 feet. As seen in Table 6-2, Wing Dams No. 6 and 15 achieved a scour depth greater than one foot by Years 2 and 3, respectively.
    iv. Success: The Cottonwood HREP is meeting the goal of rehabilitating main channel border habitat by creating scour depths greater than or equal to 1 foot downstream from the notch with respect to Wing Dam No. 6 and No. 15
    v. Conclusion: The Cottonwood HREP is meeting the goal of rehabilitating main channel border habitat
    vi. Lessons Learned & Recommendations: future sedimentation transects based on the monitoring plan should provide more adequate data to better define scour depths and size for all of the notched wing dams.

3. Restore wetland habitat
    a. Increase food, shelter, and breeding habitat for wildlife
        i. Evaluation Criteria: Wetland vegetation and animals including waterfowl

ii. General Observation: Much of Cottonwood Island was dominated by degraded, even-aged forest. More wetland habitat was created in discrete pothole wetlands.
iii. Results: Field observations indicate that these areas are receiving use by amphibians, particularly bullfrogs and possibly tree frogs, and are visited regularly by great blue herons.
iv. Success: Success was achieved for wetland plants and animals
v. Conclusion: The project feature was successful for establishing .
vi. Lessons Learned & Recommendations: State if the criteria met the needs of evaluating the project performance, or if the criteria should be modified or deleted for future evaluations.

b. Increase bottomland hardwood diversity and quality
i. Evaluation Criteria: Survival rate greater than or equal to 20%.
ii. General Observation: UMRS forests have degraded to monotypic, even-aged forests. Foresters and wildlife managers want restored forest species diversity.
iii. Results: A survival rate of 65% was observed for the Upper site, 75-80% for the Middle site and 80-85% for the Lower site.
iv. Success: Based on results from the mast tree survey taken on August 13, 2006, the overall survival rates for each of the mast tree planting sites are meeting the 50 year goal of 20%.
v. Conclusion: Forest plantings were successful.
vi. Lessons Learned & Recommendations: The overall effectiveness of the tree fences as a deer repellant may be outweighed due to increased weed growth with which the fences are associated.

Evaluation of Project Operation and Maintenance. The O&M manual was completed March 1997. Annual maintenance includes general inspection, debris removal, and herbicide and pest management for early plantings. The Cottonwood HREP project has been successful in attaining the target DO concentration (>5 mg/L) during the critical winter months. Another indication of the project's success is that USFWS and MDOC personnel have not observed any fish stress or kills since project completion. Overall, the results of these investigations suggest a positive response by fisheries to chute and deep hole excavation.

The Cottonwood HREP project is meeting the objective of increasing food, shelter, and breeding habitat for wildlife through pothole creation. Post–construction field observations have shown pothole use by various animals. Hopefully, future monitoring will show an increase in pothole use by waterfowl.

UPPER MISSISSIPPI RIVER SYSTEM
ENVIRONMENTAL MANAGEMENT PROGRAM
POST-CONSTRUCTION
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Cottonwood Island

HABITAT REHABILITATION AND ENHANCEMENT PROJECT
Mississippi River, Pool 21
River Miles 328.5 – 331.0
Lewis and Marion Counties, Missouri

TABLE OF CONTENTS

FIGURES

TABLES

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

2012

COTTONWOOD ISLAND

HABITAT REHABILITATION AND ENHANCEMENT PROJECT

MISSISSIPPI RIVER, POOL 21
RIVER MILES 328.5 – 331.0
LEWIS AND MARION COUNTIES, MISSOURI

INTRODUCTION

The Upper Mississippi River Restoration Environmental Management Program (UMRR-EMP) is a Federal-State partnership to manage, restore and monitor the UMR ecosystem. The UMRR-EMP was authorized by Congress in Section 1103 of the Water Resources Development Act of 1986 (Public Law 99-662) and reauthorized in 1999. Subsequent amendments have helped shape the two major components of EMP – the Habitat Rehabilitation and Enhancement Projects (HREPs) and Long Term Resource Monitoring (LTRM). Together, HREPs and LTRM are designed to improve the environmental health of the UMR and increase our understanding of its natural resources.

Habitat Rehabilitation and Enhancement Project (HREP) construction is one element of the UMRR-EMP. In general, the projects provide site-specific ecosystem restoration, and are intended and designed to counteract the adverse ecological effects of impoundment and river regulation through a variety of modifications, including flow introductions, modification of channel training structures, dredging, island construction, and water level management. Interagency, multi-disciplinary teams work together to plan and design these projects.

The Cottonwood Island HREP is part of the UMRR-EMP. This project consisted of mechanical dredging, tree planting, and dike notching that were designed to restore aquatic overwintering habitat, restore main channel border habitat, and restore wetland habitat.

1. Purpose of Project Evaluation Reports

The purposes of this Project Evaluation Report for Cottonwood Island are to:

1. Document the pre- and post-construction monitoring activities for the Cottonwood Island HREP
2. Summarize and evaluate project performance on the basis of project goals and objectives as stated in the Definite Project Report (DPR)
3. Summarize project operation and maintenance efforts, to date
4. Provide recommendations concerning future project performance evaluation
5. Share lessons learned and provide recommendations concerning the planning and design of future HREP projects

2. Scope

This report summarizes available monitoring data, operation, maintenance, repair, replacement, and rehabilitation (OMRR&R) information, and project observations made by the U.S. Army Corps of Engineers (USACE), US Fish and Wildlife Service, and Missouri Department of Conservation. The period of data collection covered in this report includes the pre-construction monitoring 1997 to post-construction monitoring as of 2012.

3. Project References

Published reports which relate to the Cottonwood Island HREP are presented below.

(1) Definite Project Report with Integrated Environmental Assessment (R-16F), Cottonwood Island Habitat Rehabilitation and Enhancement, Upper Mississippi River System Environmental Management Program, Pool 21, Mississippi River Miles 328.5 – 331.0, Lewis and Marion Counties, Missouri, June 1996. 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, Environmental Management Program, Pool 21, River Miles 328.5 thru 331.0, Cottonwood Island Rehabilitation and Enhancement, Solicitation No. DACW25-97-B-0011. These documents were prepared to provide sufficient detail for construction of the hydraulically dredged chutes / deep holes and mechanically excavated potholes, as well as notching of the existing wing dams.

(3) Plans and Specifications, Upper Mississippi River, Environmental Management Program, Pool 21, River Miles 328.5 thru 331.0, Cottonwood Island Rehabilitation and Enhancement, Stage II, Solicitation No. DACW25-99-B-0005. These documents were prepared to provide sufficient detail for construction of the mast tree areas.

(4) Plans and Specifications, Upper Mississippi River System, Environmental Management Program, Pool 21, Cottonwood Island, Stage III, Causeway Road Raise, Solicitation No. DACW25-00-T-0006. These documents were prepared to provide sufficient detail for construction of the causeway road.

(5) Operation and Maintenance Manual, Cottonwood Island Rehabilitation and Enhancement, Upper Mississippi River Environmental Management Program, Pool 21, River Miles 328.5

Through 331.0, Lewis and Marion Counties, Missouri, January 2001. This manual was prepared to serve as a guide for the operation and maintenance of the Cottonwood HREP project. Operation and maintenance instructions for major features of the project are presented.

(6) Post-Construction Performance Evaluation Report – Year 3 (2000), Cottonwood Island Habitat Rehabilitation and Enhancement, Upper Mississippi River System Environmental Management Program, Pool 21, Upper Mississippi River Miles 328.5 – 331.0, Lewis and Marion Counties, Missouri, June 2001.

(7) (6) Post-Construction Performance Evaluation Report – Year 4 (2001), Cottonwood Island Habitat Rehabilitation and Enhancement, Upper Mississippi River System Environmental Management Program, Pool 21, Upper Mississippi River Miles 328.5 – 331.0, Lewis and Marion Counties, Missouri, June 2002.

4. Project Location

The Cottonwood Island project is located in Lewis and Marion Counties, Missouri on the right descending bank of the Mississippi River, between river miles 328.5 – 331.0 (Figure 1). The project is operated by the Missouri Department of Conservation.

The Cottonwood HREP project consists of mechanically excavated side channel and deep holes to restore aquatic overwintering habitat, notched wing dams to restore main channel border habitat, and mechanically excavated potholes and planting mast trees to restore wetland habitat. Plate 2 in Appendix K contains the site plan for the Cottonwood HREP project.

(1) Side Channel Excavation. The lower 4,550 feet of Cottonwood Chute was mechanically excavated to improve water quality and provide overwintering water habitat for fish. The bottom width of the dredge cut was 40 feet, with a depth of 9 feet below flat pool (Elevation 470 feet MSL 1912). Cottonwood Chute includes 4 deep holes, 300 feet long and 15 feet below flat pool. Side slopes are approximately 2 to 1 horizontal on vertical. For side channel cross sections, refer to the Operation and Maintenance (O&M) Manual, Plates 11 through 13. For side channel profiles, refer to the O&M Manual, Plates 14 through 16.

(2) Wing Dam Notches. Six wing dams were notched to provide flowing water habitat for fish and additional habitat and substrate for benthic and aquatic organisms. The notches were created by removing existing wing dam material to the original river bottom or a maximum of 10 feet below flat pool. Each notch was 100 feet long. For wing dam notching details, refer to O&M Manual, Plate 17. Notches were staggered in anticipation that flow would increase in the vicinity of the notch, creating a scour hole behind the wind dams and stimulating a meander to the next wing dam. Preliminary post-construction monitoring efforts indicate the formation of scour holes behind the wing dams and an increase in velocity at and below the notches.

(3) Potholes. For the Cottonwood HREP project, two 1-acre potholes, one ¾-acre pothole, and two ½-acre potholes were mechanically excavated to increase food, shelter, and breeding

habitat for wildlife. In general, the potholes are larger and feature a 20-foot bottom width and final elevation approximately 3 feet below flat pool. The sides of the potholes are stepped. Each "step" is approximately 10 feet wide, with a 1-foot transition zone to the next step. The transition slope is 3 to 1 horizontal on vertical. For pothole details and transects, refer to the O&M Manual, Plates 18 through 23. The potholes have filled with water and were being used by deer, herons, frogs, and tadpoles less than a week after completion of construction in 1997. Fish were observed in the potholes following high water in the spring of 1998.

(4) Mast Trees. As a preparatory measure, the MDOC in June of 1998 constructed raised planting beds in the agricultural field and reseeded those areas with redtop grass. During Stage II of the Cottonwood HREP project, mast trees were planted in the agricultural field / forest management areas (FMAs), around the pothole perimeters, and on top of the excavated dredged material berm to increase bottomland hardwood diversity and quality. In the agricultural field and FMAs, trees were planted on 8-inch to 10-inch berms with 30 feet between berms. As part of a field study during the Stage II contract, 75 trees received protective fencing while another 75 trees were sprayed with deer repellent in the agricultural field and FMAs 5 & 6. The MDOC is responsible for maintaining this protective fencing and annual application of the deer repellent over a 3-year period. At the end of this period, the efficacy of both methods shall be summarized and conclusions drawn for the best method of protecting the saplings from deer. For mast tree details, refer to the O&M Manual, Plates 25 through 29.

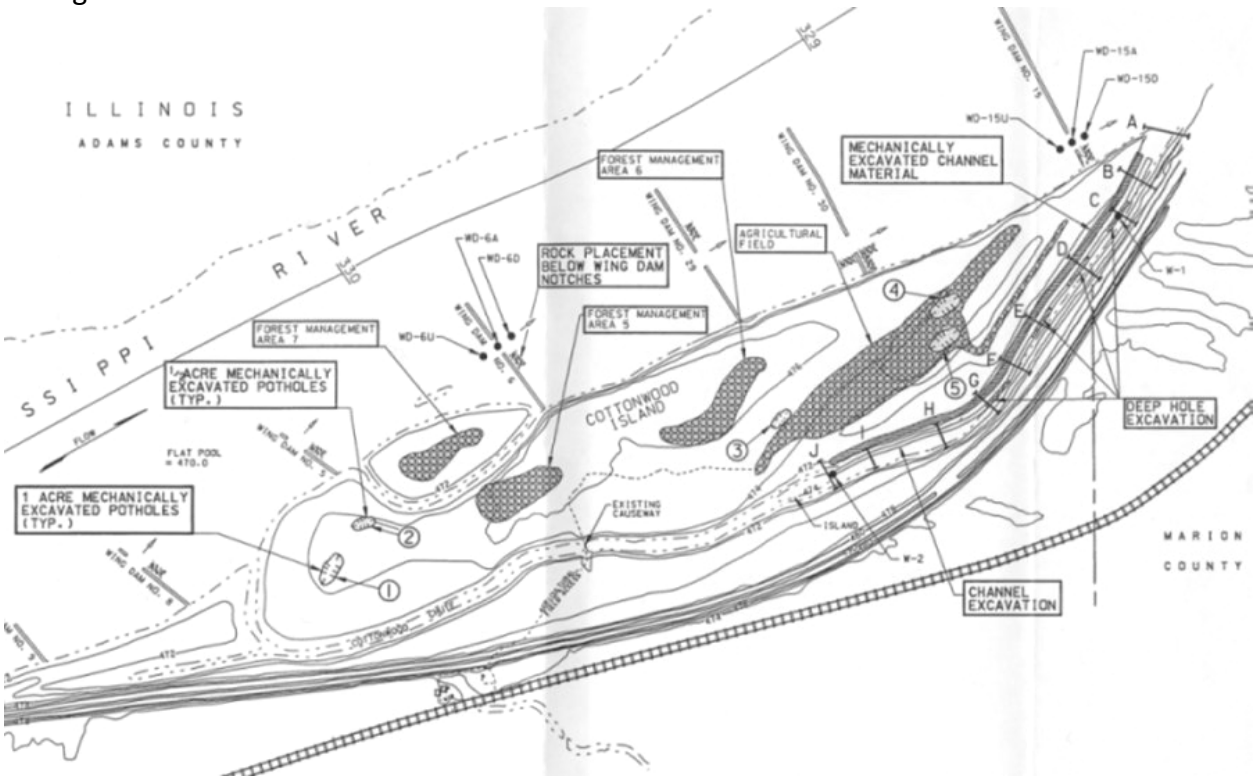


Figure 1. Cottonwood Island HREP project area

PROJECT PURPOSE

1. Overview

The design of the Cottonwood Island HREP was to provide the physical conditions necessary to improve and enhance wetland habitat quality. The specific goals as stated in the Definite Project Report (DPR) were to: restore aquatic overwintering habitat, restore main channel border habitat, and restore wetland habitat. In order to achieve these goals, sedimentation and low dissolved oxygen problems at the site needed to be addressed. These problems were contributing to the direct loss of wetlands, mast trees, and aquatic habitat. The problems, opportunities, goal, objectives and measures implemented to address the goals and objectives are listed in Table 1.

Table 1. Problems, opportunities, goals, objectives, and measures

PROBLEMS	OPPORTUNITIES	GOALS	OBJECTIVES	RESTORATION MEASURES
Sedimentation	Reestablish wetland	Restore wetland habitat	Increase food, shelter and breeding habitat for wildlife	Potholes
			Increase bottomland hardwood diversity and quality	Mast tree planting
	Reestablish deepwater areas	Restore main channel border habitat	Improve water quality for fish	Wing dam notching
			Provide flowing water habitat for fish	Wing dam notching
			Provide additional habitat and substrate for benthic invertebrate and aquatic organisms	Wing dam notching
	Restore aquatic habitat	Restore aquatic overwintering habitat	Improve water quality for fish	Dredging
			Provide overwintering habitat for fish	Dredging

2. Management Plan

There is no management plan, but the project sponsor agreed to complete many operation and maintenance requirements upon accepting the project. Management actions include inspections, debris clearing, and pest control during initial plantings.

Table 2. Original management actions for Cottonwood Island as stated in the DPR

Time Frame	Management Action	Purpose
Annual	Inspection	Project performance
Annual	Debris removal	Dike notch clearing
First 2 years	Herbicide	Weed control
First 2 years	Deer repellent	Deer herbivory
3rd year	Remove deer mesh	Deer herbivory

PROJECT DESCRIPTION

1. Project Measures

The Cottonwood Island HREP included a combination of dredging and planting (see Figure 1 for locations of measures). A detailed description of each of these measures is provided below.

(1) Side Channel Excavation. The lower 4,550 feet of Cottonwood Chute was mechanically excavated to improve water quality and provide overwintering water habitat for fish. The bottom width of the dredge cut was 40 feet, with a depth of 9 feet below flat pool (Elevation 470 feet MSL 1912). Cottonwood Chute includes 4 deep holes, 300 feet long and 15 feet below flat pool. Side slopes are approximately 2 to 1 horizontal on vertical. For side channel cross sections, refer to the Operation and Maintenance (O&M) Manual, Plates 11 through 13. For side channel profiles, refer to the O&M Manual, Plates 14 through 16.

(2) Wing Dam Notches. Six wing dams were notched to provide flowing water habitat for fish and additional habitat and substrate for benthic and aquatic organisms. The notches were created by removing existing wing dam material to the original river bottom or a maximum of 10 feet below flat pool. Each notch was 100 feet long. For wing dam notching details, refer to O&M Manual, Plate 17. Notches were staggered in anticipation that flow would increase in the vicinity of the notch, creating a scour hole behind the wind dams and stimulating a meander to the next wing dam. Preliminary post-construction monitoring efforts indicate the formation of scour holes behind the wing dams and an increase in velocity at and below the notches.

(3) Potholes. For the Cottonwood HREP project, two 1-acre potholes, one ¾-acre pothole, and two ½-acre potholes were mechanically excavated to increase food, shelter, and breeding habitat for wildlife. In general, the potholes are larger and feature a 20-foot bottom width and final elevation approximately 3 feet below flat pool. The sides of the potholes are stepped. Each "step" is approximately 10 feet wide, with a 1-foot transition zone to the next step. The

transition slope is 3 to 1 horizontal on vertical. For pothole details and transects, refer to the O&M Manual, Plates 18 through 23. The potholes have filled with water and were being used by deer, herons, frogs, and tadpoles less than a week after completion of construction in 1997. Fish were observed in the potholes following high water in the spring of 1998.

(4) Mast Trees. As a preparatory measure, the MDOC in June of 1998 constructed raised planting beds in the agricultural field and reseeded those areas with redtop grass. During Stage II of the Cottonwood HREP project, mast trees were planted in the agricultural field / forest management areas (FMAs), around the pothole perimeters, and on top of the excavated dredged material berm to increase bottomland hardwood diversity and quality. In the agricultural field and FMAs, trees were planted on 8-inch to 10-inch berms with 30 feet between berms. As part of a field study during the Stage II contract, 75 trees received protective fencing while another 75 trees were sprayed with deer repellent in the agricultural field and FMAs 5 & 6. The MDOC is responsible for maintaining this protective fencing and annual application of the deer repellent over a 3-year period. At the end of this period, the efficacy of both methods shall be summarized and conclusions drawn for the best method of protecting the saplings from deer. For mast tree details, refer to the O&M Manual, Plates 25 through 29.

2. Project Construction

The Cottonwood Island HREP project was approved for construction in June 1996 at an estimated cost of $872,378 (equivalent to $1,275,845 in FY12).

There were three construction phases for the Cottonwood HREP. The Stage I contract (No. 97-09) was awarded to Massman Construction Company, in February 1997. This Contract included all the major project features except for the planting of the mast trees and was completed in November of 1997. The planting of the mast trees was completed in the Stage II contract during the 1999 construction season. Stage III of the Cottonwood HREP consisted of a modification to the existing causeway road. Construction was complete in spring 2001. The project cost was $604,876 .

3. Project Operation and Maintenance

General. In the original DPR it was estimated that the Cottonwood Island HREP would require little or no maintenance. Operation and maintenance responsibilities for the Cottonwood Island HREP were originally outlined in the DPR. The acceptance of these responsibilities was formally recognized by an agreement signed by the Missouri Department of Conservation and the St. Louis District, USACE.

A detailed description of all operation and maintenance requirements can be found in the Project Operation, Maintenance, Repair, Replacement, and Rehabilitation Manual (OMRR&R

Manual). The OMRR&R Manual for the project delegated responsibilities and procedures for post project activities. Project operation and maintenance generally consists of the following:

1. Inspections
2. Debris management
3. Pest control on early planting

PROJECT PERFORMANCE MONITORING

1. General

Performance monitoring of the Cottonwood Island HREP has been conducted by USACE to help determine the extent to which the design meets the habitat improvement objectives. Information from this monitoring will also be used, if required, for adaptive

The monitoring and performance evaluation matrix is outlined in Table 3. Pre- and post-project monitoring, both qualitative and quantitative by each of the involved agencies is summarized below.

1. U.S. Army Corps of Engineers: The success of the project relative to original project objectives shall be measured utilizing data, field observations, and project inspections provided by the Missouri Department of Conservation and USACE. The Corps of Engineers was responsible for post-project analyses of water quality and sedimentation. The Corps of Engineers has overall responsibility to measure and document project performance.
2. Missouri Department of Conservation: The Missouri Department of Conservation is responsible for operating and maintaining the Cottonwood Island HREP. Missouri Department of Conservation was responsible for pre- and post-project vegetation establishment, snag clearing, pest control, and general inspection.

Table 3. Monitoring and Performance Evaluation Matrix

Activity	Purpose	Responsible Agency	Implementing Agency	Funding Source	Remarks
Sedimentation Problem Analysis	System-wide problem definition. Evaluates planning assumptions	USFWS	USFWS (EMTC)	LTRMP	Leads into pre-project monitoring; defines desired conditions for plan formulation
Pre-project monitoring	Identifies and defines problems at HREP site. Established need for proposed project feature	Sponsor	Sponsor	Sponsor	Attempts to begin defining baseline. See DPR.
Baseline monitoring	Establishes baselines for performance evaluation	USACE	Field station or sponsor thru Cooperative Agreements or Corps	LTRMP	See DPR for location and sites for data collection and baseline information. Actual data collection will be accomplished during Plans & Specification phase.
Data Collection for Design	Includes identification of project objectives, design of project, and development of performance evaluation plan	USACE	USACE	HREP	Comes after fact sheet. This data aids in defining the baseline
Construction Monitoring	Assesses construction impacts; assess permit conditions are met	USACE	USACE	HREP	Environmental protection specifications to be included in construction contract documents. Inter-agency field inspections will be accomplished during project construction phase
Performance Evaluation Monitoring	Determine success of project as related to objectives	USACE (quantitative), sponsor (field observations)	Field station or sponsor thru Cooperative Agreements or Corps	LTRMP Cooperative	Comes after construction phase of project
Analysis of Biological Responses to Project	Evaluates predictions and assumptions of habitat unit analysis. Determine critical impact levels, cause-effect relationships, and effect on long-term losses of significant habitat	USFWS	USFWS (EMTC)	LTRMP	Problem Analysis and Trend Analysis studies of habitat projects

2. Project-Induced Habitat Changes

Cottonwood Island habitat conditions have improved since the pre-project monitoring. Aquatic habitat in the secondary channel is improved with increased dissolved oxygen and increased depth. Flowing water habitat improvements created structural diversity in the diverse flow fields and scour holes below wing dam notches. Excavated potholes support wetland plant communities, reptiles, and amphibian which thrive in the seasonal wetlands. Tree plantings have had survival rates greater than 50 percent at all sites and as high as 85 percent at some sites. The high survival rates greater than 10 years out from the project exceed project objectives.

Figure 2. Cottonwood Island Aerial Photo

PROJECT EVALUATION

1. Construction and Engineering

Construction began in February 1997 and was initially completed in November 1997, except for planting of mast trees. Final construction was completed in 2001.

2. Costs

The Cottonwood Island HREP project was approved for construction in June 1996 at an estimated cost of $872,378 (equivalent to $1,275,845 in FY12). The project cost for the Cottonwood Island HREP $604,876 .

3. Operation and Maintenance

In the original DPR, over the 50-year project life the estimated cost was $1,255,658. From the estimate, an average annual operation and maintenance cost was calculated to be $6,006. This amount included debris removal, herbicides, and deer protection.

4. Ecological Effectiveness

Table 5 summarizes the performance evaluation plan and schedule for the Cottonwood Island HREP goals and objectives.

Table 4. Performance Evaluation and Monitoring Schedule

Goal	Objective	Enhancement Measure	Units	Monitoring Target Values Year 50 Target With Project	Monitoring Schedule
Restore & Enhance Wetland Habitat	Improve water quality for fish	Chute restoration and enhancement	Dissolved oxygen	>5mg/l	USACE annual monitoring
	Provide overwintering water habitat for fish	Create deep holes	Acre/hole	4.5 acres	USACE annual monitoring
	Provide flowing water habitat for fish	Notch wing dams	Feet/sec.	0.5 ft/sec at notch	USACE post construction inspection
	Provide additional habitat & substrate for benthic & aquatic organisms	Rock rubble below dikes	Organisms	--	
	Increase food, shelter, & breeding habitat for wildlife	Excavated potholes	Square feet	--	Sponsor annual site inspection
	Increase bottomland hardwood diversity & quality	Hardwood planting	Percent survival	20	Sponsor annual site inspection

A. Improve Water Quality for Fish.

General. The water quality objectives of the Cottonwood Island project are to improve water quality for fish, (See vicinity map and project features map on Plate 1 and 2of Appendix A).

Pre- and Post-Project Conditions. Prior to project construction, the Cottonwood area provided important wetland habitat in the low swales present on Cottonwood Island and deep water aquatic habitat in Cottonwood Chute, but sedimentation greatly reduced the quantity and quality of these habitat areas, especially in the chute's upper end. In the chute's shallow areas, low dissolved oxygen (DO) values reached critical levels and fish species diversity decreased.

. To achieve the stated goal of enhancing aquatic habitat value, the lower 4,550 feet of Cottonwood Chute was mechanically excavated. The bottom width of the dredge cut was 40 feet, with a depth of 9 feet below flat pool (elevation 470 feet MSL 1912). Cottonwood Chute also includes four deep holes, 300 feet long and 15 feet below flat pool. Deep water areas were reestablished in Cottonwood Chute to provide a greater volume of oxygenated water to sustain fish during extended periods of ice cover when dissolved oxygen levels can reach below the critical threshold of 5.0 mg/L, as defined by the Missouri State Standard for the Protection of Aquatic Life.

To enhance flowing water habitat for fish and provide additional habitat and substrate for benthic and aquatic organisms, six wing dams were notched. The notches were created by removing existing wing dam material to the original river bottom or a maximum of 10 feet below flat pool. Each notch was 100 feet long. A post-construction monitoring effort in 2004 indicates the formation of scour holes behind the wing dams and an increase in velocity at and below the notches.

Methods. Water quality baseline monitoring was performed from 7 April 1992 to 17 November 1995 at Site W-M328.7B, with minimal baseline monitoring performed at Site W-M329.3B (See water quality monitoring station locations on Plate 3 of Appendix A). Results of the baseline monitoring can be found in the Water Quality Appendix to the Definite Project Report (DPR) with Integrated Environmental Assessment for Cottonwood Habitat Rehabilitation and Enhancement. To determine the effectiveness of attaining the project goals, post-project water quality monitoring commenced on December 23, 1997 at sites W-M328.7B and W-M329.3B. Previous performance evaluation reports discuss the results of water quality monitoring through 16 March 2006. This update discusses post project construction water quality monitoring data collected by USACE Water Quality and Sedimentation Section (EC-HQ) personnel from 31 May 2006 to 13 March 2012. Due to the cyclical nature of Rock Island

District's EMP water quality monitoring program, sampling was not performed from 2007 to 2009.

During the study period noted above for Cottonwood, EC-HQ personnel performed water quality monitoring at 2 sites: W-M328.7B and W-M329.3B. Data gathered by EC-HQ staff included a combination of both periodic grab samples and in-situ continuous monitors (YSI 6000 and 6600-V2 series and Hach DS5X series sondes). Grab samples were gathered near the surface. The sites were usually visited biweekly during the summer season of June through September and 3 or 4 times total per winter season of December through March. 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, total suspended solids (TSS), chlorophyll (a, b and c) and pheophytin a.

Monitoring Results: Results of in-situ continuous water quality monitoring performed after project completion at both sites is voluminous and discussed briefly in this report, but results can be provided upon request to the District. For pre-project baseline monitoring results performed at site W-M328.7B, refer to the Water Quality Appendix of the Definite Project Report (DPR) with Integrated Environmental Assessment for Cottonwood Habitat Rehabilitation and Enhancement.

The following tables provide a summary of grab sample DO concentration results at each monitoring site during pre- and post construction. The minimum dissolved oxygen standard, particularly during winter months, was set at 5.0 mg/L for all out-years.

Site W-M328.7B:

	Pre-Project Construction	Previously Evaluated	Monitoring Update
	04/07/92 – 11/17/95	12/23/97 – 03/16/06	05/31/06 – 03/13/12
Total Times Sampled:	41	92	29
Total Samples with DO Concentrations Below 5.0 mg/L:	2 (4.9%)	1 (1.1%)	2 (6.9%)
Number of Winter Samples:	16	28	6
DO Concentrations Below 5.0 mg/L during Winter Sampling:	0	0	0
Number of Summer Samples:	25	64	23

DO Concentrations Below 5.0 mg/L during Summer Sampling:	2 (8.0%)	1 (1.6%)	2 (8.7%)
Minimum DO Concentration (mg/L)	2.96	4.67	4.13
Maximum DO Concentration (mg/L)	22.70	28.29	22.58
Average DO Concentration (mg/L)	10.39	12.54	11.76

Site W-M329.3B:

	Pre-Project Construction	Previously Evaluated	Monitoring Update
	06/18/96 – 02/25/97	12/23/97 – 03/16/06	05/31/06 – 03/13/12
Total Times Sampled:	9	92	29
Total Samples with DO Concentrations Below 5.0 mg/L:	2 (22%)	1 (1.1%)	2 (6.9%)
Number of Winter Samples:	4	28	6
DO Concentrations Below 5.0 mg/L during Winter Sampling:	0	0	0
Number of Summer Samples:	5	64	23
DO Concentrations Below 5.0 mg/L during Summer Sampling:	2 (40%)	1 (1.6%)	2 (8.7%)
Minimum DO Concentration (mg/L)	2.72	4.67	4.76
Maximum DO Concentration (mg/L)	19.95	28.29	22.58
Average DO Concentration (mg/L)	10.58	12.54	11.76

Results from DO grab sample measurements taken at the Cottonwood project area show measurements below 5.0 mg/L at both monitoring sites, but none were observed during the critical winter months for aquatic biota. Within the current monitoring period, there were 2 occurrences of low DO at site W-M328.7B and 4 occurrences at site W-M329.3B, all during the summer season. A graphic summary of water quality grab sample results is shown in Graphs 1 and 2 of Appendix A.

The pre-construction average DO concentration for site W-M328.7B was 8.82 mg/L during the summer and 13.37 mg/L during the winter sampling seasons. Pre-construction DO concentrations ranged from 2.96 mg/L to 15.10 mg/L during the summer and from 8.46 mg/L to 22.70 mg/L during the winter. During the current monitoring period of May 2006 to March 2012, the average DO concentrations at site W-M328.7B increased to 9.57 mg/L during the

summer and 13.94 mg/L in the winter. Summer DO concentrations ranged from 4.13 mg/L to 22.58 mg/L, with winter readings measuring 7.79 mg/L to 19.98 mg/L. The 2 low DO concentration grab sample events occurred on September 6th 2006 and June 15th 2010. Results from in-situ continuous monitoring indicate an almost continuous period of low DO from August 27th to September 7th in 2006, for a total of 12 straight days. The low DO grab sample event on June 15th of 2010 only lasted two hours; yet continuous monitoring data results show a period of 3 days from June 17th to 20th the DO levels remained between 1.92 mg/L and 4.97 mg/L.

Using the limited pre-construction grab sample data at site W-M329.3B, the average DO concentration was 9.51 mg/L during the summer and 12.39 mg/L during the winter sampling seasons. Pre-construction DO concentrations ranged from 2.72 mg/L to 19.95 mg/L during the summer and from 12.01 mg/L to 12.70 mg/L during the winter. During the current monitoring period, the average DO concentrations at site W-M329.3B were 9.42 mg/L during the summer and 12.25 mg/L in the winter. Summer DO concentrations ranged from 4.76 mg/L to greater than 20.0 mg/L, with winter readings measuring 8.71 mg/L to 15.75 mg/L. The 4 low DO grab sample events occurred on June 15th 2010, June 21st, July 6th, and September 13th of 2011. All of these low DO events were within 0.25 mg/L of the 5.00 mg/L standard. Results from in-situ continuous monitoring indicate periods of low DO from June 12th to 14th and June 17th to 19th in 2010. Again in the summer of 2011, DO values remained below 5.0 mg/L during the periods of June 24th to 27th and July 1st to 9th. The low DO grab sample event on September 13th of 2011 only lasted two hours, returning to values above 5.0mg/L.

Conclusion. In summary, since the Cottonwood Island project was completed in 1997, DO values showed a slight increase during both the critical winter season (4% increase) and the summer season (8% increase) at site W-M328.7B. However, at site 329.3B, average DO concentrations have decreased by 1% during both the summer and winter monitoring seasons since project completion. The minimal decrease since project completion has little potential for negative impacts to aquatic biota, as average values over the entire post construction winter monitoring period still remain over double the standard value of 5.0 mg/L required to sustain healthy aquatic habitat. Low summer DO concentrations can occasionally be an issue at W329.3B, but low DO events are typically of such short duration that aquatic biota are not harmed, which is evidenced by the lack of fish kills reported.

B. Provide overwintering habitat for fish

General. The other objective for restoring aquatic overwintering habitat is to provide overwintering water habitat for fish through chute excavation and deep hole creation. As shown in Appendix B, Table B-1, the Year 50 Target for chute excavation is to maintain 4.5 acres of water area with a flat pool depth between 6 and 10 feet. The Year 50 Target for deep hole creation is to maintain 0.3 acres per hole of water area with a flat pool depth greater than or equal to 10 feet. Sedimentation transects for Cottonwood Chute were conducted in October 1997 to reflect as-built conditions of the overwintering water habitat. Since then, additional transects have not been completed but should be in the foreseeable future. According to Table C-2 in Appendix C, sedimentation transects are required every five years.

However, during water quality monitoring, chute depths at both stations were recorded. Station W-M328.7B is located adjacent to sedimentation Transect C. This portion of the chute was designed to have an ideal water depth greater than or equal to 10 feet at Year 50 and is labeled as a deep hole on the monitoring plan. Station W-M329.3B is located adjacent to sedimentation Transect J. This portion of the chute was designed to have an ideal water depth of 6 to 10 feet at Year 50.

Results. During water quality monitoring, chute depths at both stations were recorded. Station W-M328.7B is located adjacent to sedimentation transect "C". This portion of the chute was designed to have an ideal water depth greater than or equal to 10 feet at Year 50 and is labeled as a deep hole on the monitoring plan. Station W-M329.3B is located adjacent to sedimentation transect "J". This portion of the chute was designed to have an ideal water depth of 6 to 10 feet at Year 50.

At year 3, Station W-M328.7B had an average depth of 11.66 feet, which exceeded the ideal water depth of 10 feet. Station W-M329.3B had an average depth of 7.04 feet at Year 3, which met the ideal water depth of 6 to 10 feet. The flat pool depths for both monitoring sites were determined by adjusting the water depths recorded during site visits from December 1997 to September 2000. Using historical water profiles, the pool elevation for each day data was collected could be determined by interpolating between the nearest upstream and downstream gages. To view individual water depths for each site visit, refer to Appendix B. Based on this data, annual sedimentation rates can be estimated from the decrease in water depth, as shown in the tables below.

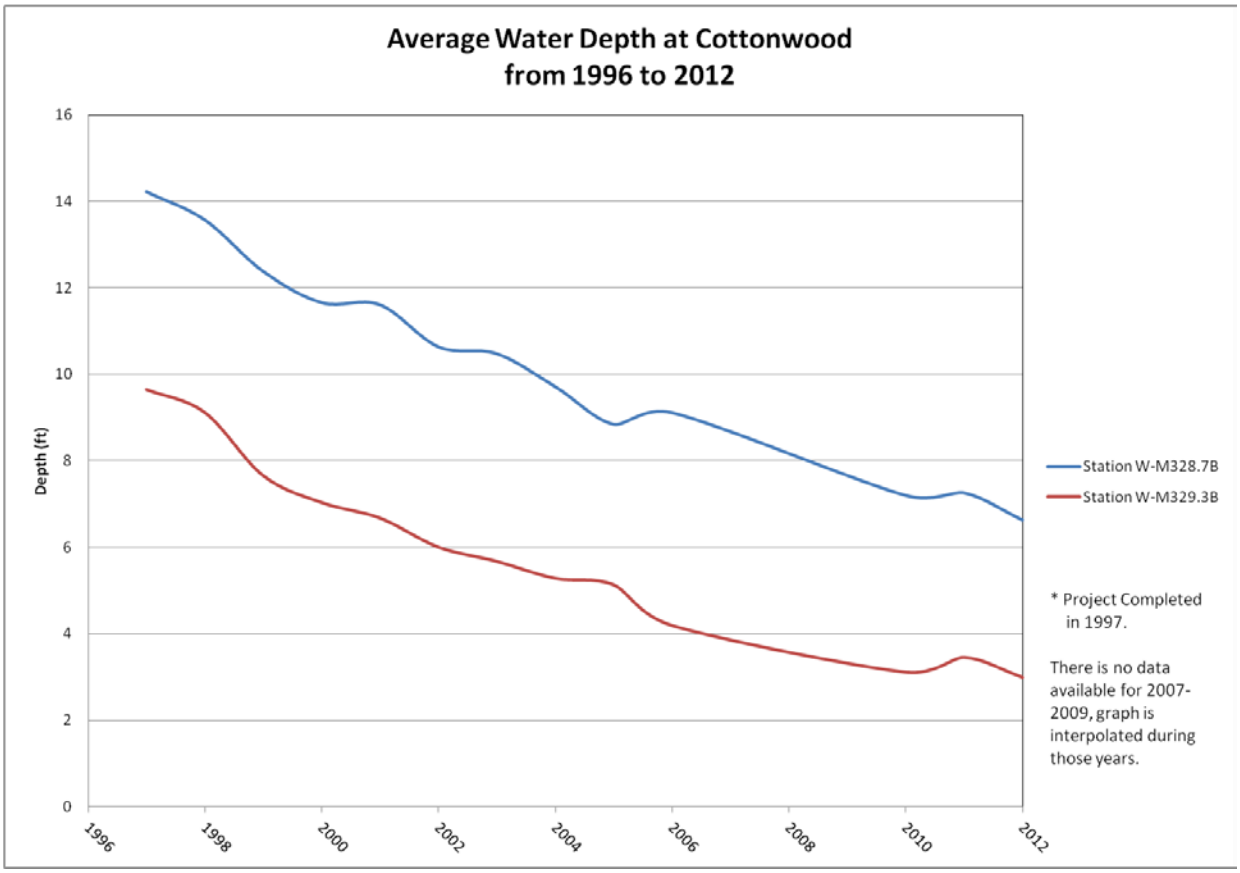
Station	Year	Ave Flat Pool Depth
W-M328.7B	1997	14.22
	1998	13.57
	1999	12.38
	2000	11.66
	2001	11.61
	2002	10.64
	2003	10.48
	2004	9.72
	2005	8.85
	2006	9.12
	2007	-
	2008	-
	2009	-
	2010	7.21
	2011	7.27
	2012	6.64

Station	Year	Ave Flat Pool Depth
W-M329.3B	1997	9.65
	1998	9.12
	1999	7.66
	2000	7.04
	2001	6.68
	2002	6.01
	2003	5.68
	2004	5.29
	2005	5.14
	2006	4.20
	2007	-
	2008	-
	2009	-
	2010	3.12
	2011	3.46
	2012	3.00

Pool depths values are shown in feet. There are no depth values for 2007 to 2009 due to lack of data, as no water quality monitoring was performed during that time frame.

The steady decline in water depths at both stations is indicative of sedimentation in the dredge channel. The average annual sedimentation rate from 1997 to 2005, the previous monitoring period, was 8.04 in/yr at site W-M328.7B and 6.72 in/yr at site W-M329.3B. During the most

recent sampling period, the estimated average sedimentation rate dropped to 6.19 in/yr for site W-M328.7B and 5.84 in/yr at site W-M329.3B. Although the sedimentation rate has decreased over the past two years, these rates are still considerably higher than the estimated sedimentation rates from the 1996 US Army Corps of Engineers DPR of 0.11 in/yr at W-M328.7B and 0.16 in/yr at site W-M329.3B.



Average water depth in feet at sites W-M328.7B and W-M329.3B of the Cottonwood project from years 1997 to 2006 and 2010 to 2012.

Response by fishes

In November 2000, the MDOC conducted an electrofishing survey in Cottonwood Chute. A water surface temperature of 53° Fahrenheit was recorded at the time of the sample. Secchi visibility was not measured, but water transparency was variable with distance along the chute from the mouth to the upper end. The upper end of the chute had a light coverage of duckweed and watermeal. The Mississippi River was estimated at one to two feet below normal pool elevation due to drought conditions at that time.

A total of 340 fish were captured, representing 19 species and one hybrid. Two sampling runs along the portion of the chute where deep holes were constructed comprised nearly two-thirds of the effort and yielded nearly three-fourths of the catch. A summary of this survey is presented in Table 5-4.

TABLE 5-4

Summary of Electrofishing Survey, November 2000

Species	No.	Length Range (Inches)	Average Length (Inches)
Paddlefish	1	33.0	-
Bowfin	2	17.6 - 21.1	19.4
Gizzard shad	37	3.9 - 8.6	6.1
Grass carp	1	18.2	-
Common carp	29	17.0 - 27.2	20.8
Emerald shiner	2	1.5 - 1.8	1.7
River carpsucker	12	14.6 - 17.3	16.3
Quillback	1	14.1	-
Smallmouth buffalo	8	10.7 - 16.7	13.4
Bigmouth buffalo	16	13.2 - 20.8	16.0
Channel catfish	7	15.9 - 24.8	19.7
Brook silversides	1	2.8	-

White bass	4	12.8 - 14.5	13.6
Green sunfish	5	2.4 - 8.7	4.6
Orangespotted sunfish	6	2.0 - 3.0	2.5
Bluegill	93	1.8 - 6.6	4.3
Largemouth bass	69	3.1 - 13.8	5.8
White crappie	35	3.0 - 13.0	9.4
Black crappie	10	4.7 - 10.6	7.7
Hybrid sunfish	1	4.4	-
TOTAL	**340**	**1.5 – 33.0**	**11.7**

A previous electrofishing survey was conducted by the MDOC in October 1998. This survey yielded 398 fish representing 20 species. When comparing the two surveys, fewer gizzard shad, carp, and white bass were found in 2000. The combination of these lower numbers with the absence of freshwater drum resulted in a decrease of the total count. However, the 2000 survey did contain more largemouth bass, bluegill, and white crappie. Most of the largemouth bass consisted of young-of-the-year and yearlings, causing the average length to be lower than in 1998.

The MDOC has expressed concerns about the construction of an impermeable causeway road and the effects this may have on fish numbers in Cottonwood Chute. MDOC explained that the advantage of a permeable road is that it does allow some water to flow through the structure and therefore creates better water quality both upstream and downstream of the structure. If a similar structure were built on a future project, MDOC would still recommend the permeable structure. Further monitoring of water quality parameters and fish numbers should determine these effects.

Conclusion. The steady decline in water depths at both stations is indicative of sedimentation in the dredge channel. The average annual sedimentation rate from 1997 to

2005, the previous monitoring period, was 8.04 in/yr at site W-M328.7B and 6.72 in/yr at site W-M329.3B. During the most recent sampling period, the estimated average sedimentation rate dropped to 6.19 in/yr for site W-M328.7B and 5.84 in/yr at site W-M329.3B. Although the sedimentation rate has decreased over the past two years, these rates are still considerably higher than the estimated sedimentation rates from the 1996 US Army Corps of Engineers DPR of 0.11 in/yr at W-M328.7B and 0.16 in/yr at site W-M329.3B.

C. Provide flowing water habitat for fish

General. . In order to attain the goal of restoring main channel border habitat, several wing dams extending from Cottonwood Island were notched. This was done in an effort to provide flowing water habitat for fish. The Year 50 Target is to maintain velocities of 0.35, 0.5, and 0.4 feet per second (ft/sec) at the following locations: 100 feet upstream of the notch, at the notch, and 100 feet downstream from the notch, respectively (see Appendix B, Table B-1). It was anticipated that water velocity would increase downstream of the notch and create a scour hole, as was the case in Iowa DNR and Waterways Experiment Station (WES) studies referenced in Appendix I of the Cottonwood Island Definite Project Report.

Pre- and Post-Project Conditions. . During previous monitoring periods, velocity and depth measurements were taken at points 100 feet upstream of the notch, at the notch, and 100 feet downstream from the notch. The results of these velocity measurements, including ancillary data, are found in Appendix E, Tables E-4 through E-9. A summary of velocities at the individual notches is illustrated in Table F-10, Appendix F. Velocity and depth measurements were not taken during the 2002 monitoring period.

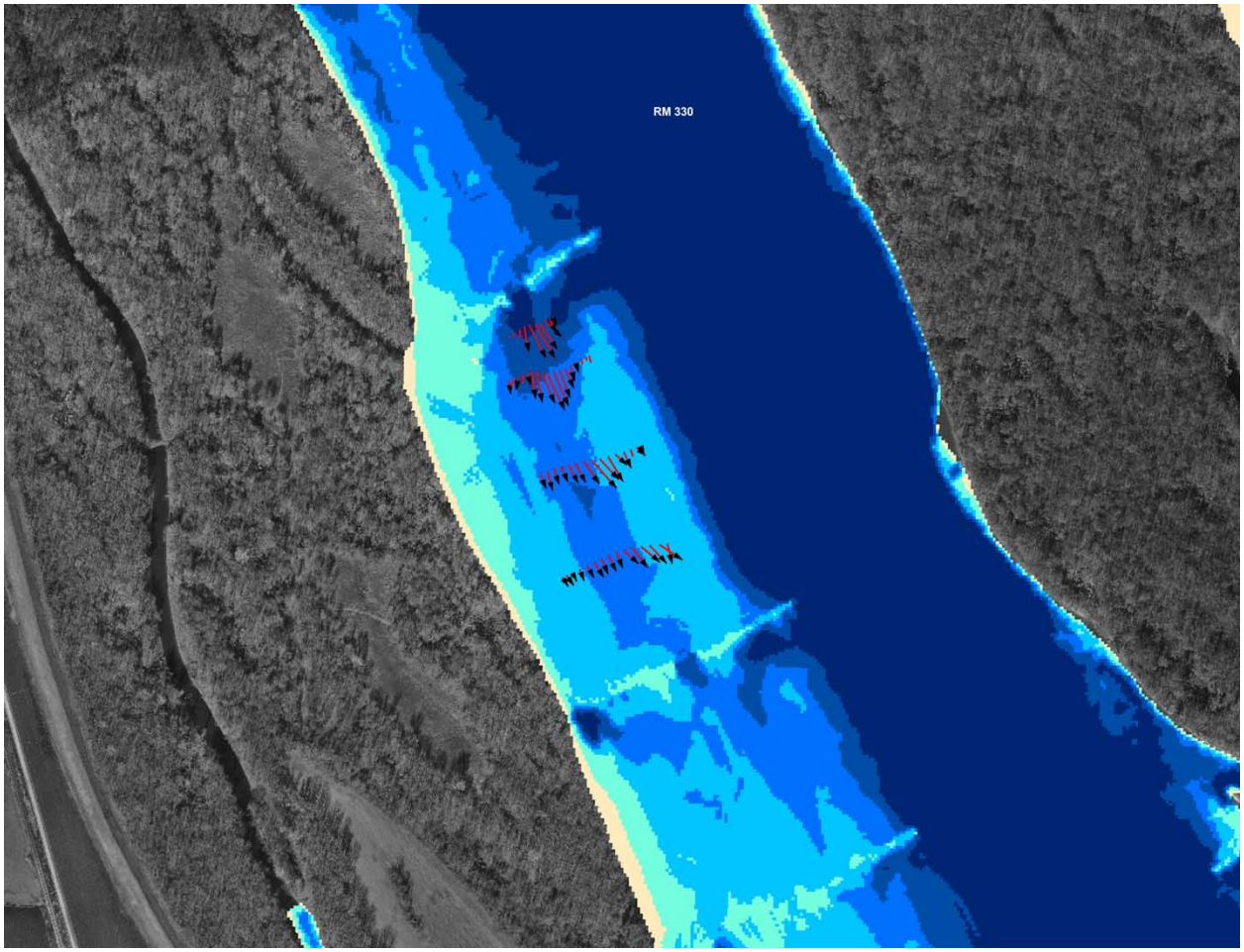
TABLE 6-1.

Summary of Notch Velocities at Wing Dams

Year	100' U/S No. 6 (Ft/s)	100' U/S No. 15 (Ft/s)	At No. 6 (Ft/s)	At No. 15 (Ft/s)	100' D/S No. 6 (Ft/s)	100' D/S No. 15 (Ft/s)
0 (1997)	1.05	0.88	2.06	1.29	1.93	1.32

Average	0.97		1.67		1.62	
1 (1998)	1.68	1.33	2.18	1.57	1.80	1.64
Average	1.50		1.87		1.72	
2 (1999)	1.22	1.10	1.85	1.33	1.47	1.47
Average	1.16		1.59		1.47	
3 (2003)	0.57	0.51	1.24	0.77	0.81	0.60
Average	0.54		1.01		0.70	
0-3 (97-00)	1.13	0.96	1.37	1.24	1.50	1.26
Average	1.05		1.31		1.38	
50 (Target)	**0.35**		**0.50**		**0.40**	

As seen in Table 6-1, the average velocity 100 feet upstream from Wing Dam No. 6 was 1.13 feet per second. This value increased to 1.37 feet per second at the notch and then rose to 1.50 feet per second 100 feet downstream from the notch. At Wing Dam No. 15, the average velocity 100 feet upstream was 0.96 feet per second. This value increased to 1.24 feet per second at the notch and 1.26 feet per second 100 feet downstream from the notch. Although the velocity measurements observed do not support the FastTABS modeling results, the refuge manager has been very pleased with the results of the notches over the years. Potential for damaging scouring and excessive velocities as stated in the DPR appear to not be of concern.



The image above shows the results of velocity measurements gathered in 2004 with an acoustic doppler current profiler (ADCP). Water depth is depicted by blue coloration, with the hue of blue getting darker as water depth increases. The red arrows show the direction and velocity of water flow, with longer arrows indicating areas of greater flow velocity.

Conclusion. Post-project measurements taken at Wing Dam Nos. 6 and 15 indicate that notching does have an impact on velocity. At both wing dams, average velocity measurements both at the notch and 100 feet downstream, were considerably higher than those observed 100 feet upstream. These findings tend to agree with the results of similar studies reported by the Iowa DNR and WES.

D. Provide additional habitat and substrate for benthic and aquatic organisms

General. The other objective for restoring main channel border habitat is to provide additional habitat and substrate for benthic and aquatic organisms through rock placement below the wing dams. As shown in Appendix B, Table B-1, the Year 50 Target is to maintain constant numbers of benthic and aquatic organisms. As part of the ancillary data for the velocity measurements, water depths were recorded. These water depths were used to analyze the scour depth downstream of the wing dams.

Pre- and Post-Project Conditions. The flat pool depths for both wing dams, as shown in Table 6-2, were determined by adjusting the channel depths recorded during site visits from June 1997 to September 2000. Using historical water profiles, the pool elevation at the Cottonwood HREP could be determined by interpolating between two stream gages. To view individual channel depths for each site visit and the intermediate used to compare the values to depths relative to flat pool, refer to Appendix F, Tables F-3 through F-8. A summary of individual scour depths is illustrated in Appendix F, Table F-9.

TABLE 6-2.

Summary of Notch Scour Depths 100' D/S of Wing Dams

Year	No. 6 Water Depth (Feet)	No. 6 Scour Depth (Feet)	No. 15 Water Depth (Feet)	No. 15 Scour Depth (Feet)
0 (1997)	19.39		10.95	
0-1		1.39		0.21
1 (1998)	20.78		11.16	
1-2		0.18		0.33
2 (1999)	20.96		11.49	

2-3		2.31		1.17
3 (2000)	23.27		12.66	
0-4		3.88		1.71

The average flat pool channel depth for Year 0 was used as the base line in determining scour depth. The average scour depth 100 feet downstream from Wing Dam No. 6 was 3.88 feet. At Wing Dam No. 15, the average scour depth 100 feet downstream was 1.71 feet. As seen in Table 6-2, Wing Dams No. 6 and 15 achieved a scour depth greater than one foot by Years 2 and 3, respectively.

Conclusions. The Cottonwood HREP is meeting the goal of rehabilitating main channel border habitat by creating scour depths greater than or equal to 1 foot downstream from the notch with respect to Wing Dam No. 6 and No. 15. It could be assumed that these depths are representative of all notched wing dams but since the monitoring results were based solely on ancillary data collected at only two wing dams, it is not known for sure if this is indeed the case. In addition, the locations of the velocity measurements are determined through use of landmarks rather than coordinates, so channel depths are not necessarily recorded in the exact same spot each time. Therefore, future sedimentation transects based on the monitoring plan should provide more adequate data to better define scour depths and size for all of the notched wing dams. At both wing dams, average channel depths at the notch and 100 feet upstream from the notch essentially remained the same while those depths 100 feet downstream from the notch gradually increased. By the end of Year 4, both wing dams had scour depths greater than one foot. Cross sections are necessary downstream from the notches to determine the extent and size of these scour areas.

E. Increase Food, Shelter, and Breeding Habitat for Wildlife

General. One of the objectives for restoring wetland habitat is to increase food, shelter, and breeding habitat for wildlife through pothole creation. As shown in Appendix B, Table B-1, the Year 50 Target is to maintain a cross-sectional area (short chord) below elevation 475 feet MSL similar to that determined at project completion with some allowance for sedimentation. Pothole transects were conducted in October 1997 and August 2002 to reflect as-built conditions of the food, shelter, and breeding habitat. According to Table C-2 in Appendix C, pothole transects are only required every five years.

Pre- and Post-Project Conditions.

Areas surrounding the potholes have been planted with millet. General comments regarding pothole use have been made by the MDOC. In particular, the MDOC Site Manager has not observed any pothole use by waterfowl. However, field observations indicate that these areas are receiving use by amphibians, particularly bullfrogs and possibly tree frogs, and are visited regularly by great blue herons. In addition, deer and turkey tracks are typically abundant around the perimeter of the potholes. In the past year, waterfowl surveys or any other type of scientific survey based on wildlife usage for Cottonwood Island have not been conducted. Waterfowl surveys are only performed every other year.

Conclusion. Overall, the Cottonwood HREP appears to be meeting the objective of increasing food, shelter, and breeding habitat for wildlife through pothole creation. Post–construction field observations have shown pothole use by various animals. Future monitoring will show pothole use by waterfowl.

F . Increase Bottomland Hardwood Diversity and Quality

General. The other objective for restoring wetland habitat is to increase bottomland hardwood diversity and quality through establishment of hardwood trees within the forest management units. As shown in Appendix B, Table B-1, the Year 50 Target is to maintain a survival rate greater than or equal to 20%.

Pre- and Post-Project Conditions. The MDOC Site Manager has performed regular maintenance of the forest management units. A survival rate of 65% was observed for the Upper site, 75-80% for the Middle site and 80-85% for the Lower site. The red top grass that was planted has successfully choked out the other weeds and has required relatively minimal mowing. The MDOC Site Manager reports that the grass is typically mowed about twice per year. These sites were being mowed during the site visit in November 2001 as illustrated in Appendix G. Discussion of the efficacy of tree fences versus deer repellant was intended for inclusion in this report. Unfortunately, due to changes in MDOC personnel, routine observation

of this response was not maintained. However, during the August 13, 2006 site visit, MDOC Site Manager reported that the trees with fence protection were susceptible to competition from vines that readily grow up along the fences. These vines often shade and choke out the saplings. Furthermore it was noted that the fences can cause branches to get stuck, resulting in damage as the tree grows. Beginning in Fall 2004 wheat was planted between the rows of trees as a weed reduction measure. This has proven successful based on feedback from the MDOC site manager.

Conclusion. Based on results from the mast tree survey taken on August 13, 2006, the overall survival rates for each of the mast tree planting sites are meeting the 50 year goal of 20%. Although routine monitoring of the efficacy of deer repellant spray versus tree fences is no longer ongoing, we can make some general conclusions regarding the performance of the tree fences. The overall effectiveness of the tree fences as a deer repellant may be outweighed due to increased weed growth with which the fences are associated.

LESSONS LEARNED AND RECOMMENDATIONS FOR FUTURE SIMILAR PROJECTS

The goals and objectives established in the DPR have been mostly met. Regular monitoring data has not been collected for this project; however ancillary data indicated that the objectives are being achieved for the most part. The opportunity to conduct more and regular monitoring data would increase the success rate for the Cottonwood Island HREP.

REFERENCES

1) Definite Project Report with Integrated Environmental Assessment (R-16F), Cottonwood Island Habitat Rehabilitation and Enhancement, Upper Mississippi River System Environmental Management Program, Pool 21, Mississippi River Miles 328.5 – 331.0, Lewis and Marion Counties, Missouri, June 1996. 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, Environmental Management Program, Pool 21, River Miles 328.5 thru 331.0, Cottonwood Island Rehabilitation and Enhancement, Solicitation No. DACW25-97-B-0011. These documents were prepared to provide sufficient detail for construction of the hydraulically dredged chutes / deep holes and mechanically excavated potholes, as well as notching of the existing wing dams.

(3) Plans and Specifications, Upper Mississippi River, Environmental Management Program, Pool 21, River Miles 328.5 thru 331.0, Cottonwood Island Rehabilitation and Enhancement, Stage II, Solicitation No. DACW25-99-B-0005. These documents were prepared to provide sufficient detail for construction of the mast tree areas.

(4) Plans and Specifications, Upper Mississippi River System, Environmental Management Program, Pool 21, Cottonwood Island, Stage III, Causeway Road Raise, Solicitation No. DACW25-00-T-0006. These documents were prepared to provide sufficient detail for construction of the causeway road.

(5) Operation and Maintenance Manual, Cottonwood Island Rehabilitation and Enhancement, Upper Mississippi River Environmental Management Program, Pool 21, River Miles 328.5 Through 331.0, Lewis and Marion Counties, Missouri, January 2001. This manual was prepared to serve as a guide for the operation and maintenance of the Cottonwood HREP project. Operation and maintenance instructions for major features of the project are presented.

(6) Post-Construction Performance Evaluation Report – Year 3 (2000), Cottonwood Island Habitat Rehabilitation and Enhancement, Upper Mississippi River System Environmental Management Program, Pool 21, Upper Mississippi River Miles 328.5 – 331.0, Lewis and Marion Counties, Missouri, June 2001.

(7) (6) Post-Construction Performance Evaluation Report – Year 4 (2001), Cottonwood Island Habitat Rehabilitation and Enhancement, Upper Mississippi River System Environmental Management Program, Pool 21, Upper Mississippi River Miles 328.5 – 331.0, Lewis and Marion Counties, Missouri, June 2002.

APPENDIX A

Water Quality Assessment

COTTONWOOD ISLAND
MISSISSIPPI RIVER
LEWIS COUNTY, MO
MARION COUNTY, MO

POST-CONSTRUCTION PERFORMANCE EVALUATION REPORT

WATER QUALITY ANALYSIS

August 2012

US Army Corps of Engineers
Rock Island District

COTTONWOOD ISLAND POST-CONSTRUCTION
PERFORMANCE EVALUATION REPORT
WATER QUALITY ANALYSIS

TABLE OF CONTENTS

APPENDICES

COTTONWOOD ISLAND PERFORMANCE EVALUATION REPORT (WATER QUALITY)

Goal: Restore aquatic overwintering, main channel border, and wetland habitats.

Objectives: Improve water quality for fish; provide overwintering habitat for fish; provide flowing water habitat for fish; and provide additional habitat and substrate for benthic and aquatic organisms

Enhancement Features: Water control structure, dredging, deflection levee

Background: The water quality objectives of the Cottonwood Island project are to improve water quality for fish, provide overwintering habitat for fish, provide flowing water habitat for fish, and provide additional habitat and substrate for benthic and aquatic organisms (See vicinity map and project features map on Plate 1 and 2of Appendix A). Prior to project construction, the Cottonwood area provided important wetland habitat in the low swales present on Cottonwood Island and deep water aquatic habitat in Cottonwood Chute, but sedimentation greatly reduced the quantity and quality of these habitat areas, especially in the chute's upper end. In the chute's shallow areas, low dissolved oxygen (DO) values reached critical levels and fish species diversity decreased.

To achieve the stated goal of enhancing aquatic habitat value, the lower 4,550 feet of Cottonwood Chute was mechanically excavated. The bottom width of the dredge cut was 40 feet, with a depth of 9 feet below flat pool (elevation 470 feet MSL 1912). Cottonwood Chute also includes four deep holes, 300 feet long and 15 feet below flat pool. Deep water areas were reestablished in Cottonwood Chute to provide a greater volume of oxygenated water to sustain fish during extended periods of ice cover when dissolved oxygen levels can reach below the critical threshold of 5.0 mg/L, as defined by the Missouri State Standard for the Protection of Aquatic Life.

To enhance flowing water habitat for fish and provide additional habitat and substrate for benthic and aquatic organisms, six wing dams were notched. The notches were created by removing existing wing dam material to the original river bottom or a maximum of 10 feet below flat pool. Each notch was 100 feet long. A post-construction monitoring effort in 2004 indicates the formation of scour holes behind the wing dams and an increase in velocity at and below the notches.

Water quality baseline monitoring was performed from 7 April 1992 to 17 November 1995 at Site W-M328.7B, with minimal baseline monitoring performed at Site W-M329.3B (See water quality monitoring station locations on Plate 3 of Appendix A). Results of the baseline monitoring can be found in the Water Quality Appendix to the Definite Project Report (DPR) with Integrated Environmental Assessment for Cottonwood Habitat Rehabilitation and Enhancement. To determine the effectiveness of attaining the project goals, post-project water quality monitoring commenced on December 23, 1997 at sites W-M328.7B and W-M329.3B. Previous performance evaluation reports discuss the results of water quality monitoring through 16 March 2006. This update discusses post project construction water quality monitoring data collected by USACE Water Quality and Sedimentation Section (EC-HQ) personnel from 31 May 2006 to 13 March 2012. Due to the cyclical nature of Rock Island District's EMP water quality monitoring program, sampling was not performed from 2007 to 2009.

During the study period noted above for Cottonwood, EC-HQ personnel performed water quality monitoring at 2 sites: W-M328.7B and W-M329.3B. Data gathered by EC-HQ staff included a combination of both periodic grab samples and in-situ continuous monitors (YSI 6000 and 6600-V2

series and Hach DS5X series sondes). Grab samples were gathered near the surface. The sites were usually visited biweekly during the summer season of June through September and 3 or 4 times total per winter season of December through March. 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, total suspended solids (TSS), chlorophyll (a, b and c) and pheophytin a.

Monitoring Results: Results of in-situ continuous water quality monitoring performed after project completion at both sites is voluminous and discussed briefly in this report, but results can be provided upon request to the District. For pre-project baseline monitoring results performed at site W-M328.7B, refer to the Water Quality Appendix of the Definite Project Report (DPR) with Integrated Environmental Assessment for Cottonwood Habitat Rehabilitation and Enhancement.

The following tables provide a summary of grab sample DO concentration results at each monitoring site during pre- and post construction.

Site W-M328.7B:

	Pre-Project Construction	Previously Evaluated	Monitoring Update
	04/07/92 – 11/17/95	12/23/97 – 03/16/06	05/31/06 – 03/13/12
Total Times Sampled:	41	92	29
Total Samples with DO Concentrations Below 5.0 mg/L:	2 (4.9%)	1 (1.1%)	2 (6.9%)
Number of Winter Samples:	16	28	6
DO Concentrations Below 5.0 mg/L during Winter Sampling:	0	0	0
Number of Summer Samples:	25	64	23
DO Concentrations Below 5.0 mg/L during Summer Sampling:	2 (8.0%)	1 (1.6%)	2 (8.7%)
Minimum DO Concentration (mg/L)	2.96	4.67	4.13
Maximum DO Concentration (mg/L)	22.70	28.29	22.58
Average DO Concentration (mg/L)	10.39	12.54	11.76

Site W-M329.3B:

	Pre-Project Construction	Previously Evaluated	Monitoring Update
	06/18/96 – 02/25/97	12/23/97 – 03/16/06	05/31/06 – 03/13/12
Total Times Sampled:	9	92	29
Total Samples with DO Concentrations Below 5.0 mg/L:	2 (22%)	1 (1.1%)	2 (6.9%)
Number of Winter Samples:	4	28	6
DO Concentrations Below 5.0 mg/L during Winter Sampling:	0	0	0
Number of Summer Samples:	5	64	23
DO Concentrations Below 5.0 mg/L during Summer Sampling:	2 (40%)	1 (1.6%)	2 (8.7%)
Minimum DO Concentration (mg/L)	2.72	4.67	4.76
Maximum DO Concentration (mg/L)	19.95	28.29	22.58
Average DO Concentration (mg/L)	10.58	12.54	11.76

As identified in Table 13-4 of the Pool 11 Islands DPR, water quality related post construction evaluation criteria includes dissolved oxygen concentration, current velocity, and water depth. The minimum dissolved oxygen standard, particularly during winter months, was set at 5.0 mg/L for all out-years. Current velocity relates to the notched wing dams project feature and has a 50 year target of 0.40 ft/sec at 100' downstream of the notched wing dams. Another important water quality parameter identified in Table 13-4 of the DPR evaluation plan that needs to be discussed as an overall project objective is water depth, which has a 50 year target of 4.5 acres of aquatic habitat with a depth of at least 6' and no more than 10' and 0.3 acres of scour hole habitat with a depth of at least 10'. Although there have been no bathymetric surveys to measure against, the water depth objective can be evaluated by comparing pre and post project construction average annual water depths at the 2 water quality monitoring sites, as shown in Graphs 3 and 4 of Appendix A.

Dissolved Oxygen. Results from DO grab sample measurements taken at the Cottonwood project area show measurements below 5.0 mg/L at both monitoring sites, but none were observed during the critical winter months for aquatic biota. Within the current monitoring period, there were 2 occurrences of low DO at site W-M328.7B and 4 occurrences at site W-M329.3B, all during the summer season. A graphic summary of water quality grab sample results is shown in Graphs 1 and 2 of Appendix A.

The pre-construction average DO concentration for site W-M328.7B was 8.82 mg/L during the summer and 13.37 mg/L during the winter sampling seasons. Pre-construction DO concentrations ranged from 2.96 mg/L to 15.10 mg/L during the summer and from 8.46 mg/L to 22.70 mg/L during the winter. During the current monitoring period of May 2006 to March 2012, the average DO concentrations at site W-M328.7B increased to 9.57 mg/L during the summer and 13.94 mg/L in the winter. Summer DO concentrations ranged from 4.13 mg/L to 22.58 mg/L, with winter readings measuring 7.79 mg/L to 19.98 mg/L. The 2 low DO concentration grab sample events occurred on September 6th 2006 and June 15th 2010. Results from in-situ continuous monitoring indicate an almost continuous period of low DO from

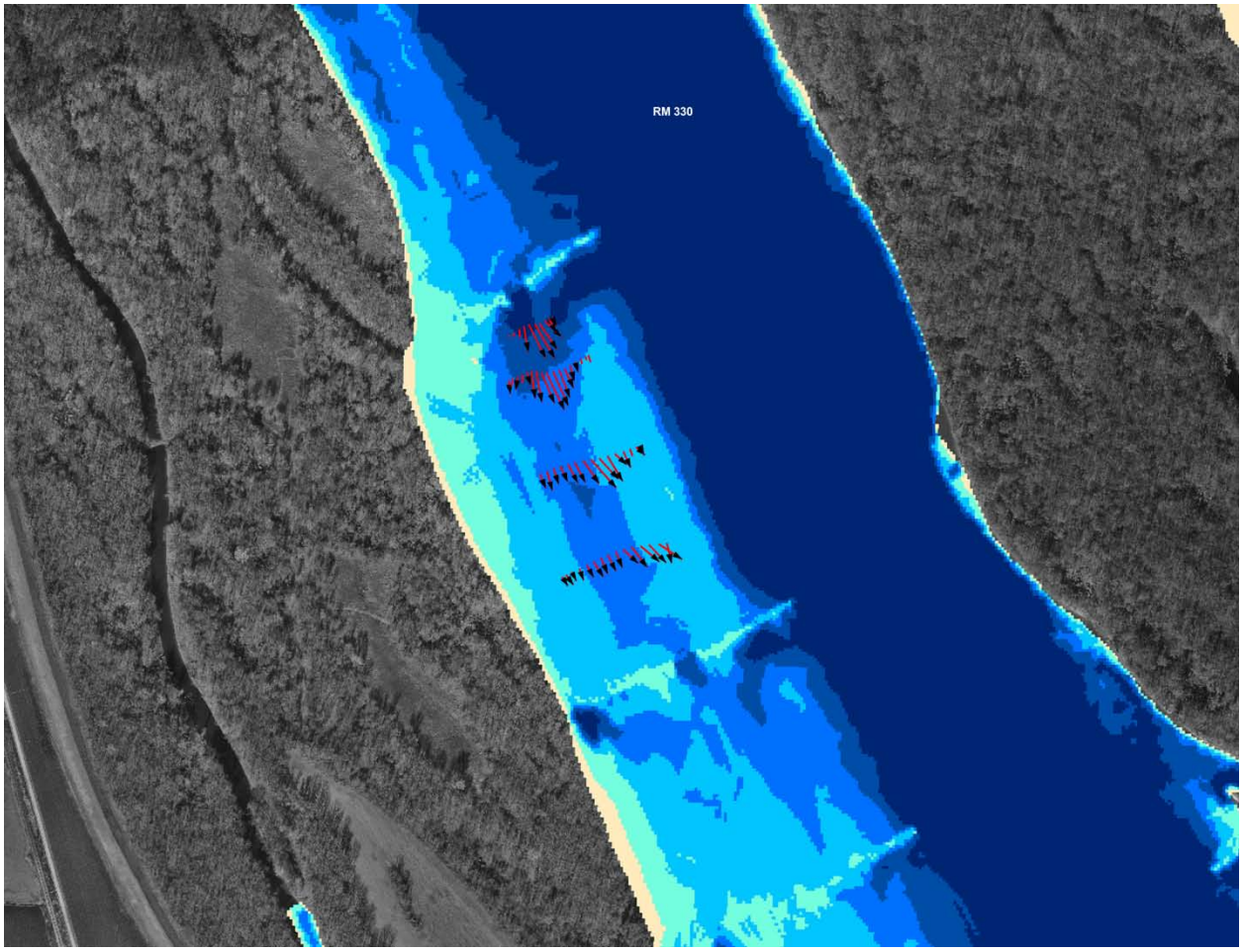
August 27th to September 7th in 2006, for a total of 12 straight days. The low DO grab sample event on June 15th of 2010 only lasted two hours; yet continuous monitoring data results show a period of 3 days from June 17th to 20th the DO levels remained between 1.92 mg/L and 4.97 mg/L.

Using the limited pre-construction grab sample data at site W-M329.3B, the average DO concentration was 9.51 mg/L during the summer and 12.39 mg/L during the winter sampling seasons. Pre-construction DO concentrations ranged from 2.72 mg/L to 19.95 mg/L during the summer and from 12.01 mg/L to 12.70 mg/L during the winter. During the current monitoring period, the average DO concentrations at site W-M329.3B were 9.42 mg/L during the summer and 12.25 mg/L in the winter. Summer DO concentrations ranged from 4.76 mg/L to greater than 20.0 mg/L, with winter readings measuring 8.71 mg/L to 15.75 mg/L. The 4 low DO grab sample events occurred on June 15th 2010, June 21st, July 6th, and September 13th of 2011. All of these low DO events were within 0.25 mg/L of the 5.00 mg/L standard. Results from in-situ continuous monitoring indicate periods of low DO from June 12th to 14th and June 17th to 19th in 2010. Again in the summer of 2011, DO values remained below 5.0 mg/L during the periods of June 24th to 27th and July 1st to 9th. The low DO grab sample event on September 13th of 2011 only lasted two hours, returning to values above 5.0mg/L.

In summary, since the Cottonwood Island project was completed in 1997, DO values showed a slight increase during both the critical winter season (4% increase) and the summer season (8% increase) at site W-M328.7B. However, at site 329.3B, average DO concentrations have decreased by 1% during both the summer and winter monitoring seasons since project completion. The minimal decrease since project completion has little potential for negative impacts to aquatic biota, as average values over the entire post construction winter monitoring period still remain over double the standard value of 5.0 mg/L required to sustain healthy aquatic habitat. Low summer DO concentrations can occasionally be an issue at W329.3B, but low DO events are typically of such short duration that aquatic biota are not harmed, which is evidenced by the lack of fish kills reported.

Current Velocity. Several wing dams extending from Cottonwood Island were notched in an effort to restore main channel border habitat. This was done in an effort to provide flowing water habitat for fish. The Year 50 Target is to maintain velocities of 0.35, 0.5, and 0.4 ft/sec at the following locations: 100 feet upstream of the notch, at the notch, and 100 feet downstream from the notch, respectively. It was anticipated that water velocity would increase downstream of the notch and create a scour hole.

In an effort to determine the actual impact of these notches, post-construction velocity measurements were taken from 23 December to 19 September 2000, and again in 2004. At each wing dam, velocity measurements were taken with a Price meter at points 100 feet upstream of the notch, at the notch, and 100 feet downstream from the notch. Post-project measurements taken at Wing Dam Nos. 6 and 15 indicate that notching does have an impact on velocity. At both wing dams, average velocity measurements at the notch and 100 feet downstream of the notch were considerably higher than those observed 100 feet upstream.



The image above shows the results of velocity measurements gathered in 2004 with an acoustic doppler current profiler (ADCP). Water depth is depicted by blue coloration, with the hue of blue getting darker as water depth increases. The red arrows show the direction and velocity of water flow, with longer arrows indicating areas of greater flow velocity.

See Appendix E, Tables E-4 through E-9, of the 2006 Cottonwood Island PER for a summary of results from velocity and depth measurements taken at the wing dam notches. No further monitoring has been performed since that effort.

Water Depth. During water quality monitoring, chute depths at both stations were recorded. Station W-M328.7B is located adjacent to sedimentation transect "C". This portion of the chute was designed to have an ideal water depth greater than or equal to 10 feet at Year 50 and is labeled as a deep hole on the monitoring plan. Station W-M329.3B is located adjacent to sedimentation transect "J". This portion of the chute was designed to have an ideal water depth of 6 to 10 feet at Year 50.

At year 3, Station W-M328.7B had an average depth of 11.66 feet, which exceeded the ideal water depth of 10 feet. Station W-M329.3B had an average depth of 7.04 feet at Year 3, which met the ideal water depth of 6 to 10 feet. The flat pool depths for both monitoring sites were determined by adjusting the water depths recorded during site visits from December 1997 to September 2000. Using historical water profiles, the pool elevation for each day data was collected could be determined by interpolating between

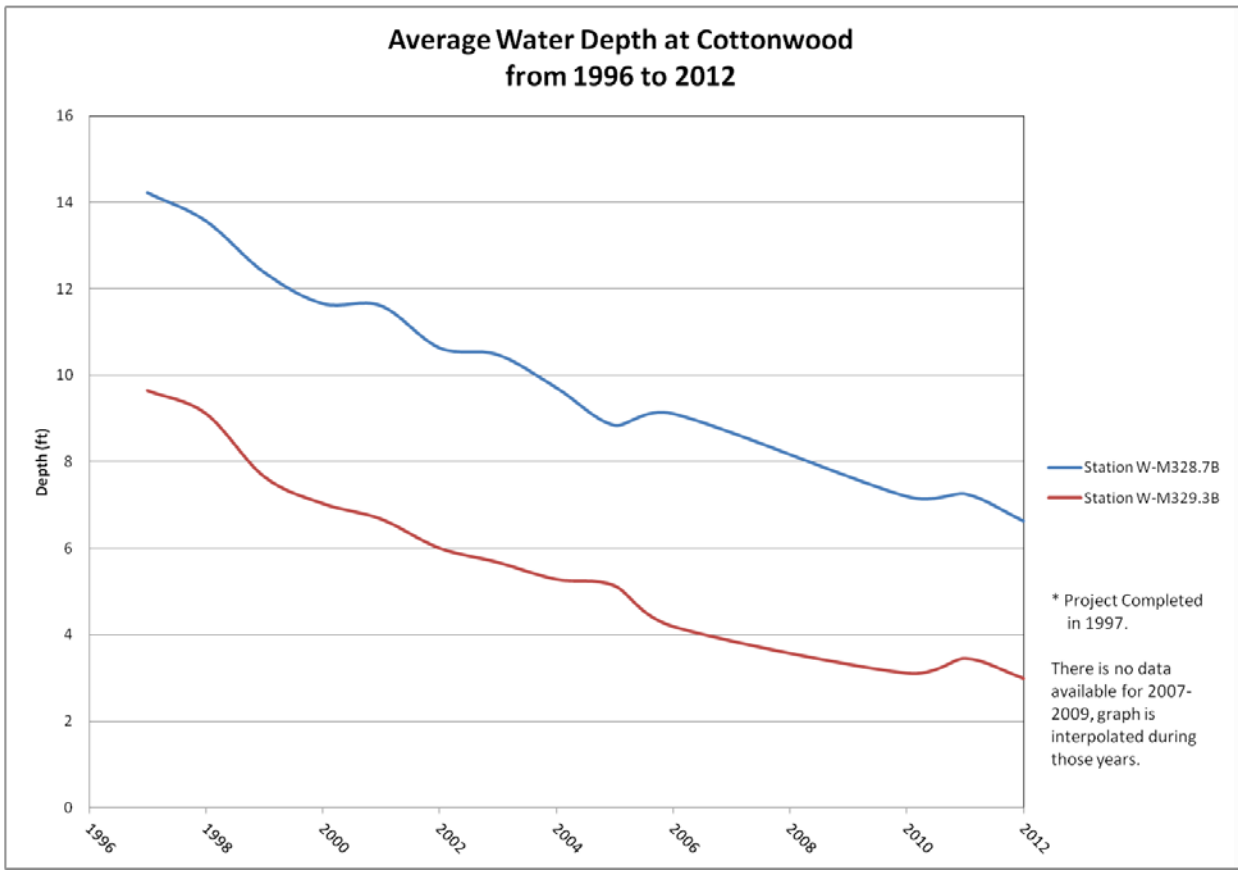
the nearest upstream and downstream gages. To view individual water depths for each site visit, refer to Appendix B. Based on this data, annual sedimentation rates can be estimated from the decrease in water depth, as shown in the tables below.

Station	Year	Ave Flat Pool Depth
W-M328.7B	1997	14.22
	1998	13.57
	1999	12.38
	2000	11.66
	2001	11.61
	2002	10.64
	2003	10.48
	2004	9.72
	2005	8.85
	2006	9.12
	2007	-
	2008	-
	2009	-
	2010	7.21
	2011	7.27
	2012	6.64

Station	Year	Ave Flat Pool Depth
W-M329.3B	1997	9.65
	1998	9.12
	1999	7.66
	2000	7.04
	2001	6.68
	2002	6.01
	2003	5.68
	2004	5.29
	2005	5.14
	2006	4.20
	2007	-
	2008	-
	2009	-
	2010	3.12
	2011	3.46
	2012	3.00

Pool depths values are shown in feet. There are no depth values for 2007 to 2009 due to lack of data, as no water quality monitoring was performed during that time frame.

The steady decline in water depths at both stations is indicative of sedimentation in the dredge channel. The average annual sedimentation rate from 1997 to 2005, the previous monitoring period, was 8.04 in/yr at site W-M328.7B and 6.72 in/yr at site W-M329.3B. During the most recent sampling period, the estimated average sedimentation rate dropped to 6.19 in/yr for site W-M328.7B and 5.84 in/yr at site W-M329.3B. Although the sedimentation rate has decreased over the past two years, these rates are still considerably higher than the estimated sedimentation rates from the 1996 US Army Corps of Engineers DPR of 0.11 in/yr at W-M328.7B and 0.16 in/yr at site W-M329.3B.



Average water depth in feet at sites W-M328.7B and W-M329.3B of the Cottonwood project from years 1997 to 2006 and 2010 to 2012.

Discussion and Conclusions. The water quality objectives of the Cottonwood Island project are to improve water quality for fish, provide overwintering habitat for fish, provide flowing water habitat for fish, and provide additional habitat and substrate for benthic and aquatic organisms. To meet the objective of improving water quality, the chute was deepened to allow for a greater volume of oxygen to sustain fish during extended periods of ice cover. The goal was to maintain a DO concentration above 5 mg/l during the winter months. In order attain the goal of restoring main channel border habitat with flowing water, several wing dams extending from Cottonwood Island were notched. It was anticipated that water velocity would increase downstream of the notch and create a scour hole.

In comparing overall pre- and post-construction average DO values since the Cottonwood Island project was completed in 1997, average DO values showed a small increase during both the critical winter season

(4% increase) and the summer season (8% increase) at site W-M328.7B. At site 329.3B, average DO concentrations decreased slightly by 1% during both the summer and winter monitoring seasons since project completion. When examining the grab sample results closer, a trend in average DO concentrations for both sites shows an initial increase, followed by a decrease (See Graphs 1 and 2 of Appendix A). Average DO concentrations increased each year at both sites during approximately the first 5 years after project completion, but starting around 2003 at site 329.3B and 2001 at site 328.7B, average DO concentrations began to decrease each year. This decrease could be partially due to increased average water temperatures as sediment fills the backwater area. Even though average DO concentrations started to decrease, there was little potential for negative impacts to aquatic biota, as average values over the entire post construction winter monitoring period still remain over double the standard value of 5.0 mg/L required to sustain healthy aquatic habitat.

Low DO concentration events can occasionally be an issue at W329.3B during the summer months, but are typically of such short duration that aquatic biota are not harmed, which is evidenced by the lack of fish kills reported or observed.

When analyzing post-project velocity measurements taken at Wing Dam Nos. 6 and 15, it appears that notching does have an impact on velocity. At both wing dams, average velocity measurements at the notch and 100 feet downstream of the notch were considerably higher than those observed 100 feet upstream. Scour holes formed behind the wing dam notches, as anticipated, but the depth of the scour holes was actually deeper than originally estimated. See Cottonwood Island Performance Evaluation Report from 2002 for a further discussion regarding the wing dam notches. It is recommended that additional ADCP measurements be taken in the vicinity of the notched wing dams to determine if additional scouring and/or velocity changes have occurred since the last measurement in 2004.

Estimated annual sedimentation rates illustrate the steady decline in average flat pool adjusted water depth. The estimated average annual sedimentation rate from 1997 to 2005, the previous monitoring period, was 8.04 in/yr at site W-M328.7B and 6.72 in/yr at site W-M329.3B. During the most recent sampling period, the average sedimentation rate dropped to 6.19 in/yr for site W-M328.7B and 5.84 in/yr at site W-M329.3B. Although the sedimentation rate has decreased over the past two years, these rates are still considerably higher than the estimated sedimentation rates from the 1996 US Army Corps of Engineers DPR of 0.11 in/yr at W-M328.7B and 0.16 in/yr at site W-M329.3B.

Overall, results from the current evaluation period indicate that the Cottonwood Island project has been effective at providing sufficient DO concentrations to support aquatic life, thus providing year round quality backwater aquatic habitat for native fisheries. With sedimentation rates drastically higher than originally estimated and water depth steadily decreasing, the effectiveness of the project to produce the water quality objectives has begun to decrease.

The current method of backwater restoration that is often utilized is to dredge a linear channel or chute. With this form of dredging failing to sustain desired depth, other dredging options should be explored, such as changing the footprint of the dredge cut to include a whole backwater pool. Mechanical dredging does not always permit this, but the use of hydraulic dredging would allow for more removal and placement options.

References:

US Army Corps of Engineers, Rock Island District, 1996. *Definite Project Report with Integrated Environmental Assessment (R-16F),Cottonwood Island Habitat Rehabilitation and Enhancement, Upper Mississippi River System Environmental Management Program, Pool 21, Mississippi River Miles 328.5 – 331.0, Lewis and Marion Counties, Missouri, June 1996.*

US Army Corps of Engineers, Rock Island District, 2002. *Upper Mississippi River System Environmental Management Program Post-Construction Performance Evaluation Report – Year 5 (2002)Cottonwood Island Habitat Rehabilitation And Enhancement Project, Pool 21, Mississippi River Miles328.5 – 331.0R,Lewis and Marion County, Missouri.*

US Army Corps of Engineers, Rock Island District, January 2007. *Upper Mississippi River System Environmental Management Program Post-Construction Performance Evaluation Report – Year 10 (2007)Cottonwood Island Habitat Rehabilitation And Enhancement Project, Pool 21, Mississippi River Miles328.5 – 331.0R,Lewis and Marion County, Missouri.*

US Army Corps of Engineers, Rock Island District. *Rivergages.com*. March 2012. Web. http://www2.mvr.usace.army.mil/WaterControl/new/layout.cfm

COTTONWOOD ISLAND
POST-CONSTRUCTION
PERFORMANCE EVALUATION REPORT

WATER QUALITY ANALYSIS
AUGUST 2012

APPENDIX A

PLATES AND GRAPHS

Vicinity Map

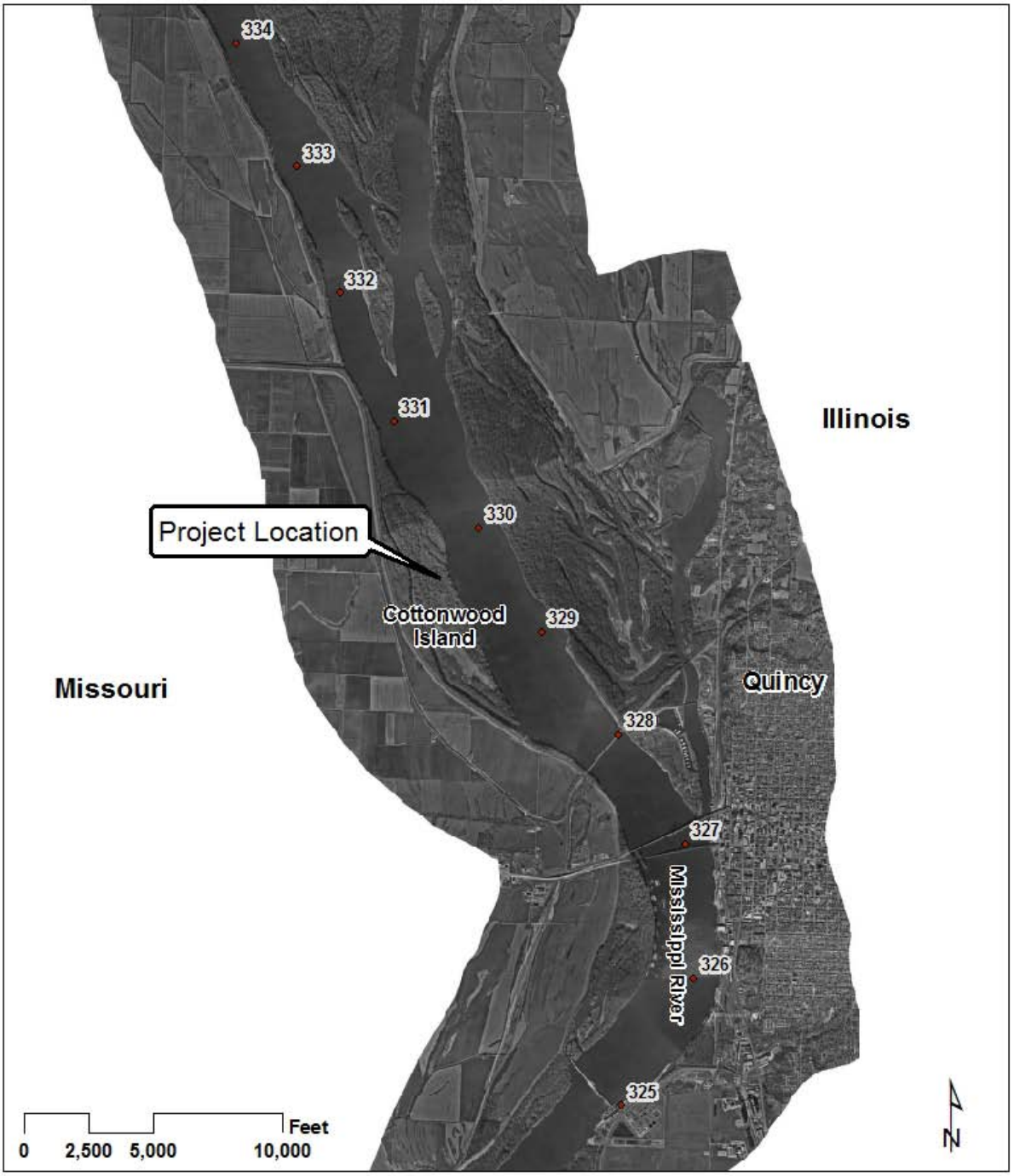
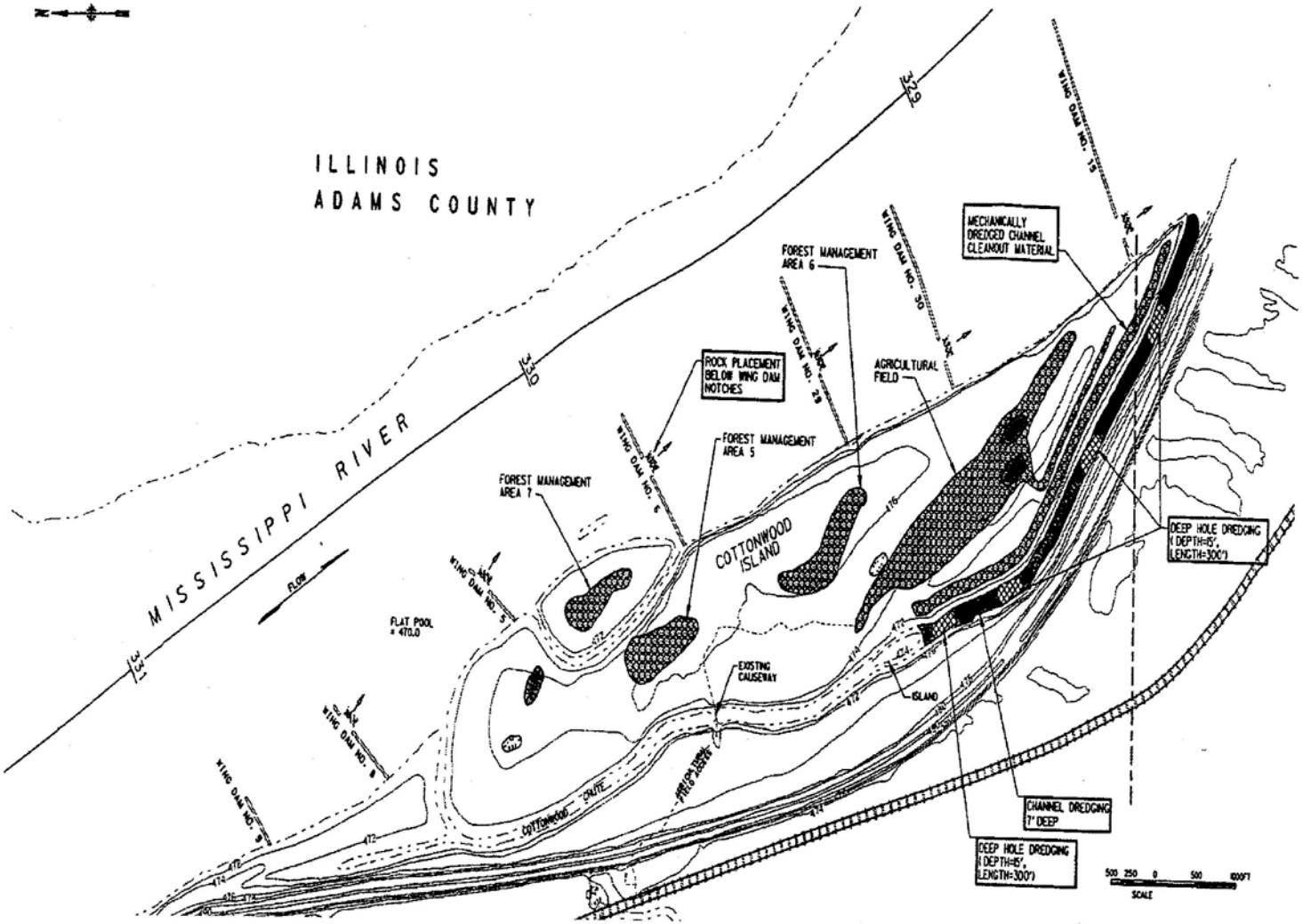


PLATE 1



Cottonwood Island Project Features

PLATE 2

Water Quality Monitoring Stations

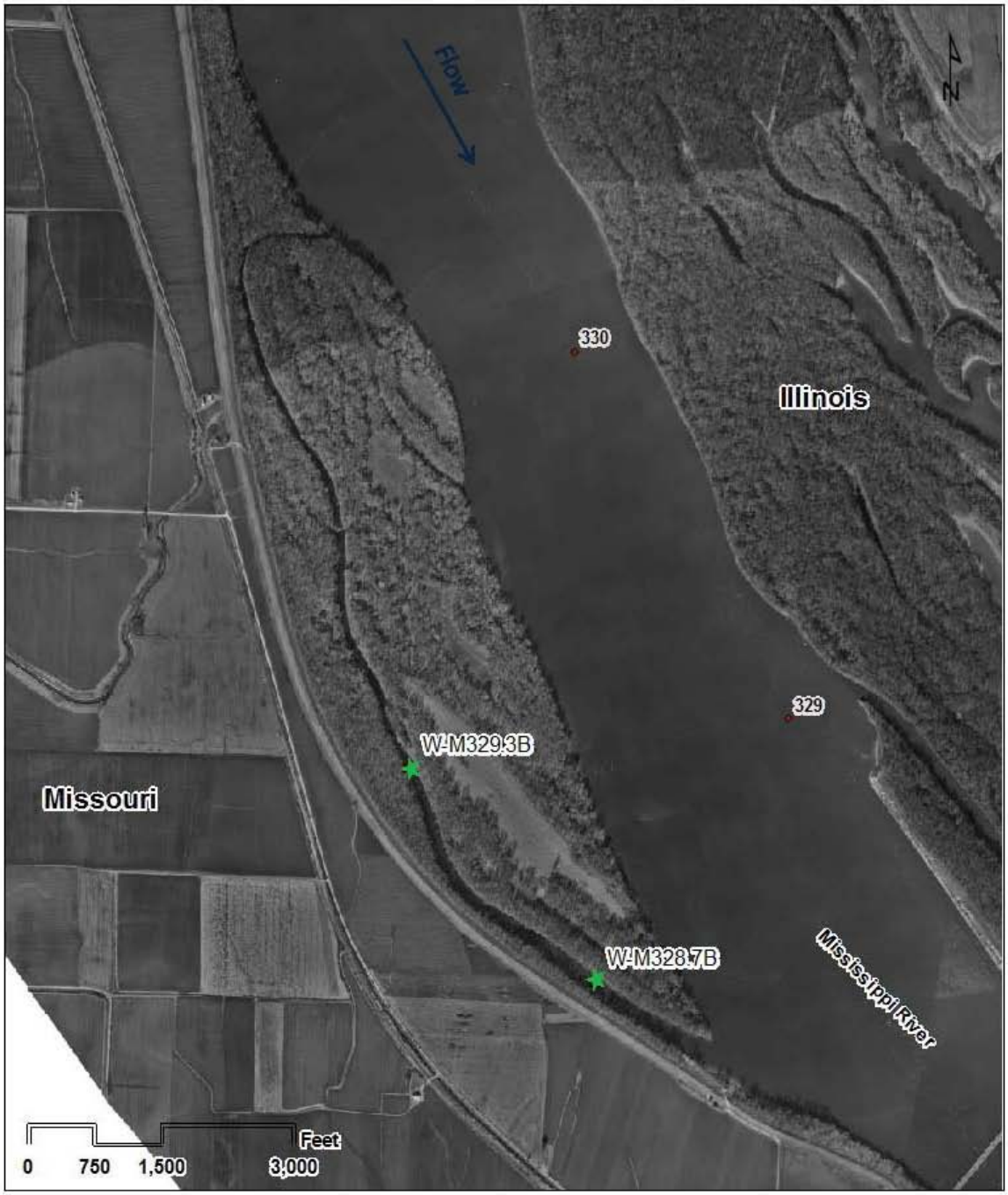
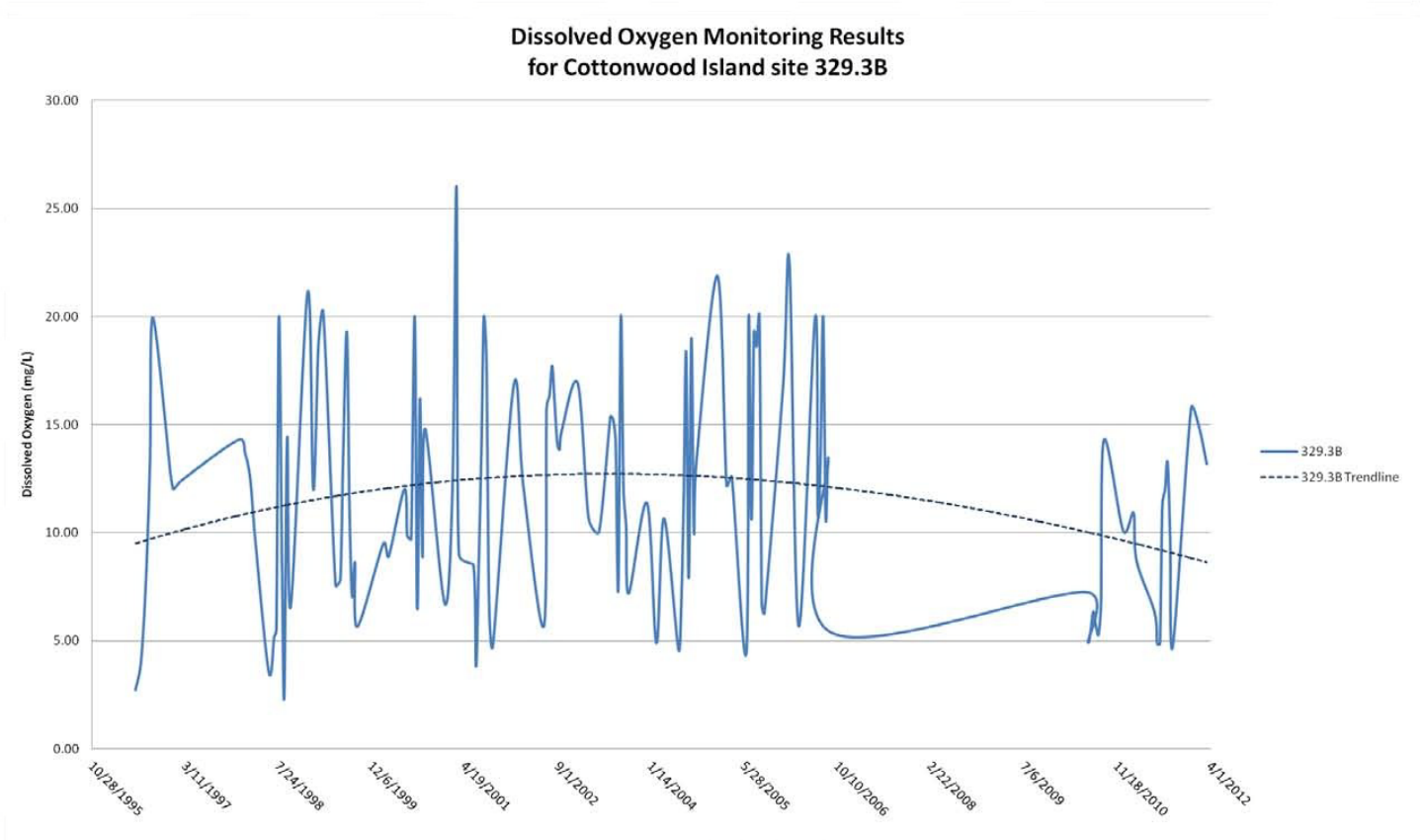
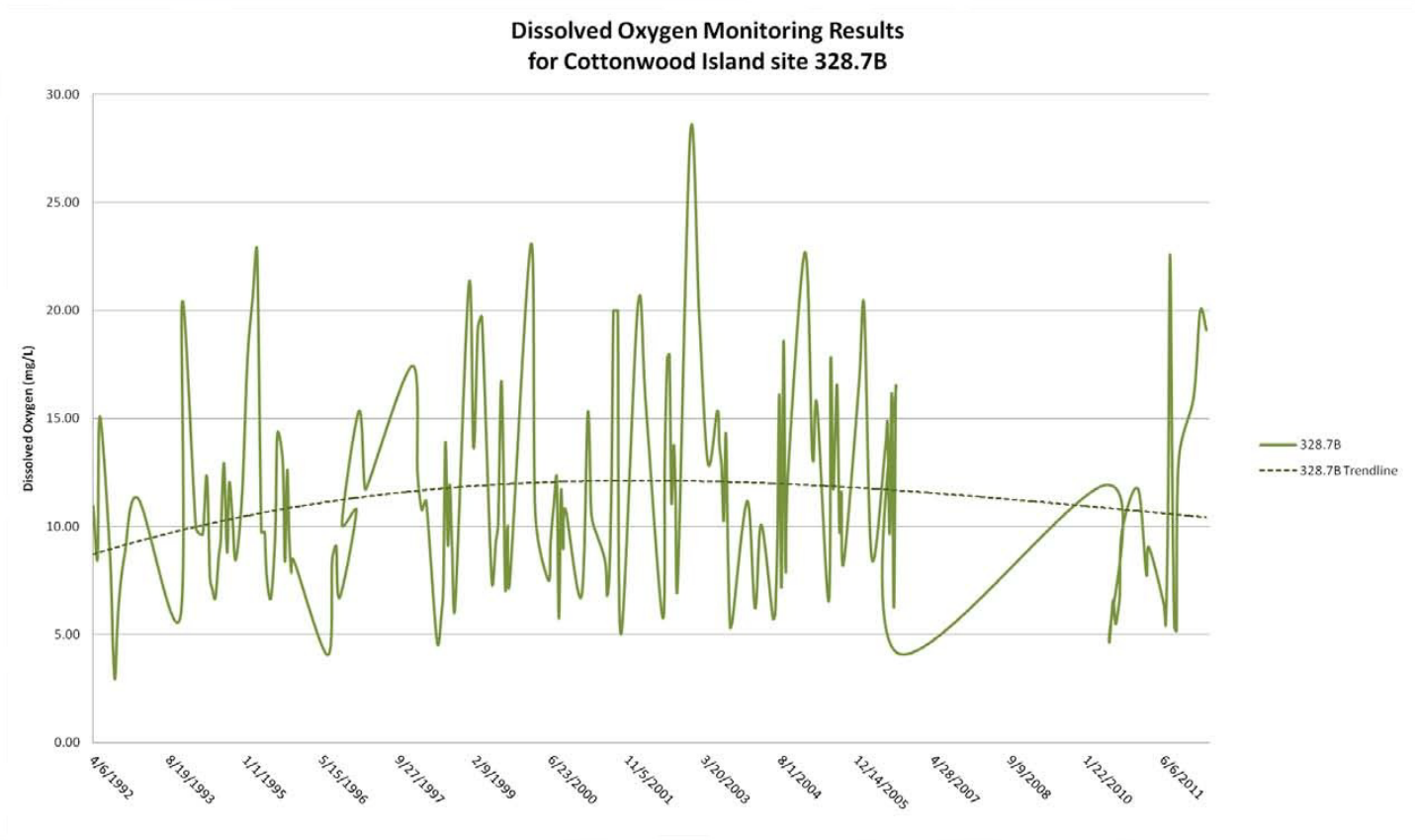


PLATE 3



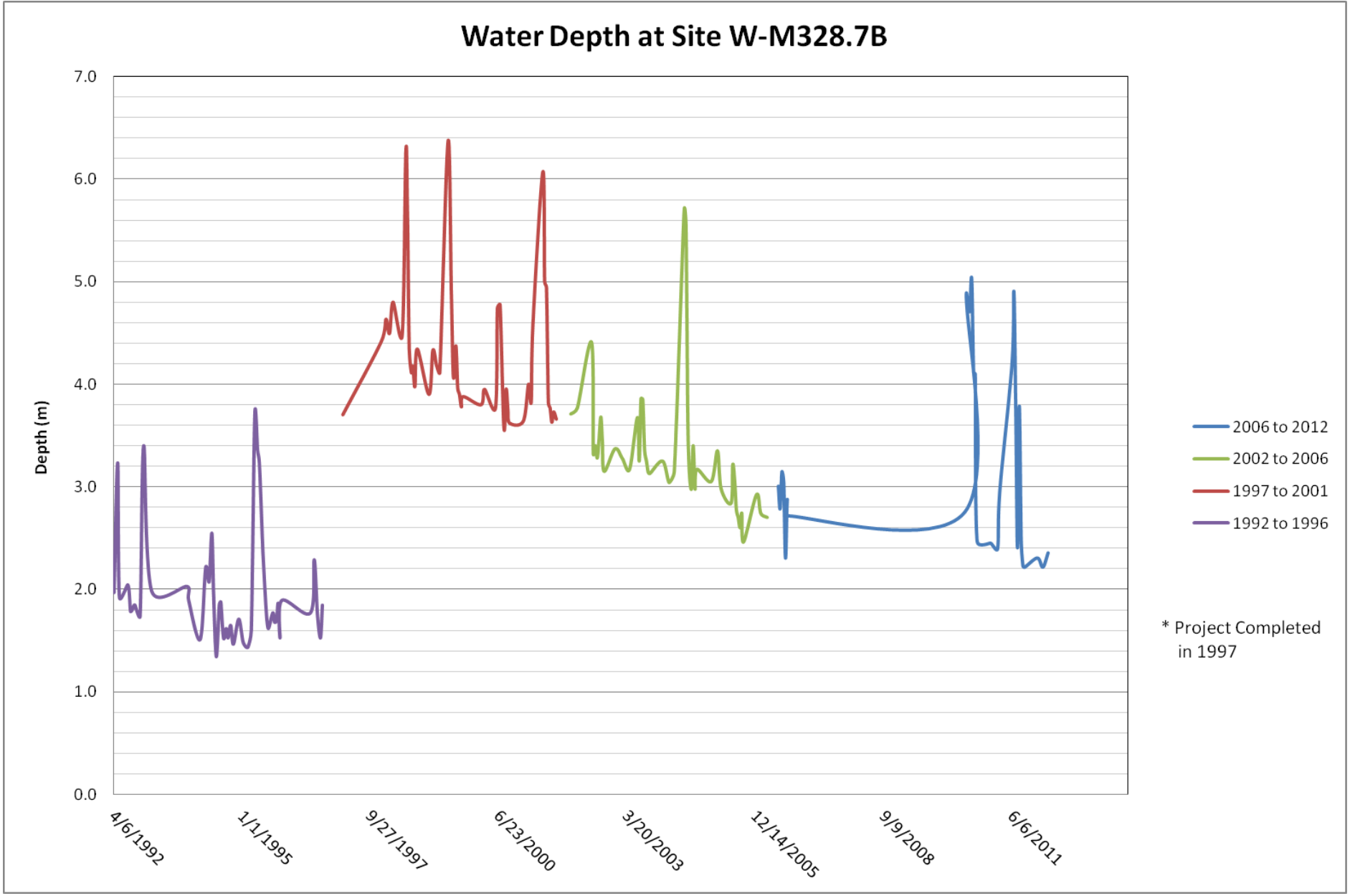
Graph 1 illustrates the dissolved oxygen concentrations (mg/L) at site 329.3B from 18 June 1996 to 13 March 2012. Due to the cyclical nature of EMP water quality monitoring, no data is available from 7 September 2006 to 2 June 2010.

GRAPH 1

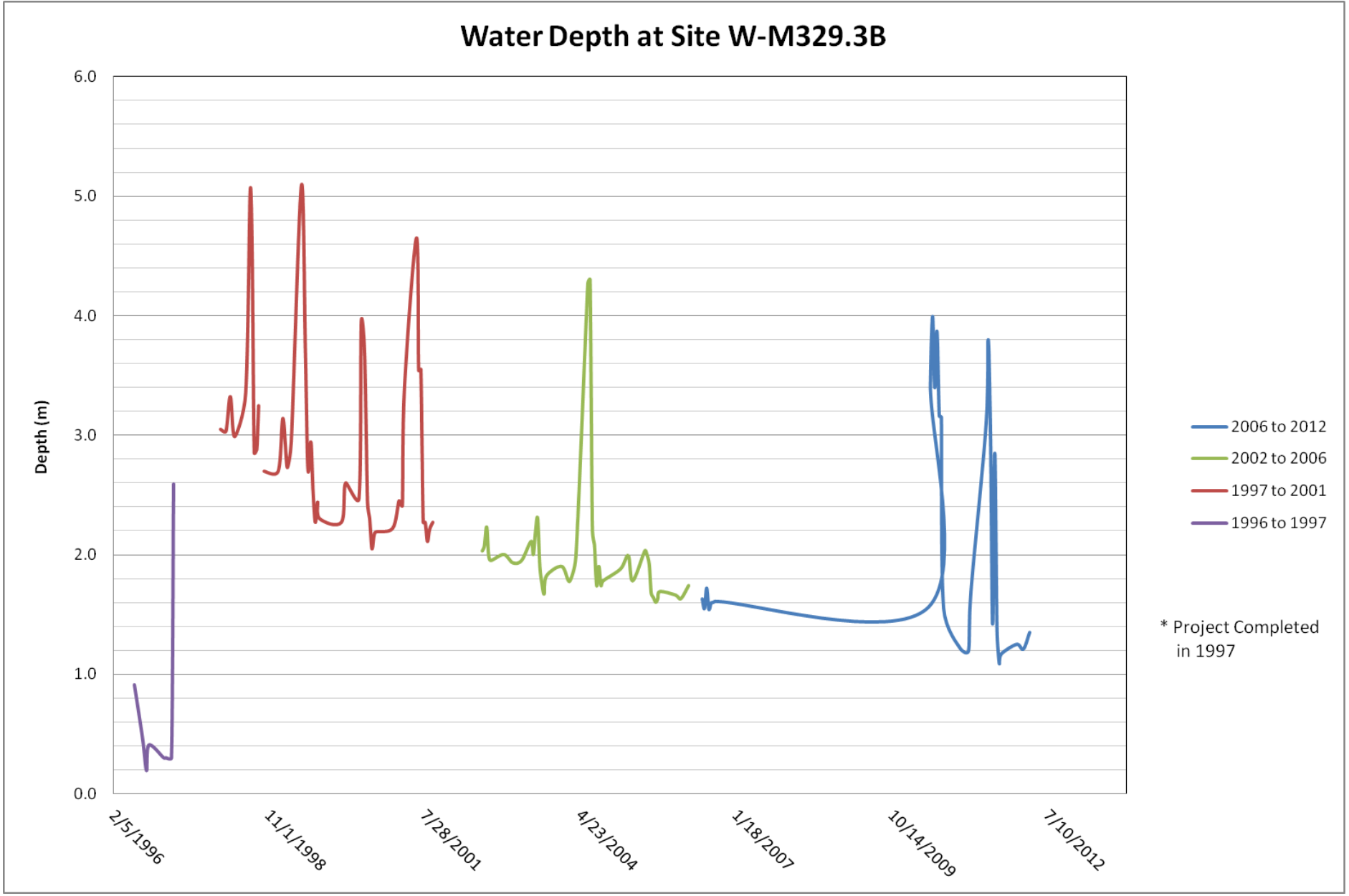


Graph 2 illustrates the dissolved oxygen concentrations (mg/L) at site 328.7B from 7 April 1992 to 13 March 2012. Due to the cyclical nature of EMP water quality monitoring, no data is available from 7 September 2006 to 2 June 2010.

GRAPH 2


Water Depth at Site W-M328.7B
Depth (m)
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
4/6/1992
1/1/1995
9/27/1997
6/23/2000
3/20/2003
12/14/2005
9/9/2008
6/6/2011
2006 to 2012
2002 to 2006
1997 to 2001
1992 to 1996
* Project Completed in 1997

GRAPH 3


Water Depth at Site W-M329.3B
Depth (m)
6.0
5.0
4.0
3.0
2.0
1.0
0.0
2/5/1996
11/1/1998
7/28/2001
4/23/2004
1/18/2007
10/14/2009
7/10/2012
2006 to 2012
2002 to 2006
1997 to 2001
1996 to 1997
* Project Completed in 1997

GRAPH 4

COTTONWOOD ISLAND
POST-CONSTRUCTION
PERFORMANCE EVALUATION REPORT

WATER QUALITY ANALYSIS
AUGUST 2012

APPENDIX B

WATER QUALITY MONITORING
GRAB SAMPLE RESULTS

Post-Project Monitoring Results at Station W-M328.7B 31 May 06 to 13 Mar 12						
DATE	WATER DEPTH (M)	VELOCITY (CM/SEC)	WATER TEMP. (°C)	DISSOLVED OXYGEN (MG/L)	pH (SU)	CHLOROPHYLL a (MG/M3)
5/31/2006	-	-	-	-	-	26.0
6/13/2006	3.010	0.91	28.2	13.66	8.80	50.0
6/27/2006	2.790	1.48	27.5	14.82	8.90	150.0
7/11/2006	3.150	0.16	27.9	9.66	8.40	170.0
7/25/2006	3.045	0.93	31.8	16.15	9.10	76.0
8/8/2006	2.310	1.37	29.9	6.26	8.40	68.0
8/22/2006	2.880	-	29.5	16.52	9.00	74.0
9/6/2006	2.720	0.90	23.2	4.13	7.70	37.0
6/2/2010	2.755	0.63	26.4	11.93	8.30	93.0
6/15/2010	4.880	-	24.1	4.73	7.60	8.0
6/29/2010	4.750	-	25.4	5.66	7.70	6.0
7/13/2010	4.715	-	27.2	6.61	8.00	8.0
7/27/2010	5.030	-	27.4	5.50	7.60	11.0
8/11/2010	4.120	-	29.3	6.00	8.00	9.0
8/24/2010	4.100	-	27.8	6.80	7.80	10.0
9/8/2010	2.470	-	25.5	9.80	7.80	48.0
12/21/2010	2.455	0.31	1.7	11.75	8.00	-
2/14/2011	2.400	0.54	0.7	7.79	7.60	-
3/2/2011	2.950	0.99	3.2	9.05	7.40	-
6/7/2011	4.220	3.27	28.8	6.45	7.60	11.0
6/21/2011	4.900	13.60	23.8	5.53	7.30	6.0
7/6/2011	3.690	1.24	30.0	11.09	-	83.0
7/19/2011	2.410	0.62	33.9	22.58	8.79	159.0
8/2/2011	3.790	1.15	33.0	12.64	8.40	56.0
8/16/2011	2.490	1.86	26.0	5.37	7.80	51.0
8/30/2011	2.235	-	25.8	5.19	8.00	87.0
9/13/2011	2.220	0.38	26.2	13.00	8.80	109.0
12/20/2011	2.310	1.42	4.6	15.98	8.90	-
2/1/2012	2.220	0.94	5.1	19.98	8.90	-
3/13/2012	2.360	0.52	13.5	19.10	8.90	-
Summer Min	2.2	0.16	23.2	4.13	7.3	6
Max	5.0	13.60	33.9	22.58	9.1	170
Ave	3.4	2.04	27.8	9.57	-	59
Samples	-	-	-	23	-	-
Winter Min	2.2	0.31	0.7	7.79	7.4	-
Max	3.0	1.42	13.5	19.98	8.9	-
Ave	2.4	0.79	4.8	13.94	-	-
Samples	-	-	-	6	-	-

Post-Project Monitoring Results at Station W-M329.3B
31 May 06 to 13 Mar 12

	DATE	WATER DEPTH (M)	VELOCITY (CM/SEC)	WATER TEMP. (°C)	DISSOLVED OXYGEN (MG/L)	pH (SU)	CHLOROPHYLL a (MG/M3)
	5/31/2006	-	-	-	-	-	68.0
	6/13/2006	1.630	0.69	27.9	>20	9.20	140.0
	6/27/2006	1.550	0.64	26.0	10.87	8.30	170.0
	7/11/2006	1.720	0.33	28.9	13.40	9.00	370.0
	7/25/2006	1.545	1.29	33.2	>20	9.50	170.0
	8/8/2006	1.595	0.43	29.4	10.69	8.50	150.0
	8/22/2006	1.600	0.33	28.6	13.35	8.80	190.0
	9/7/2006	1.610	0.39	22.0	5.37	7.70	72.0
	6/2/2010	1.560	2.16	26.1	7.25	7.80	146.0
	6/15/2010	3.420	-	23.9	4.96	7.60	7.0
	6/29/2010	3.995	-	25.7	5.44	7.70	6.0
	7/13/2010	3.400	-	26.7	6.34	8.00	10.0
	7/27/2010	3.870	-	28.1	5.71	7.70	10.0
	8/11/2010	3.160	-	27.7	5.30	7.70	10.0
	8/24/2010	3.152	-	27.6	6.81	7.80	15.0
	9/8/2010	1.550	-	25.9	14.29	7.90	173.0
	12/21/2010	1.220	0.31	2.0	10.08	7.70	-
	2/14/2011	1.195	0.32	0.9	10.93	7.50	-
	3/2/2011	1.690	0.21	3.5	8.71	7.40	-
	6/7/2011	3.090	4.06	25.8	6.32	7.70	11.0
	6/21/2011	3.800	15.32	23.7	4.86	7.20	6.0
	7/6/2011	2.970	0.47	28.8	4.85	-	51.0
	7/19/2011	1.420	0.86	33.5	11.29	8.00	73.0
	8/2/2011	2.850	1.68	33.4	11.96	8.20	114.0
	8/16/2011	1.390	0.96	25.9	13.24	-	313.0
	8/30/2011	1.095	0.37	26.1	9.69	8.40	225.0
	9/13/2011	1.170	-	23.8	4.76	7.90	57.0
	12/20/2011	1.250	1.29	5	15.75	8.8	-
	2/1/2012	1.210	0.79	5.4	14.87	8.30	-
	3/13/2012	1.350	0.63	6.0	13.18	8.60	-
Summer	Min	1.1	0.33	22.0	4.76	7.2	6
	Max	4.0	15.32	33.5	14.29	9.5	370
	Ave	2.3	2.00	27.3	8.42	-	107
	Samples	-	-	-	23	-	-
Winter	Min	1.2	0.21	0.9	8.71	7.4	-
	Max	1.7	1.29	6.0	15.75	8.8	-
	Ave	1.3	0.59	3.8	12.25	-	-
	Samples	-	-	-	6	-	-

Post-Project Monitoring Results at Station W-M328.7B
23 Dec 97 to 16 Mar 06

DATE	WATER DEPTH (M)	VELOCITY (CM/SEC)	WATER TEMP. (°C)	DISSOLVED OXYGEN (MG/L)	pH (SU)	CHLOROPHYLL a (MG/M3)
12/23/1997	4.420	0.00	2.6	17.44	-	18.0
1/27/1998	4.633	0.00	1.5	12.41	8.19	11.0
2/24/1998	4.496	-	7.3	10.76	8.13	18.0
3/24/1998	4.801	1.80	5.7	11.17	6.79	7.5
6/3/1998	4.481	4.42	22.9	4.67	7.49	11.0
7/2/1998	6.279	3.63	29.8	5.99	7.57	4.4
7/14/1998	5.654	1.65	29.0	7.20	7.90	6.7
7/28/1998	4.343	0.00	29.6	13.90	8.44	42.0
8/13/1998	4.115	4.21	27.9	9.13	8.20	59.0
8/25/1998	4.176	3.32	30.6	11.95	8.53	93.0
9/10/1998	3.978	1.55	26.6	8.92	8.14	33.0
9/29/1998	4.343	3.66	24.2	6.30	7.28	34.0
12/29/1998	3.901	0.00	1.6	21.26	8.40	52.0
1/28/1999	4.328	0.00	0.7	13.65	7.90	2.9
2/25/1999	4.191	0.00	4.6	19.18	8.80	54.0
3/23/1999	4.115	2.96	9.9	19.68	9.00	80.0
5/27/1999	6.370	12.25	20.3	7.48	7.32	4.9
6/22/1999	4.877	2.38	26.8	9.29	8.20	19.0
7/8/1999	4.069	6.22	31.2	10.19	8.50	26.0
7/27/1999	4.374	0.00	34.3	16.65	8.90	120.0
8/10/1999	3.962	3.32	29.6	13.42	8.60	54.0
8/24/1999	3.901	-	25.5	7.07	8.10	45.0
9/8/1999	3.780	-	26.4	10.04	8.40	33.0
9/21/1999	3.880	-	20.7	7.40	8.00	27.0
2/8/2000	3.800	0.00	2.9	23.08	8.70	70.0
3/7/2000	3.950	3.17	13.8	10.53	8.00	31.0
5/31/2000	3.770	2.38	27.4	7.51	8.10	14.0
6/15/2000	4.740	-	27.4	9.33	8.40	17.0
7/6/2000	4.775	-	29.6	11.03	8.40	22.0
7/25/2000	3.970	-	27.8	12.24	8.50	34.0
8/8/2000	3.550	-	26.2	5.75	7.80	6.2
8/22/2000	3.950	-	28.6	11.66	8.70	28.0
9/5/2000	3.745	-	27.8	8.98	8.20	45.0
9/19/2000	3.620	-	23.6	10.81	8.30	74.0
1/3/2001	3.640	-	0.8	6.79	7.90	354.0
2/13/2001	4.000	-	0.9	15.27	8.10	233.0
3/6/2001	3.830	0.00	3.1	10.86	7.60	19.0
3/20/2001	4.600	0.00	9.1	10.12	7.70	4.3
6/5/2001	6.070	2.04	15.7	8.45	7.60	<1
6/19/2001	5.000	0.00	25.6	6.81	7.80	10.0
7/3/2001	4.940	3.08	26.6	7.62	7.90	14.0
7/18/2001	3.820	-	28.4	12.08	8.50	247.0
7/31/2001	3.770	0.00	33.4	>20	9.00	46.0
8/14/2001	3.630	0.00	30.9	>20	9.20	134.0
8/28/2001	3.730	3.29	30.6	>20	9.30	155.0
9/18/2001	3.660	0.00	21.3	5.02	7.80	34.0

Post-Project Monitoring Results at Station W-M328.7B
23 Dec 97 to 16 Mar 06 (Continued)

	DATE	WATER DEPTH (M)	VELOCITY (CM/SEC)	WATER TEMP. (°C)	DISSOLVED OXYGEN (MG/L)	pH (SU)	CHLOROPHYLL a (MG/M3)
	1/8/2002	3.710	0.00	2.3	20.30	8.40	41.0
	2/28/2002	3.770	-	3.8	15.60	8.30	36.0
	6/18/2002	4.410	-	25.0	5.78	7.40	1.4
	7/2/2002	3.320	-	31.2	13.22	8.60	66.0
	7/18/2002	3.400	0.00	30.9	17.82	8.80	125.0
	8/1/2002	3.280	-	34.5	17.96	9.10	75.0
	8/14/2002	3.440	-	29.8	11.15	8.50	29.0
	8/29/2002	3.680	-	28.2	13.78	8.60	83.0
	9/10/2002	3.450	3.54	28.9	11.53	8.50	69.0
	9/24/2002	3.150	-	21.8	7.39	7.90	30.0
	12/17/2002	3.370	0.75	1.8	28.29	-	-
	2/13/2003	3.275	0.47	1.9	19.67	8.76	-
	4/10/2003	3.170	-	15.2	12.93	8.40	-
	6/10/2003	3.675	-	23.2	15.36	8.70	86.0
	6/24/2003	3.250	-	29.6	13.76	8.40	29.0
	7/8/2003	3.860	-	30.3	12.76	8.70	83.0
	7/22/2003	3.850	-	28.8	10.27	8.40	53.0
	8/5/2003	3.350	4.48	29.1	14.33	9.00	87.0
	8/19/2003	3.250	-	30.5	8.68	8.40	34.0
	9/2/2003	3.140	-	26.3	5.31	7.70	11.0
	9/16/2003	3.130	3.51	24.3	5.62	7.90	18.0
	12/23/2003	3.250	-	2.0	11.18	8.13	-
	2/12/2004	3.040	0.29	1.2	6.22	7.70	-
	3/23/2004	3.150	-	8.4	10.09	7.60	-
	6/8/2004	5.705	9.53	24.8	5.75	7.30	4.3
	6/22/2004	5.560	10.48	23.0	5.92	7.20	<1
	7/7/2004	3.590	1.01	27.3	9.37	7.40	53.0
	7/20/2004	3.090	0.63	30.2	16.08	8.60	18.3
	8/3/2004	2.980	0.31	29.9	7.18	7.70	9.0
	8/17/2004	3.400	1.06	25.8	18.59	8.90	-
	8/31/2004	2.980	0.90	26.8	8.04	7.60	29.0
	9/14/2004	3.170	0.55	26.0	12.42	8.80	69.0
	1/4/2005	3.050	0.84	2.4	22.71	9.10	52.0
	2/22/2005	3.350	0.56	4.3	13.20	7.90	5.2
	3/22/2005	2.980	-	7.7	15.67	8.80	98.0
	6/8/2005	2.840	-	25.8	6.56	8.10	30.0
	6/21/2005	3.215	1.51	30.3	17.75	8.60	54.0
	7/6/2005	3.050	4.01	29.4	11.84	8.60	67.0
	7/19/2005	2.775	1.75	31.3	14.01	8.50	58.0
	8/2/2005	2.700	-	31.4	16.44	8.60	51.0
	8/17/2005	2.600	-	27.4	9.84	8.40	110.0
	8/30/2005	2.740	1.65	27.8	11.60	8.60	70.0
	9/13/2005	2.460	2.36	27.6	8.31	8.20	51.0
	12/22/2005	2.920	0.34	1.5	16.56	8.40	13.0
	1/25/2006	2.740	-	2.3	20.19	8.80	92.0
	3/16/2006	2.700	-	9.8	8.55	7.70	7.1
Summer	Min	2.5	0.00	15.7	4.67	7.2	1.4
	Max	6.4	12.25	34.5	18.59	9.3	247.0
	Ave	3.9	2.75	27.6	10.35	-	49.9
	Samples	-	-	-	61	-	-
Winter	Min	2.7	0.0	0.7	6.2	6.8	2.9
	Max	4.8	3.2	15.2	28.3	9.1	354.0
	Ave	3.7	0.6	4.6	15.1	-	59.0
	Samples	-	-	-	28	-	-

Post-Project Monitoring Results at Station W-M329.3B
23 Dec 97 to 16 Mar 06

DATE	WATER DEPTH (M)	VELOCITY (CM/SEC)	WATER TEMP. (°C)	DISSOLVED OXYGEN (MG/L)	pH (SU)	CHLOROPHYLL a (MG/M3)
12/23/1997	3.048	0.00	3.6	14.30	-	18.0
1/27/1998	3.033	0.00	2.1	13.68	8.08	17.0
2/24/1998	3.322	-	7.4	12.45	8.15	15.0
3/24/1998	2.987	0.00	6.5	9.53	6.77	7.7
6/3/1998	3.353	2.26	22.7	3.55	7.35	22.0
7/2/1998	5.044	6.77	26.4	5.18	7.46	8.0
7/14/1998	4.572	0.00	27.8	5.51	7.71	4.3
7/28/1998	2.850	0.00	33.9	>20.00	8.75	78.0
8/13/1998	2.880	3.44	28.3	8.71	8.03	110.0
8/25/1998	3.246	0.00	28.8	2.41	7.64	24.0
9/10/1998	-	-	27.8	14.39	8.49	129.0
9/29/1998	2.697	3.17	24.0	6.60	7.44	150.0
12/29/1998	2.697	0.00	3.0	21.13	8.80	50.0
1/28/1999	3.139	0.00	1.0	11.99	7.80	7.1
2/25/1999	2.728	0.00	6.5	18.75	8.90	32.0
3/23/1999	2.941	0.00	11.4	20.13	9.00	81.0
5/27/1999	5.090	17.92	20.0	7.57	7.53	4.8
6/22/1999	3.688	4.75	25.6	7.82	8.20	12.0
7/8/1999	2.713	6.25	34.0	13.92	8.70	52.0
7/27/1999	2.941	0.00	34.6	19.27	8.60	210.0
8/10/1999	2.530	0.00	28.0	11.19	8.60	53.0
8/24/1999	2.271	-	25.1	7.06	8.10	85.0
9/8/1999	2.438	-	25.9	8.61	8.30	28.0
9/21/1999	2.300	0.00	18.8	5.65	7.80	39.0
2/8/2000	2.270	0.00	3.0	9.50	7.70	16.0
3/7/2000	2.600	1.07	16.1	8.90	7.90	85.0
5/31/2000	2.470	1.04	31.0	12.02	8.50	47.0
6/15/2000	3.950	-	28.8	9.85	8.50	9.0
7/6/2000	3.702	-	28.5	9.70	8.00	69.0
7/25/2000	2.440	-	29.6	>20	9.00	430.0
8/8/2000	2.300	-	26.7	6.48	8.00	9.0
8/22/2000	2.050	-	30.4	16.20	8.90	46.0
9/5/2000	2.160	-	29.1	8.87	8.20	43.0
9/19/2000	2.190	-	24.8	14.80	8.70	190.0
1/3/2001	2.220	-	0.8	6.70	7.70	444.0
2/13/2001	2.450	-	0.8	12.24	8.00	92.0
3/6/2001	2.410	-	4.3	26.01	9.30	170.0
3/20/2001	3.400	0.00	5.5	9.00	7.60	1.8
6/5/2001	4.65	2.47	15.6	8.5	7.7	<1
6/19/2001	3.540	0.00	25.6	3.80	7.60	31.0
7/3/2001	3.550	0.00	26.6	8.37	8.10	39.0
7/18/2001	2.270	-	29.3	13.90	8.60	57.0
7/31/2001	2.270	0.00	36.5	>20	9.10	143.0
8/14/2001	2.110	0.00	30.2	17.98	-	126.0
8/28/2001	2.210	-	27.2	6.77	8.10	43.0
9/18/2001	2.270	0.00	21.1	4.83	7.80	280.0
1/8/2002	2.220	0.00	2.1	16.86	8.10	38.0
2/28/2002	2.250	-	6.0	12.11	8.00	12.0
6/18/2002	2.900	-	26.6	5.68	7.40	28.0
7/2/2002	2.350	-	32.3	15.72	8.60	179.0
7/18/2002	2.070	0.00	32.7	16.33	8.80	158.0

Post-Project Monitoring Results at Station W-M329.3B
23 Dec 97 to 16 Mar 06 (Continued)

	DATE	WATER DEPTH (M)	VELOCITY (CM/SEC)	WATER TEMP. (°C)	DISSOLVED OXYGEN (MG/L)	pH (SU)	CHLOROPHYLL a (MG/M3)
	8/1/2002	2.030	-	34.7	17.72	-	57.0
	8/14/2002	2.070	-	30.8	16.08	8.80	58.0
	8/29/2002	2.230	-	28.6	14.11	8.60	76.0
	9/10/2002	2.000	0.00	29.0	13.84	8.40	171.0
	9/24/2002	1.950	-	22.4	14.81	8.60	124.0
	12/17/2002	2.000	-	3.9	16.89	-	-
	2/13/2003	1.930	0.13	1.7	10.66	8.08	-
	4/10/2003	1.950	-	11.5	10.05	8.00	-
	6/10/2003	2.110	-	24.1	15.38	8.60	158.0
	6/24/2003	2.000	-	31.4	15.25	8.40	107.0
	7/8/2003	2.190	2.46	32.4	14.20	8.70	84.0
	7/22/2003	2.300	1.76	27.6	7.36	8.00	62.0
	8/5/2003	1.900	2.42	30.4	>20	9.30	234.0
	8/19/2003	1.750	-	33.9	12.06	8.80	67.0
	9/2/2003	1.670	0.33	25.5	10.34	8.20	88.0
	9/16/2003	1.820	-	27.2	7.19	7.70	34.0
	12/23/2003	1.900	-	2.4	11.38	8.15	-
	2/12/2004	1.775	0.16	1.2	4.88	7.60	-
	3/23/2004	1.980	-	10.2	10.66	7.70	-
	6/8/2004	4.270	2.97	23.8	4.64	7.10	5.1
	6/22/2004	4.300	9.20	22.9	6.09	7.30	1.2
	7/7/2004	2.200	-	28.3	11.50	7.50	71.0
	7/20/2004	2.080	1.06	31.3	18.35	8.70	106.0
	8/3/2004	1.740	0.56	31.8	7.89	7.90	40.0
	8/17/2004	1.900	0.97	28.5	18.99	9.00	-
	8/31/2004	1.740	0.66	28.5	10.08	7.70	36.0
	9/14/2004	1.780	-	28.5	13.38	8.60	134.0
	1/4/2005	1.880	0.48	3.8	21.88	8.70	33.0
	2/22/2005	1.990	1.18	5.5	12.19	7.90	13.0
	3/22/2005	1.780	-	9.3	12.58	8.40	151.0
	6/8/2005	2.030	-	26.9	4.43	7.80	61.0
	6/21/2005	2.000	2.18	29.8	>20	8.90	120.0
	7/6/2005	1.920	0.11	27.6	10.61	8.30	100.0
	7/19/2005	1.675	0.97	34.4	19.27	8.70	81.0
	8/2/2005	1.640	0.45	34.6	18.61	8.80	120.0
	8/17/2005	1.600	-	29.9	>20	9.10	280.0
	8/30/2005	1.630	0.57	26.6	6.70	7.80	44.0
	9/13/2005	1.690	1.88	28.5	6.28	8.00	73.0
	12/22/2005	1.660	0.39	1.8	16.79	8.30	22.0
	1/25/2006	1.630	-	3.2	22.49	8.90	81.0
	3/16/2006	1.740	-	10.9	5.68	7.70	6.3
Summer	Min	1.6	0.0	15.6	2.4	7.1	1.2
	Max	5.1	17.9	36.5	19.3	9.3	430.0
	Ave	2.5	2.0	28.2	10.7	-	89.2
	Samples	-	-	-	58	-	-
Winter	Min	1.6	0.0	0.8	4.9	6.8	1.8
	Max	3.4	1.2	16.1	26.0	9.3	444.0
	Ave	2.4	0.2	5.2	13.6	-	63.3
	Samples	-	-	-	28	-	-

Pre-Project Monitoring Results at Station W-M328.7B
07 Apr 92 to 25 Feb 97

	DATE	WATER DEPTH (M)	VELOCITY (CM/SEC)	WATER TEMP. (°C)	DISSOLVED OXYGEN (MG/L)	pH (SU)	CHLOROPHYLL a (MG/M3)
	4/7/1992	1.966	-	11.4	10.96	7.97	19.0
	5/5/1992	3.231	6.58	15.8	8.56	8.18	15.0
	5/19/1992	1.920	2.62	26.6	15.10	8.92	40.0
	7/23/1992	2.042	1.74	26.5	8.96	8.22	37.0
	8/13/1992	1.783	1.43	25.1	4.52	7.55	33.0
	8/27/1992	1.798	5.12	24.7	2.96	7.52	20.7
	9/17/1992	1.844	8.26	23.8	6.11	-	21.9
	10/27/1992	1.737	3.20	13.7	8.62	7.95	67.8
	11/24/1992	3.399	7.32	5.7	-	7.88	29.1
	1/25/1993	1.981	0.00	0.7	11.30	8.35	20.8
	10/27/1993	2.027	3.54	12.3	5.78	7.95	43.4
	11/10/1993	1.890	3.81	6.7	20.40	8.98	8.2
	2/8/1994	1.509	0.00	0.4	9.92	8.04	45.2
	3/23/1994	2.210	3.87	11.0	9.63	8.17	38.0
	4/19/1994	2.073	2.29	18.3	12.34	8.69	110.0
	5/10/1994	2.545	1.62	17.7	7.62	7.42	17.0
	5/24/1994	1.951	2.38	26.1	7.14	7.91	15.0
	6/14/1994	1.341	3.57	29.8	6.70	8.02	14.0
	7/7/1994	1.844	-	29.8	8.69	8.24	29.0
	7/19/1994	1.875	4.33	30.3	9.35	8.21	33.0
	8/9/1994	1.524	0.00	29.1	12.94	8.81	56.0
	8/30/1994	1.615	4.63	25.8	8.81	8.19	86.0
	9/13/1994	1.524	2.26	26.1	12.03	8.63	96.0
	10/4/1994	1.646	0.00	21.2	10.42	8.46	53.0
	10/25/1994	1.463	6.71	14.0	8.46	8.48	18.0
	12/6/1994	1.707	3.96	5.5	11.48	8.23	16.0
	1/10/1995	1.478	0.00	0.3	17.70	8.90	44.0
	2/15/1995	1.433	0.30	1.7	20.70	-	65.0
	3/14/1995	1.600	4.57	14.0	22.70	9.03	-
	4/11/1995	3.719	4.72	6.4	9.74	7.84	8.9
	5/2/1995	3.353	9.91	13.7	9.76	8.38	20.0
	5/16/1995	3.231	26.88	17.9	7.70	7.72	4.0
	6/13/1995	2.362	1.40	24.7	6.72	7.97	8.1
	6/27/1995			BOAT WOULD NOT START			
	7/11/1995	1.737	-	30.6	9.75	8.38	24.0
	7/25/1995	1.615	0.00	31.6	14.31	8.63	51.0
	8/29/1995	1.768	-	32.8	12.99	8.59	31.0
	9/12/1995	1.676	0.00	23.0	8.39	-	34.0
	9/27/1995	1.692	0.00	18.9	12.62	-	31.0
	10/10/1995	1.859	0.00	18.2	9.53	8.26	12.0
	10/24/1995	1.524	0.00	11.8	7.87	8.10	16.0
	11/7/1995	1.890	4.88	6.3	8.46	8.00	9.8
	6/18/1996	1.768	5.18	24.2	4.06	7.45	13.0
	7/17/1996	2.286	3.72	25.8	8.43	8.31	32.0
	8/12/1996	1.737	2.65	27.0	9.11	8.42	36.0
	9/4/1996	1.524	2.07	27.6	6.72	8.19	59.0
	12/23/1996	1.585	0.00	2.3	10.78	-	50.0
	9/19/1996	1.844	6.16	21.0	10.10	8.31	39.0
	1/7/1997	1.463	-	2.2	15.34	-	53.0
	2/11/1997	1.509	0.00	0.8	12.18	-	17.0
	2/25/1997	3.703	19.20	2.2	11.76	-	<1
Summer	Min	1.3	0.0	11.8	3.0	7.4	4.0
	Max	3.4	26.9	32.8	15.1	8.9	96.0
	Ave	1.9	3.8	23.5	8.8	-	34.0
	Samples	-	-	-	32	-	-
Winter	Min	1.4	0.0	0.3	8.5	7.8	8.2
	Max	3.7	7.3	18.3	22.7	9.0	110.0
	Ave	2.0	3.3	7.3	13.4	-	33.2
	Samples	-	-	-	13	-	-

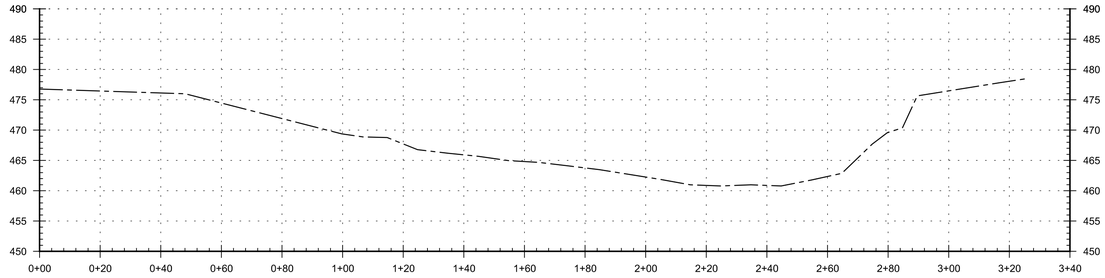
Pre-Project Monitoring Results at Station W-M329.3B
18 Jun 96 to 25 Feb 97

	DATE	WATER DEPTH (M)	VELOCITY (CM/SEC)	WATER TEMP. (°C)	DISSOLVED OXYGEN (MG/L)	pH (SU)	CHLOROPHYLL a (MG/M3)
	6/18/1996	0.914	4.82	23.2	2.72	7.57	13.0
	7/17/1996	0.671	0.00	27.3	3.98	8.09	72.0
	8/12/1996	0.442	2.32	25.2	7.60	8.20	48.0
	9/4/1996	0.198	2.16	28.8	13.28	8.50	120.0
	9/19/1996	0.411	5.61	21.4	19.95	9.01	280.0
	12/23/1996	0.305	0.00	1.3	12.70	-	9.7
	1/7/1997	0.305	-	2.6	12.01	-	18.0
	2/11/1997	0.305	0.00	0.5	-	-	2.8
	2/25/1997	2.591	22.86	1.8	12.45	-	5.8
Summer	Min	0.2	0.0	21.4	2.7	7.6	13.0
	Max	0.9	5.6	28.8	20.0	9.0	280.0
	Ave	0.5	3.0	25.2	9.5	-	106.6
	Samples	-	-	-	5	-	-
Winter	Min	0.3	0.00	0.5	12.5	-	2.8
	Max	2.6	22.9	1.8	12.7	-	5.8
	Ave	1.4	11.4	1.2	12.4	-	4.3
	Samples	-	-	-	3	-	-

APPENDIX B

Project Plates

2012 Sediment Transects



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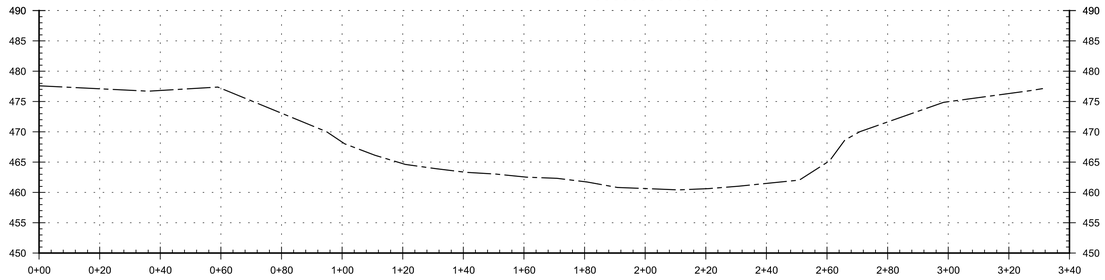
Scaled 1.0000 Times Ver.
Scaled 0.5000 Times Hor.

TRANSECT D



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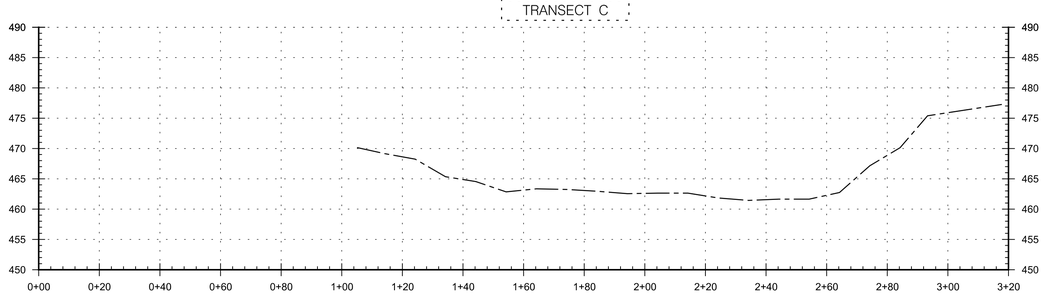
TRANSECT C



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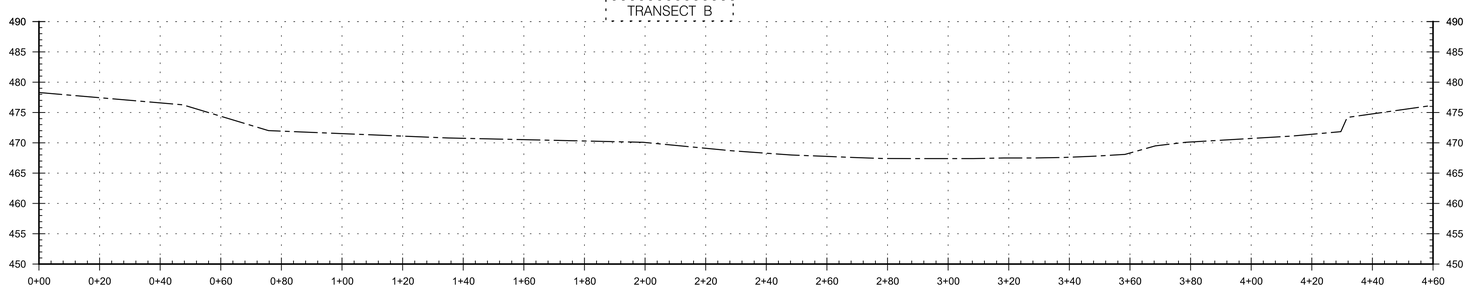
Scaled 0.5000 Times Hor.

TRANSECT B



LINE	SURFACE	OFFSET
——	CTxx_SVYBSE_V-TB0002	

Scaled 1.0000 Times Ver.
Scaled 0.5000 Times Hor.

TRANSECT A

DWG REF(s) :

A1 2012 EMP MONITORING

US Army Corps of Engineers®

MARK	DESCRIPTION	DATE	APPR.

DESIGNED BY:
DWN BY: MLS
CKD BY:
SUBMITTED BY:
DATE: 2012/09/14
SOLICITATION NO.:
CONTRACT NO.:
PROJECT CODE:
PLOT SCALE: AS SHOWN
PLOT DATE: Plotted
FILE NAME: CTxx_SC-401.dgn
SIZE:

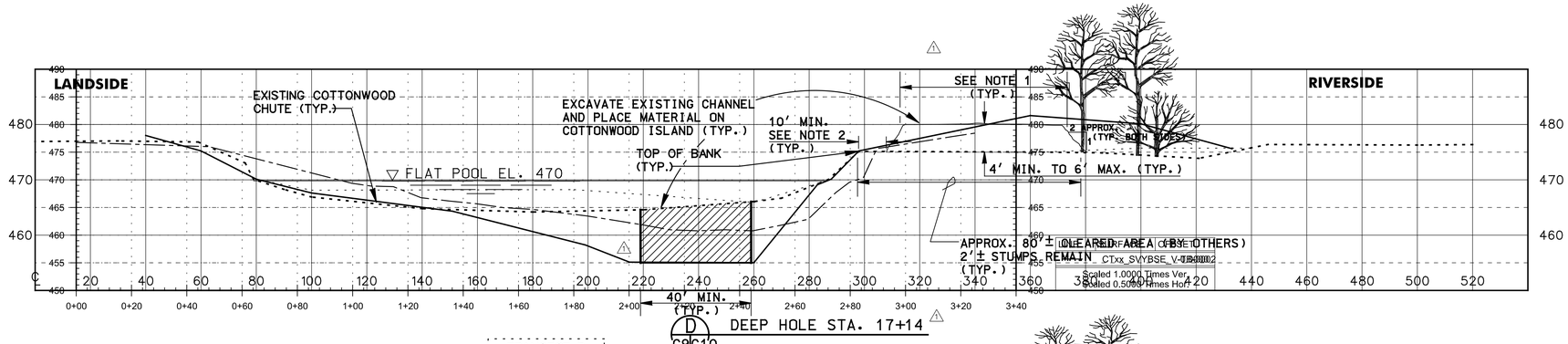
MISSISSIPPI RIVER
COTTONWOOD ISLAND EMP

TRANSECTS A, B, C & D MONITORING

Sheet ID
V-401

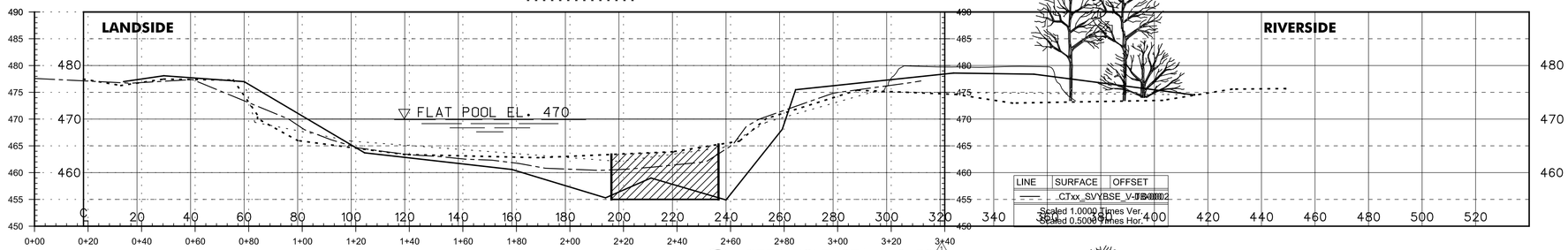
FOR SHEETS: 28

FOR SHEETS: 11



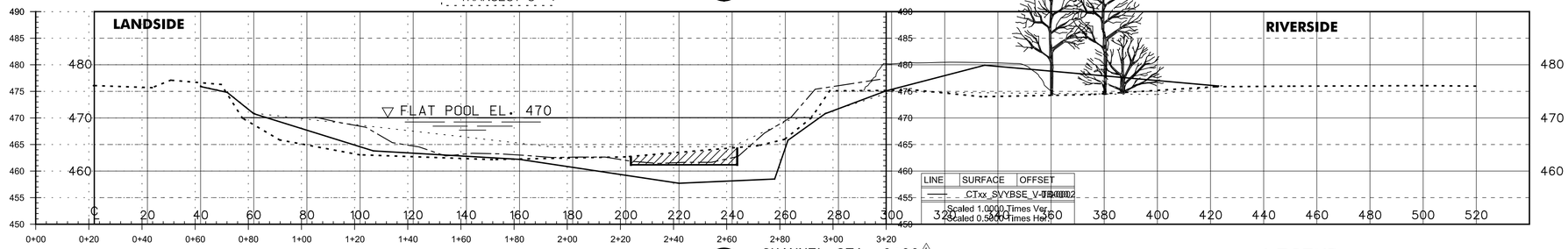
D C9C10 DEEP HOLE STA. 17+14

TRANSECT D



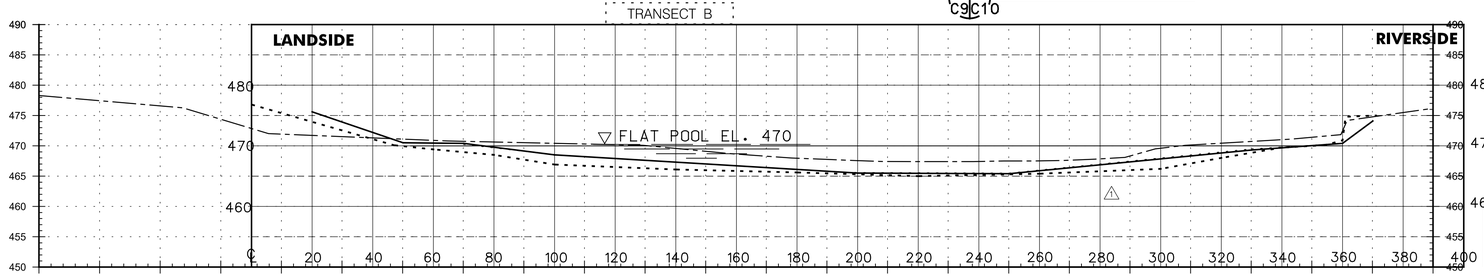
C C9C10 DEEP HOLE STA. 10+59

TRANSECT C



B C9C10 CHANNEL STA. 6+66

TRANSECT B



A C9C10 CHANNEL STA. 0+47

TRANSECT A

LEGEND

CORPS AS ADVERTISED

CONTRACTOR PRECONSTRUCTION

CONTRACTOR POST-CONSTRUCTION

NOTES:

1. POST-DISPOSAL GRADING AND SHAPING TO APPROXIMATELY 70' WIDTH.
2. FOR EXCAVATED MATERIAL PLACEMENT SITE AND LIMITS, SEE SHEET C9.

CORPS SURVEY FIELD BOOKS: FC-94-36, FC-95-24 AND FC-95-3

CONTRACTOR SURVEY: SEPTEMBER 5, 1997 (PRECONSTRUCTION)
OCTOBER 21, 1997 (AS-BUILT)

DWG REF(s) :

A1 2012 EMP MONITORING

US Army Corps of Engineers®

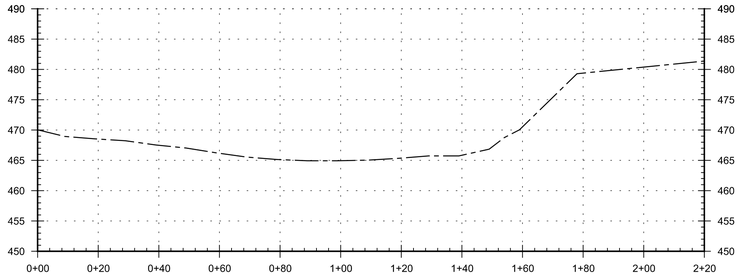
MARK	DESCRIPTION	DATE	APPR.

DESIGNED BY:
DWN BY: MLS
CKD BY:
SUBMITTED BY:
DATE: 20120914
SOLICITATION NO.:
CONTRACT NO.:
PROJECT CODE:
PLOT SCALE: AS SHOWN
PLOT DATE:
FILE NAME: CTxx_SC-401.dgn
SIZE:

MISSISSIPPI RIVER
COTTONWOOD ISLAND EMP

TRANSECTS A, B, C & D MONITORING

Sheet ID
V-401



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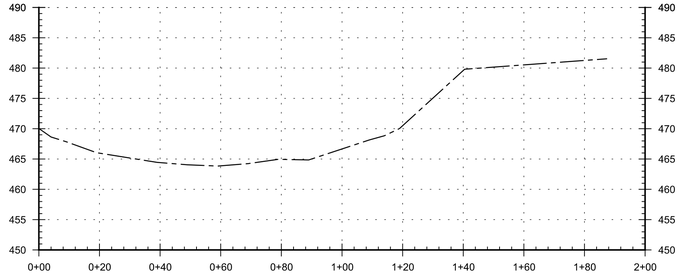

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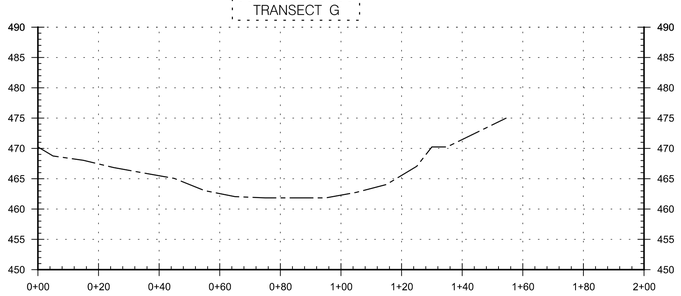
TRANSECT G



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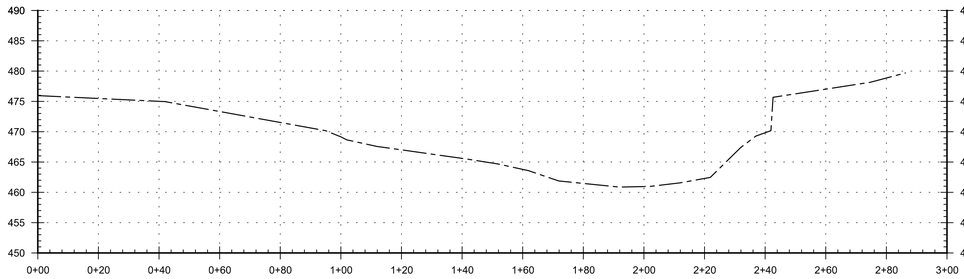

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Scaled 1.0000 Times Ver. Scaled 0.5000 Times Hor.		

TRANSECT E

DWG REF(s) :

A1 2012 EMP MONITORING

US Army Corps of Engineers®

MARK	DESCRIPTION	DATE	APPR.

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CKD BY:
SUBMITTED BY:
DATE: 2012/09/14
SOLICITATION NO.:
CONTRACT NO.:
PROJECT CODE:
PLOT SCALE: As Shown
PLOT DATE: None
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FILE NAME: CTxx_SC-402.dgn

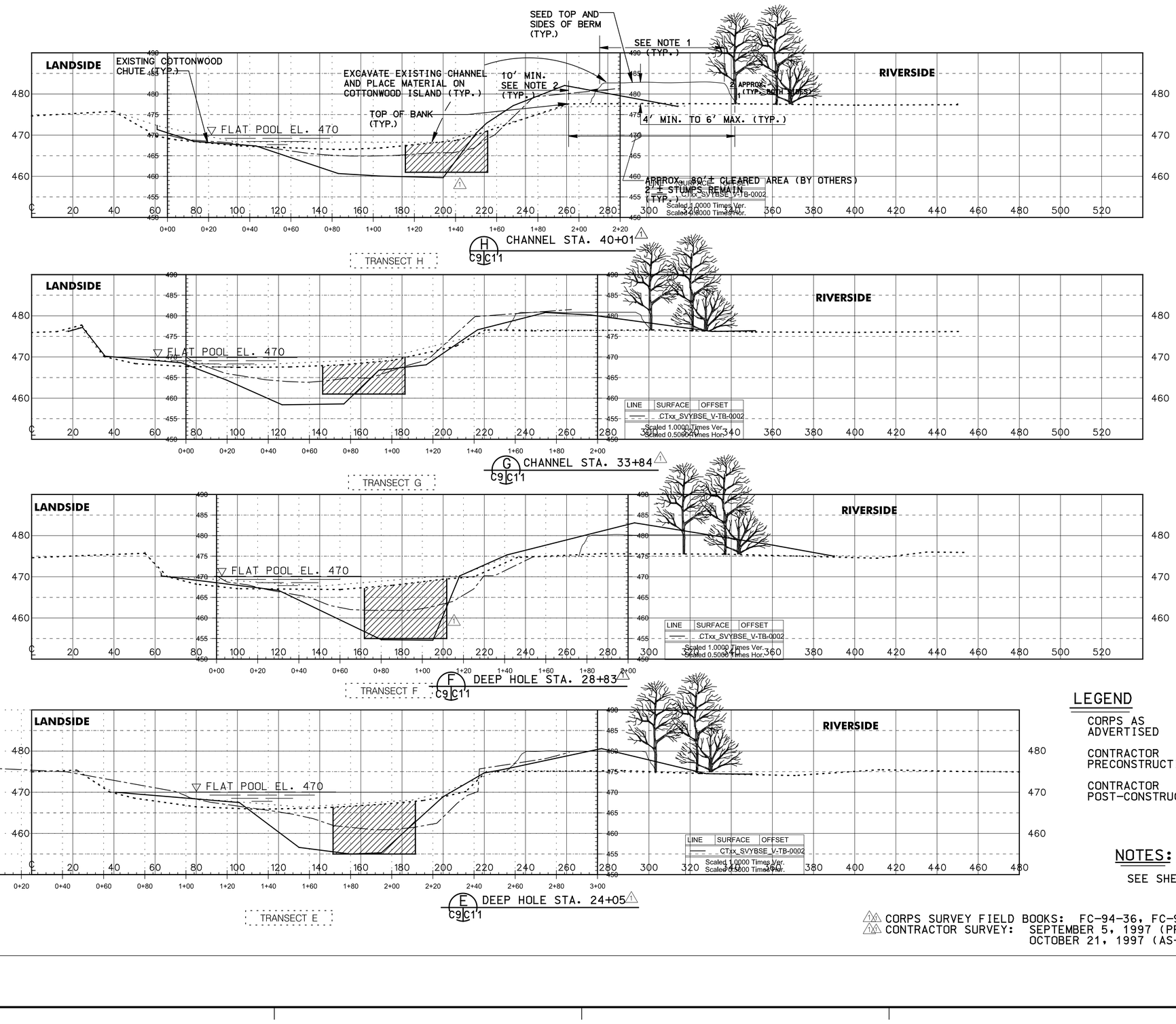
MISSISSIPPI RIVER
COTTONWOOD ISLAND EMP

TRANSECTS E, F, G & H MONITORING

Sheet ID
V-402

FOR SHEETS: 28

FOR SHEETS: 11



LEGEND

CORPS AS ADVERTISED

CONTRACTOR PRECONSTRUCTION

CONTRACTOR POST-CONSTRUCTION

NOTES:

SEE SHEET C10.

1 CORPS SURVEY FIELD BOOKS: FC-94-36, FC-95-24 AND FC-95-3

1 CONTRACTOR SURVEY: SEPTEMBER 5, 1997 (PRECONSTRUCTION)
OCTOBER 21, 1997 (AS-BUILT)

DWG REF(s) :

A1 2012 EMP MONITORING

US Army Corps of Engineers®

MARK	DESCRIPTION	DATE	APPR.

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SUBMITTED BY:
DATE: 20120919
CKD BY:
PLOT SCALE: As Shown
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CONTRACT NO.:
PLOT DATE:
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PROJECT CODE:

MISSISSIPPI RIVER
COTTONWOOD ISLAND EMP

TRANSECTS E, F, G & H MONITORING

Sheet ID
V-402

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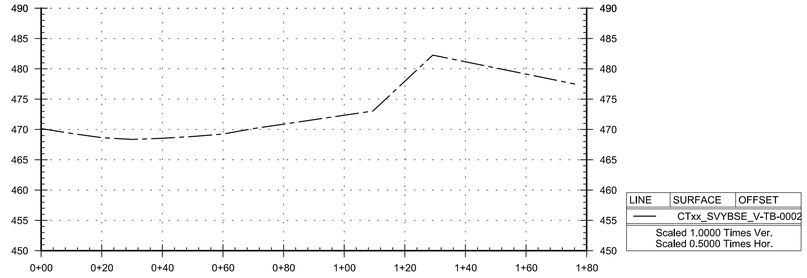

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Scaled 0.5000 Times Hor.

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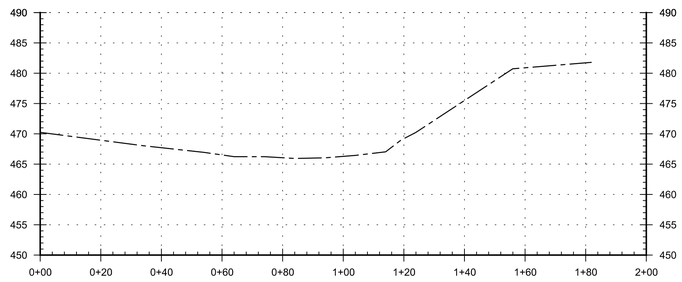

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TRANSECT I

DWG REF(s) :

A1 2012 EMP MONITORING

US Army Corps of Engineers®

MARK	DESCRIPTION	DATE	APPR.

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DWN BY: MLS
CKD BY:
SUBMITTED BY:
DATE: 20120914
SOLICITATION NO.:
CONTRACT NO.:
PROJECT CODE:
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FILE NAME: CTxx_SC-403.dgn

MISSISSIPPI RIVER
COTTONWOOD ISLAND EMP

TRANSECTS I & J MONITORING

Sheet ID
V-403

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FOR PLATES: 25
FOR SHEETS: 28

BORDER
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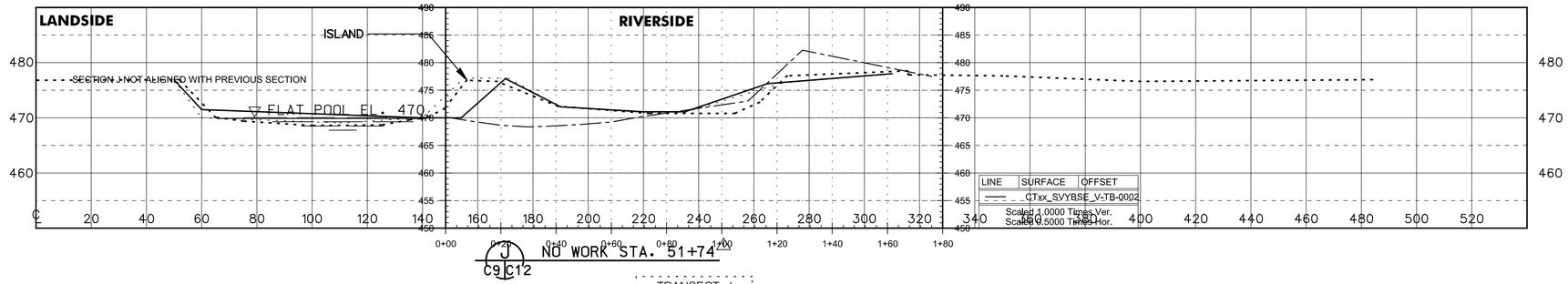
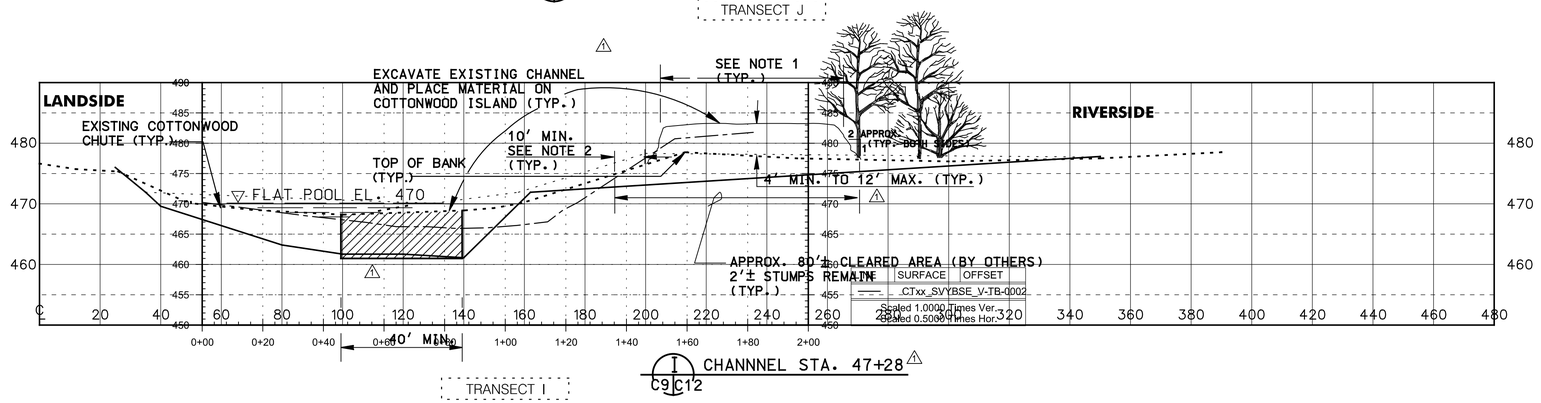
FOR PLATES: 10
FOR SHEETS: 11





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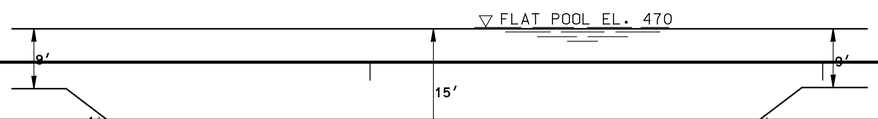

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US Army Corps of Engineers®

MARK	DESCRIPTION	DATE	APPR.
	REVISED AS CONSTRUCTED		

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DWN BY: M.S	CKD BY:	SUBMITTED BY:	CONTRACT NO.:
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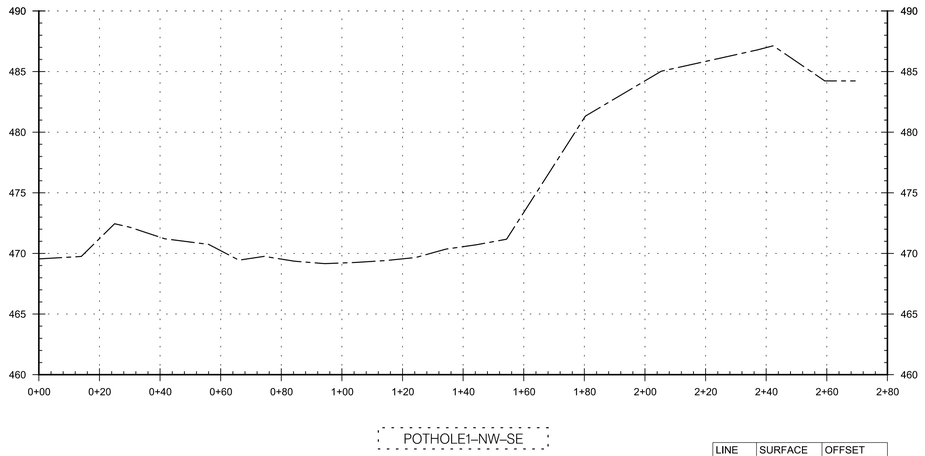
MISSISSIPPI RIVER
COTTONWOOD ISLAND EMP

TRANSECTS I & J MONITORING

Sheet ID
V-403



POTHOLE1–NW–SE

LINE	SURFACE	OFFSET
——	CTxx_SVYBSE_V-TB-0002	

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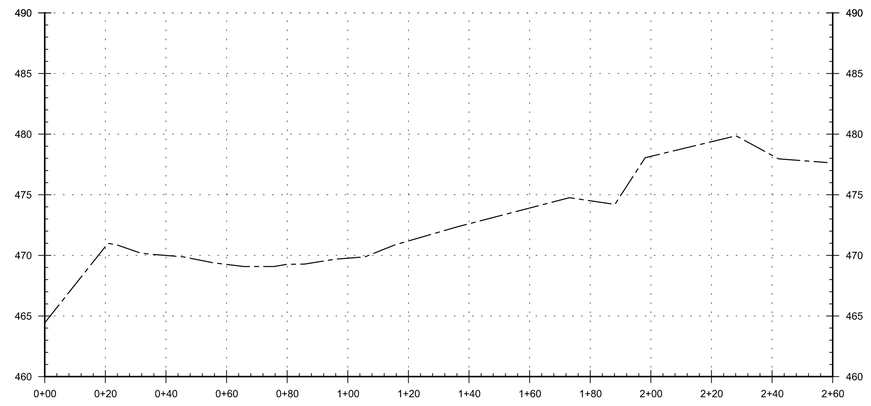

POTHOLE1–SW–NE

LINE	SURFACE	OFFSET
——	CTxx_SVYBSE_V-TB-0002	

Scaled 2.0000 Times Ver.
Scaled 0.5000 Times Hor.

DWG REF(s) :

A1 2012 EMP MONITORING

US Army Corps of Engineers®

MARK	DESCRIPTION	DATE	APPR.

DESIGNED BY:
DWN BY: MLS
CKD BY:
SUBMITTED BY:
DATE: 2012/09/14
SOLICITATION NO.:
CONTRACT NO.:
PROJECT CODE:
PLOT SCALE: As Shown
PLOT DATE: None
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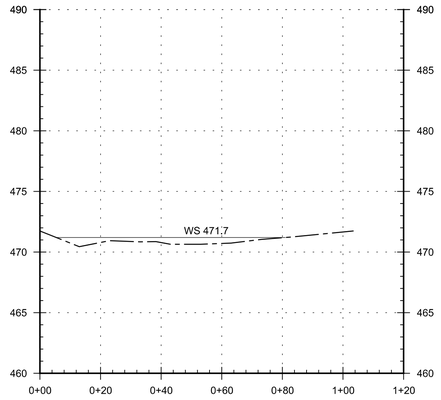
MISSISSIPPI RIVER
COTTONWOOD ISLAND EMP

POTHOLE #1

Sheet ID
V-404



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——	CTxx_SVYBSE_V-TB-0002	

Scaled 2.0000 Times Ver.
Scaled 0.5000 Times Hor.

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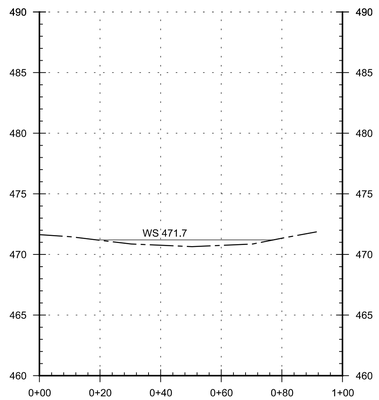

LINE	SURFACE	OFFSET
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Scaled 2.0000 Times Ver.
Scaled 0.5000 Times Hor.

POTHOLE2–SW–NE

DWG REF(s) :

A1 2012 EMP MONITORING

US Army Corps of Engineers®

MARK	DESCRIPTION	DATE	APPR.

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DWN BY: MLS
CKD BY:
SUBMITTED BY:
DATE: 2012/09/14
SOLICITATION NO.:
CONTRACT NO.:
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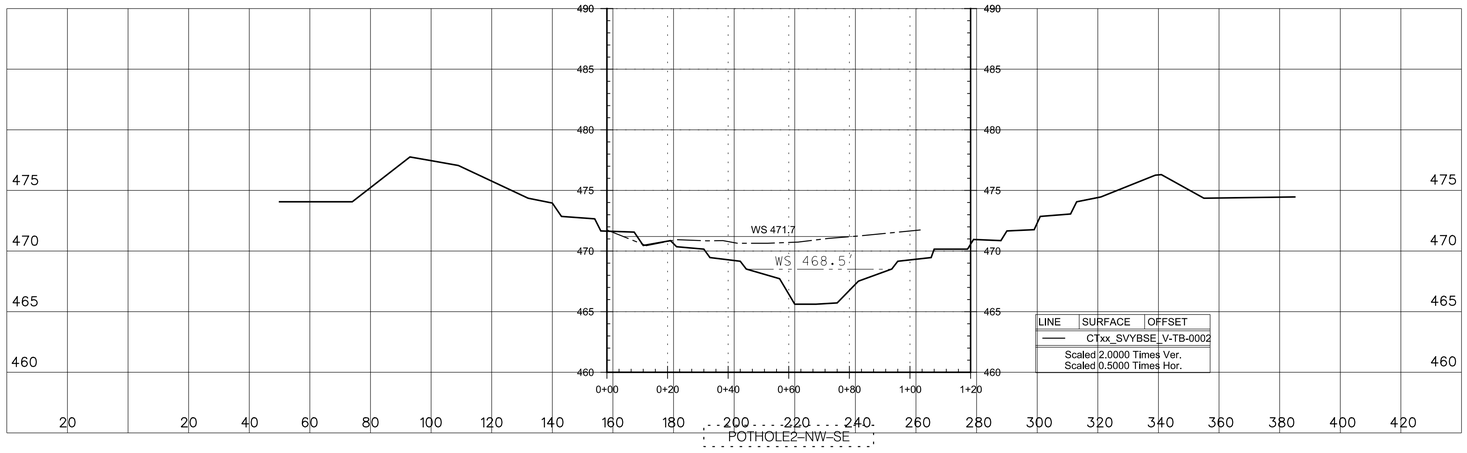
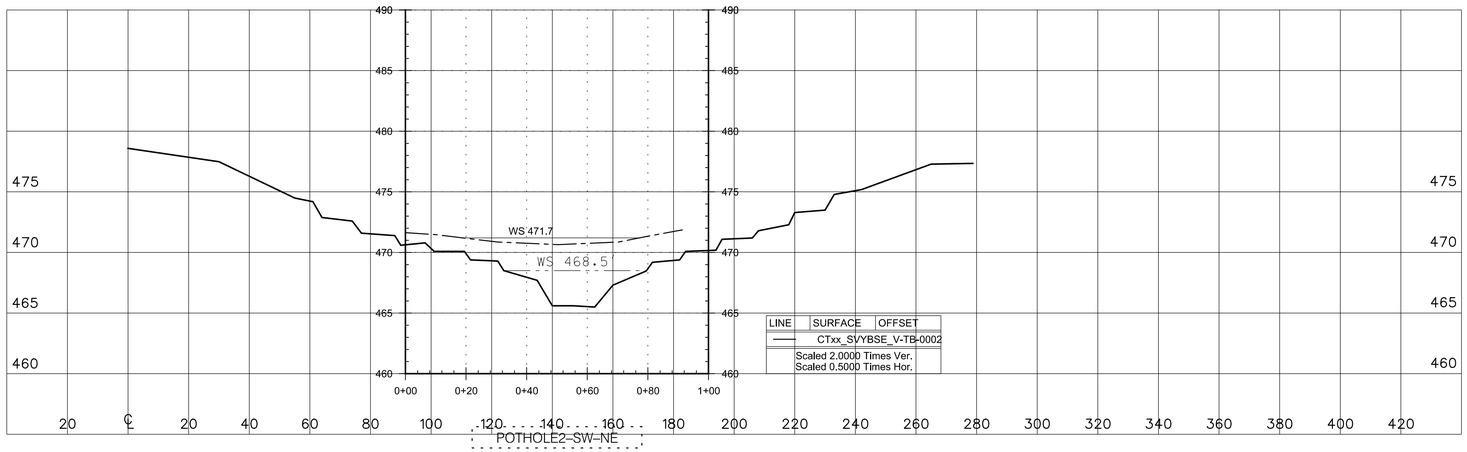
MISSISSIPPI RIVER
COTTONWOOD ISLAND EMP

POTHOLE #2 MONITORING

Sheet ID
V-405



POTHOLE #2 – SHORT CHORD



POTHOLE #2 – LONG CHORD

9 JAN '98 CCK/RLK

REVISED AS CONSTRUCTED-ADDED SHEET TO SET

POTHOLE 2 TRANSECTS

SURVEY FIELD BOOKS: FC-97-4
DATE OF SURVEY 10/21/97-10/23/97

C16
21

DWG REF(s) :

A1 2012 EMP MONITORING

US Army Corps of Engineers®

MARK	DESCRIPTION	DATE	APPR.

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DWN BY: MLS
CKD BY:
SUBMITTED BY:
DATE: 2012/09/14
SOLICITATION NO.:
CONTRACT NO.:
PROJECT CODE:
PLOT SCALE: As shown
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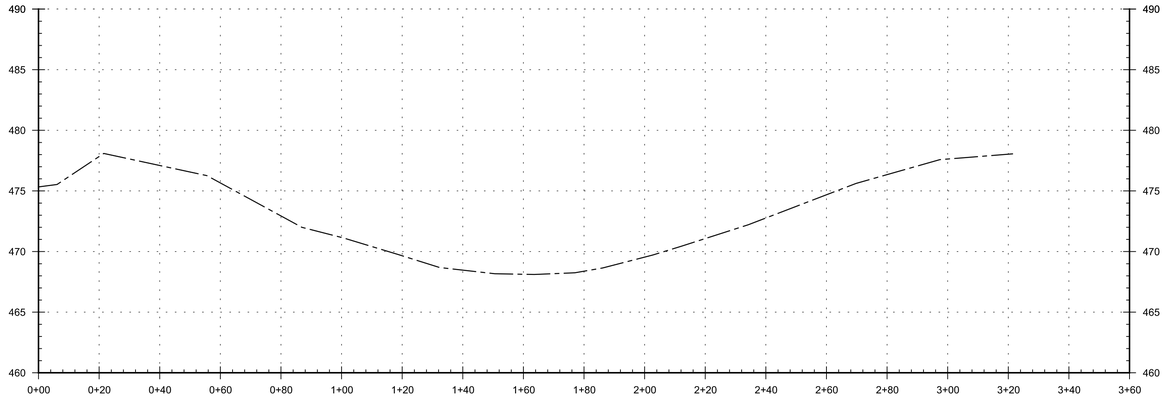
MISSISSIPPI RIVER
COTTONWOOD ISLAND EMP

POTHOLE #2 MONITORING

Sheet ID
V-405



POTHOLE3–E–W

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Scaled 2.0000 Times Ver.
Scaled 0.5000 Times Hor.

POTHOLE3–N–S

LINE	SURFACE	OFFSET
——	CTxx_SVYBSE_V-TB-0002	

Scaled 2.0000 Times Ver.
Scaled 0.5000 Times Hor.

DWG REF(s) :

A1 2012 EMP MONITORING

US Army Corps of Engineers®

MARK	DESCRIPTION	DATE	APPR.

DESIGNED BY: None
DRN BY: MLS
CKD BY:
SUBMITTED BY:
DATE: 2012/09/14
SOLICITATION NO.:
CONTRACT NO.:
PROJECT CODE:
PLOT SCALE: As Shown
PLOT DATE: None
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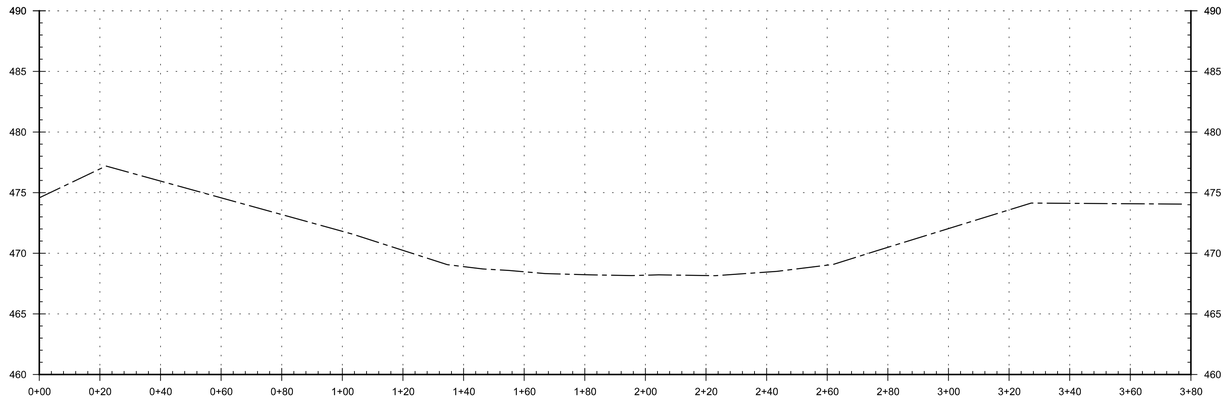
MISSISSIPPI RIVER
COTTONWOOD ISLAND EMP

POTHOLE #3 MONITORING

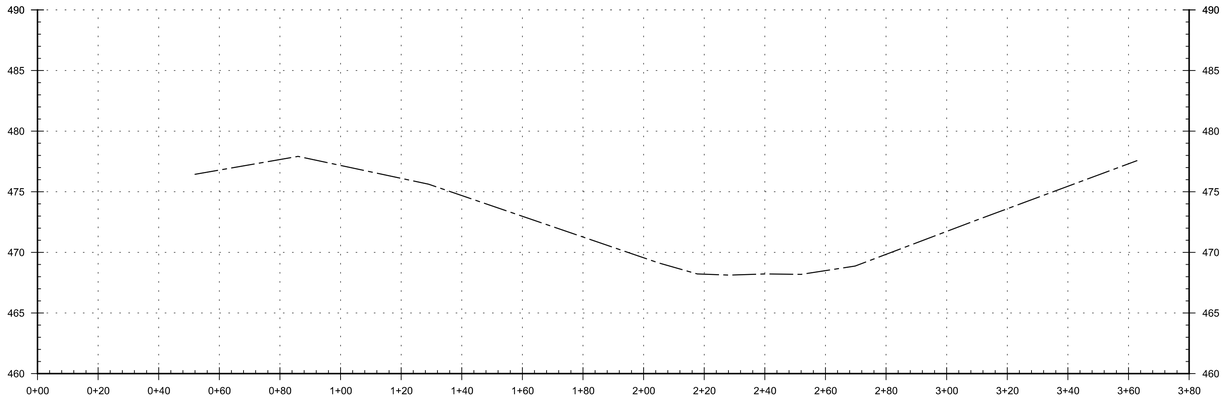
Sheet ID
V-406



POTHOLE4–NW–SE

LINE	SURFACE	OFFSET
——	CTxx_SVYBSE_V-TB-0002	

Scaled 2.0000 Times Ver.
Scaled 0.5000 Times Hor.



POTHOLE4–SW–NE

LINE	SURFACE	OFFSET
——	CTxx_SVYBSE_V-TB-0002	

Scaled 2.0000 Times Ver.
Scaled 0.5000 Times Hor.

DWG REF(s) :

A1 2012 EMP MONITORING

US Army Corps of Engineers®

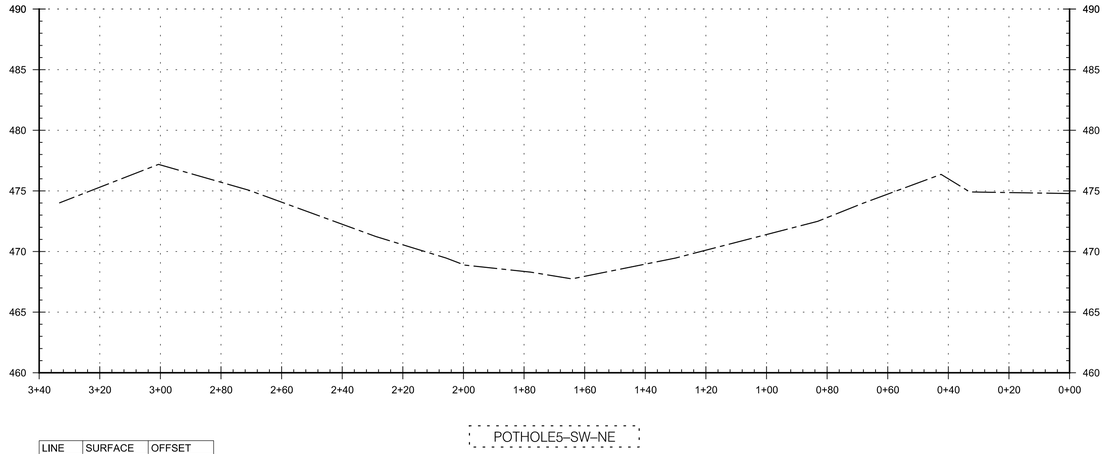
MARK	DESCRIPTION	DATE	APPR.

DESIGNED BY:
DWN BY: MLS
CKD BY:
SUBMITTED BY:
DATE: 2012/09/14
SOLICITATION NO.:
CONTRACT NO.:
PROJECT CODE:
PLOT SCALE: As shown
PLOT DATE: None
SIZE:
FILE NAME: CTxx_SC-407.dgn

MISSISSIPPI RIVER
COTTONWOOD ISLAND EMP

POTHOLE #4 MONITORING

Sheet ID
V-407



LINE	SURFACE	OFFSET
——	CTxx_SVYBSE_V-TB-0002	

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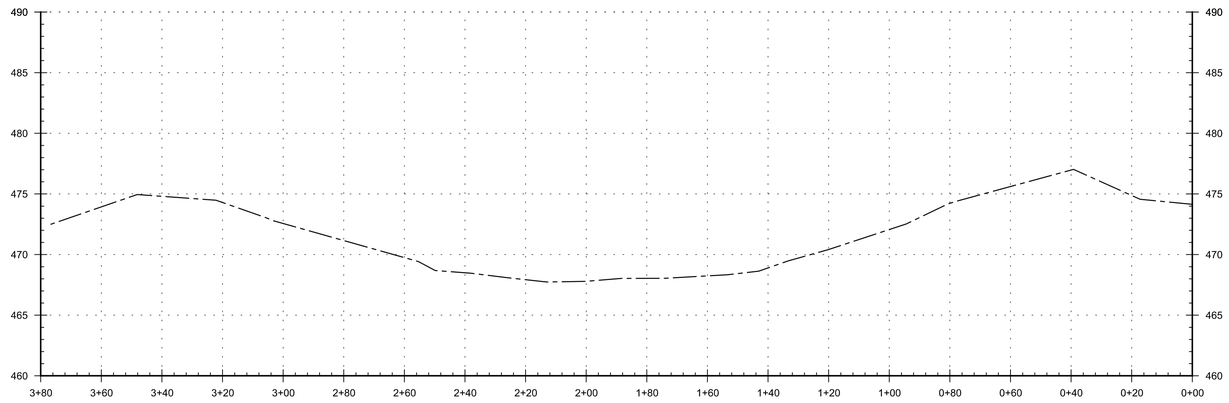
POTHOLE5–SW–NE



LINE	SURFACE	OFFSET
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Scaled 2.0000 Times Ver.
Scaled 0.5000 Times Hor.

POTHOLE5–NW–SE

DWG REF(s) :

A1 2012 EMP MONITORING

US Army Corps of Engineers®

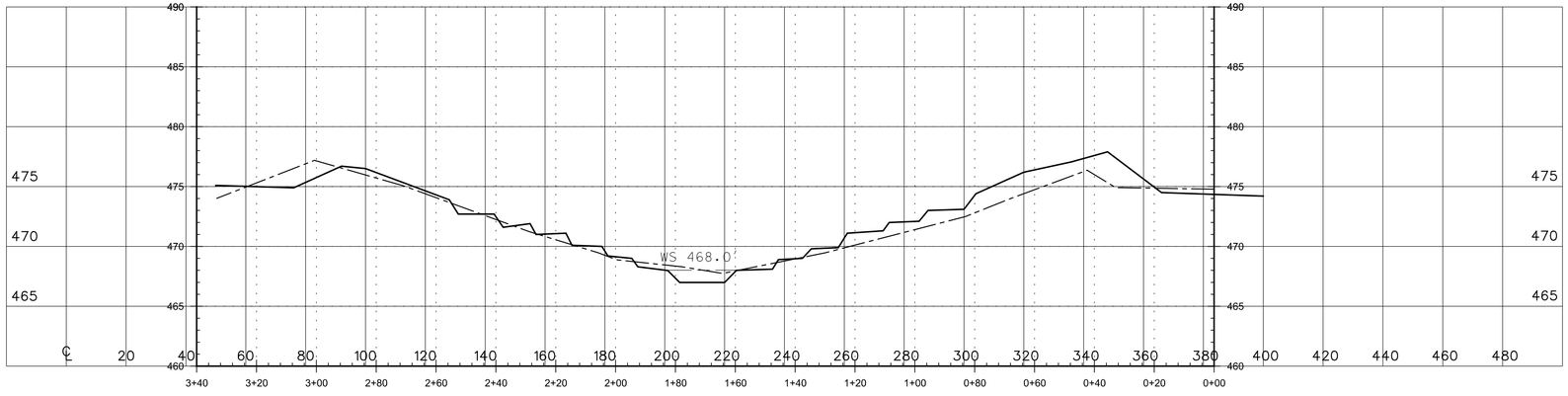
MARK	DESCRIPTION	DATE	APPR.

DESIGNED BY:		DATE: 2012/09/14	SOLICITATION NO.:
DWN BY: MLS	CKD BY:	SUBMITTED BY:	CONTRACT NO.:
PLOT SCALE: As shown	PLOT DATE: None	PROJECT CODE:	
SIZE:	FILE NAME: CTxx_SC-408.dgn		

MISSISSIPPI RIVER
COTTONWOOD ISLAND EMP

POTHOLE #5 MONITORING

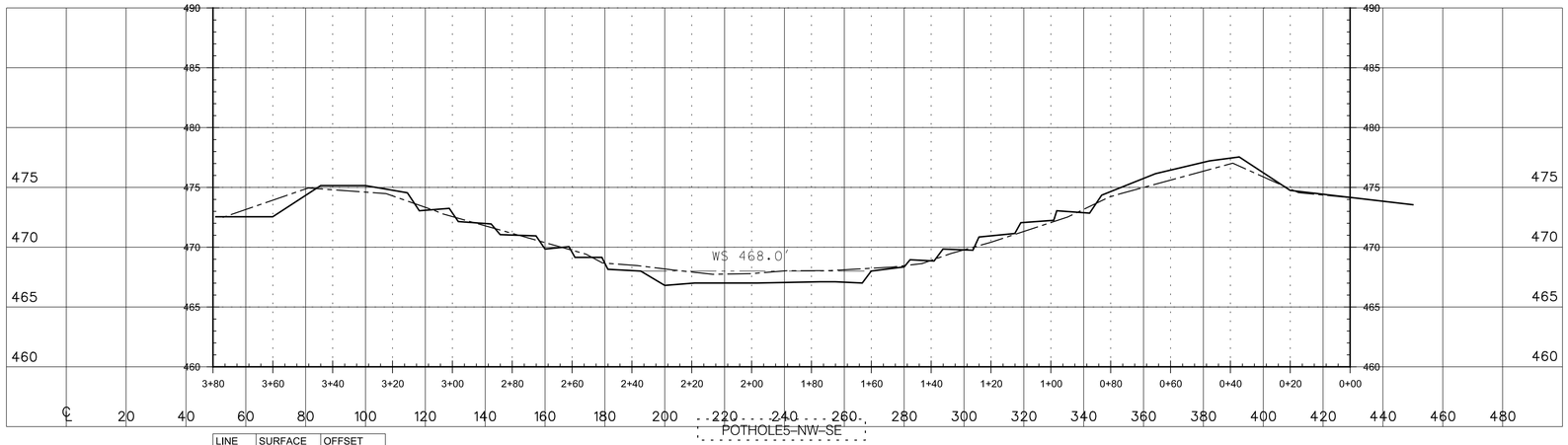
Sheet ID
V-408



LINE	SURFACE	OFFSET
——	CTxx_SVYBSE_V-TB-0002	

Scaled 2.0000 Times Ver.
Scaled 0.5000 Times Hor.

POTHOLE #5 – SHORT CHORD



LINE	SURFACE	OFFSET
——	CTxx_SVYBSE_V-TB-0002	

Scaled 2.0000 Times Ver.
Scaled 0.5000 Times Hor.

POTHOLE #5 – LONG CHORD

SURVEY FIELD BOOKS: FC-97-4
DATE OF SURVEY 10/21/97-10/23/97

DWG REF(s) :

A1 2012 EMP MONITORING

US Army Corps of Engineers®

MARK	DESCRIPTION	DATE	APPR.
1	REVISED AS CONSTRUCTED-ADDED SHEET TO SET	9 JAN '98	COR/BLK

DESIGNED BY:
DWN BY: MLS
CKD BY:
SUBMITTED BY:
DATE: 2012/09/14
SOLICITATION NO.:
CONTRACT NO.:
PROJECT CODE:
PLOT SCALE: As shown
PLOT DATE: None
SIZE:
FILE NAME: CTxx_SC-408.dgn

MISSISSIPPI RIVER
COTTONWOOD ISLAND EMP

POTHOLE 5 TRANSECTS

POTHOLE #5 MONITORING

C19

Sheet ID
V-408